HSI Course Projects

April 4-May 5, 2022

Projects

Projects	Advisors/Referents
All projects	Guy Andre Boy (guy-andre.boy@centralesupelec.fr)
1. INNOMED: General Practitioner-centered Health system	Dimitri Masson (d.masson@estia.fr) Jean-Benoit Pécastaing (dr.jbpecastaing@gmail.com)
2. FCAS (Future Combat Air System) shared situation awareness system	Chloé Morel (c.morel@estia.fr) Jean-Patrick Gaviard (jeanpatrickgaviard@gmail.com)
3. Digital aviation air traffic system	Thomas Brethomé (thomas.brethome@csgroup.eu) Alexandre Disdier (alexandre.disdier@csgroup.eu)
4. Small nuclear reactors system	Bertrand Lantes (bertrand.lantes@wanadoo.fr) Ludovic Loine (ludovic.loine@gmail.com)
5. Digital twin for helicopter engine diagnostic and repair system	Quentin Lorente (q.lorente@net.estia.fr) François Thermy (francois.thermy@safrangroup.com)
6. Offshore oil-&-gas platform telerobotic system	Élise Durnerin (e.durnerin@estia.fr) Eric Bartoli (eric.bartoli@totalenergies.com)
7. Model-Based-HSI in rail systems	Sun Yang (yang.sun@sncf.fr) Marc Sango (marc.sango@sncf.fr)

Expectations

Students are expected to provide a full literature review (both scientific and technological), an appropriate problem statement of the project and requirements that have been assigned to. Depending on the complexity of the project, they should provide a first mock-up of the system to be designed (a PowerPoint slide presentation). Every Friday, a small work-in-progress report on the project should be posted (email to guy-andre.boy@centralesupelec.fr). Product should be as complete, clean and original as possible.

Procedure

1	• You will fill in the table of scores (Excel spreadsheet) (most preferred [7]; less preferred [1])	April 4, 2022
2	• We will form groups (up to 4 students) …	April 4, 2022
6	• You will be able to interact with us on your project for 10 to 15 minutes, via email and/or TEAMS (see your advisors/referents)	April 4-May 5, 2022
7	• Final presentation of each project (20 minutes + 10 minutes Q&A) – (14:00—18:00)	May 5, 2022
8	• Project paper of each project, 6 pages, ACM format (provided)	May 12, 2022

1. INNOMED: General Practitioner-centered Health system

Imagine a national health system (e.g., in France) where your general practitioner would come to your house and have a primary role in your health, connecting you to the best hospital specialists, filtering and framing your current specific disease (when appropriate of course) and most importantly knowing you as a mentor and constant health support. What would the national health system look like? What kind of technology would be developed to support such a system? What kind of human-centered artificial intelligence (AI) should be developed to support the general practitioner? How would you design connectivity between you, the general practitioner, the hospital, the national health system, etc.? Could you take the COVID pandemic as an example?

Three solutions are proposed. The first one, which could be applicable in the short term, would be to give the GPs back control over the consultation of specialists by their patients. The idea would be that the validation of an appointment requires the agreement of all three parties (the GP, the specialist, and the patient). The GP would then have better management of his patients and would begin to assume the role of point of entry. However, the list of specialists involved remains to be defined (would psychologists fit into this scheme, for example?). In addition, some disciplines would remain outside this system, such as dentistry and ophthalmology.

The second proposal, which is slower to implement than the first, would consist in transforming part of the consultation hours of general practitioners into on-call hours during which they could remain available for their patients, in teleconsultation for example, at times when pressure is generally put on the emergency room and the SAMU (night hours in particular). This measure would help to relieve the pressure on emergency rooms, which are too often used for minor problems that do not require hospital care. And there would also be a pseudo return of the status of the family doctor, being the privileged interlocutor of the patient.

The third proposal is the one that would require the most time, because it will depend on the evolution of a measure taken very recently, the end of the "numerus clausus" which limited the number of places in medical studies after the PACES (First year common to health studies). Some statistics announce the arrival of nearly 10,000 doctors in 14 years for 3,500 retirements. The aim would be to limit the number of patients having the same doctor. If the general practitioner is to become a conduit of information between the patient and the French health system, then too many people to manage would be detrimental to the whole. With each general practitioner having a limited number of patients, care would be better and information management for the doctor would be considerably reduced.

2. FCAS (Future Combat Air System) shared situation awareness system

The FCAS (Future Combat Air System) is a European combat air system of systems (SoS) developed by Airbus, Thales Group, Indra Sistemas and Dassault Aviation. The FCAS will consist of a next-generation weapon system as well as other air assets in the future operational battle space. There will be a mix of manned aircraft and UAVs that must be coordinated. It will be a multi-agent system, in the sense of AI. How would you state the overall problem to be solved? How would you model the situation awareness (SA) problem for each pilot, and more generally each FCAS stakeholder? What do we mean by shared SA? What would you provide each FCAS stakeholder with? What kind of organization? What kind of complexity?

Some of the risks associated with using machines differ from those associated with using humans for the intervention: the very low but potentially catastrophic risk of having the machines used hacked is possible and would mean the failure of the intervention, and the danger of having the machines turn against the allied forces. Given the lower reliability and adaptability of the machines, the risk of mission failure goes from low to medium. The risk of seeing the machines destroyed during the intervention is high, because the machines have no survival instinct, but will have only minor consequences. Finally, the risk of injuring or killing civilians goes from high to high, because the machines will not think before firing as a human might.

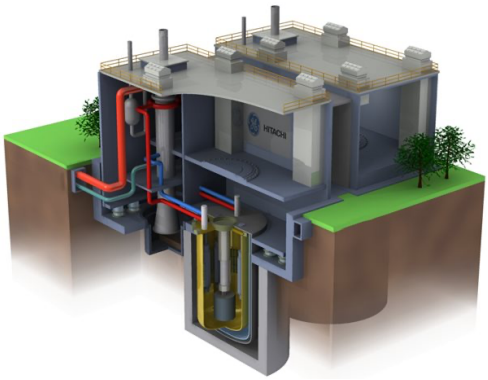
Therefore, the main topic of this project should be focused on function allocation between humans and machines with respect to principles and criteria that you will have to define. You will need to elicit scenarios from subject matter experts (a fighter pilot for example) that will guide in these definitions.

3. Digital aviation air traffic system

Digital aviation has often been cited as being the next significant business transformation in the sector and one which can support the aerospace industry towards delivering greater customer satisfaction while addressing efficiency, cost, and capacity issues. A Digital Air Traffic System (DATS) will provide new kinds of support for air traffic control (ATC) and, more generally, air traffic management (ATM). The digital air traffic control tower (DATCT) should enable smarter approaches and new airport functions that will need to be integrated. DATS should enhance the controller's situational awareness, enabling quick and informed decisions. DATCT should provide a 360-degree view of the airport and the ability to zoom in on aircraft, improving visibility. How would you model the resulting system of systems (SoS)? How would you allocate functions of cyber-physical systems and human operators? You should take a scenario-based design approach.

Several obstacles can be anticipated. First, the acceptance of change due to the implementation of new working methods and the training of controllers to these new technologies. It is also essential to ensure that the mental load of operators does not increase. Social maturity comes into play here, controllers must be ready to accept this new way of doing their job. From a standards and regulations point of view, a work of implementation is necessary so that they do not represent a limit to the development of the project. It will be necessary to have a clear and precise documentation, to respect to the maximum the terms of safety and to avoid the problems which can occur. Technological risks are also at stake, such as hardware quality and reliability (failures, breakdowns of sensors, acquisition system, ...) and system connectivity that prevents from undesired interruption. It is also necessary to place the human being at the heart of the reflection and to consider the problems due to the appearance of emergent functions during simulations and tests.

4. Small nuclear reactors system



At a time when climate change issues are extremely serious, nuclear energy comes back to the front line. How can we imagine sustainable electric vehicles without sustainable and affordable energy source. Advanced Small Modular Reactors (SMRs) could be good solutions for developing safe, clean, and affordable nuclear power options. Advanced SMRs can vary in size from tens of megawatts up to hundreds of megawatts, can be used for power generation, process heat, desalination, or other industrial uses. SMR designs may employ light water as a coolant or other non-light water coolants such as a gas, liquid metal, or molten salt. SMRs advantages are relatively small physical footprints, reduced capital investment, ability to be sited in locations not possible for larger nuclear plants, and provisions for incremental power additions. SMRs also offer distinct safeguards, security and nonproliferation advantages. How would you develop and organize SMRs? What would be the organizational and safety issues?

Considering:

- the French context, in particular, the objective of carbon neutrality by 2050 and on the basis of the latest RTE report (Réseau **de** Transport d'Électricité), which presents different scenarios for achieving it;
- the progress of the Nuward file (SMR: Small Nuclear Reactors);
- the EPR2 safety file (evolution of the Flamanville EPR: European Pressurised Reactor);
- the deployment objectives of other renewable energy sources (e.g., wind, photovoltaic), considering the already operational hydraulic power;
- that nuclear power is proving to be an essential "flexible" electricity production method at consumption levels higher than those currently in use (i.e., drastic reduction in fossil fuels, such as oil and gas).

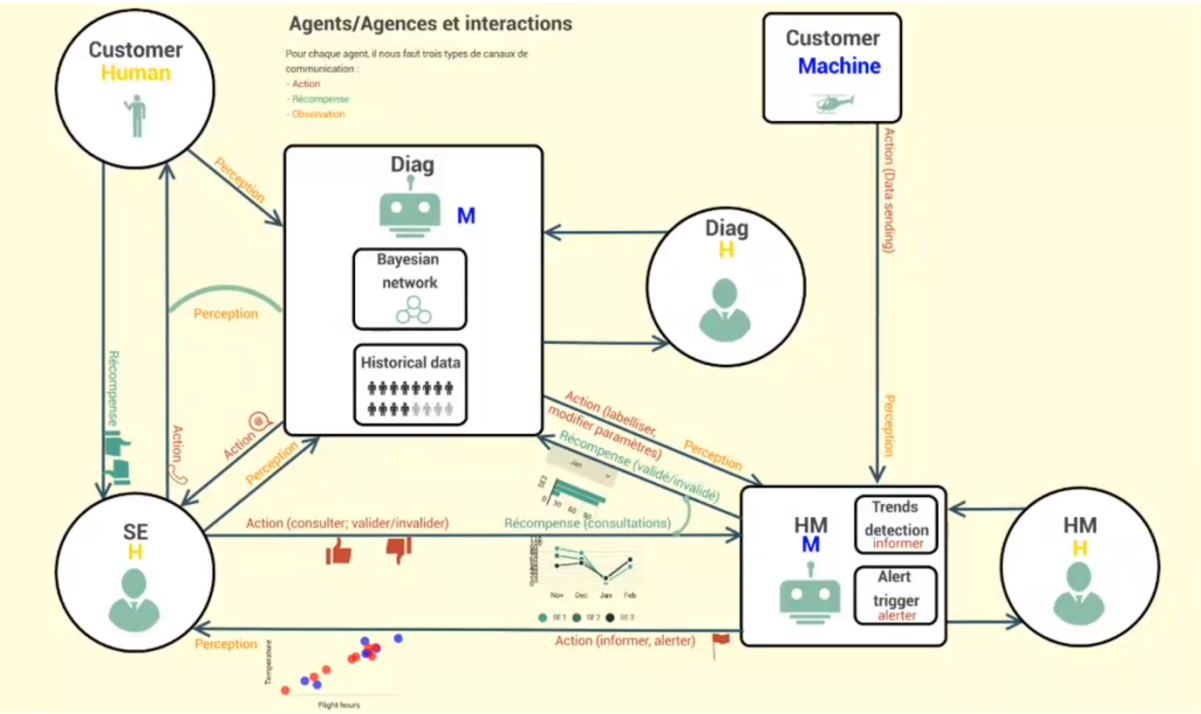
Comparatively evaluate the different types of reactors (current 900/1300 MW which will have to stop over time, EPR2, SMR) on the plans (Documentation will be provided). Based on this evaluation, can you propose an alternative scenario that you consider to be optimal compared to those presented in the RTE report? These questions should be answered along with the following perspectives:

- HSI (staff, skills...) reactor management, maintenance in operation, dealing with human errors in operation, with serious consequences in terms of downtime;
- Environment (in normal operations whether CO2 impact (transport) or effluents and radioactive waste from operations, spent fuel and in degraded or accidental operation);
- Economic: number of reactors (commissioning schedule, engineering resources perhaps not at the RoV), locations, network balance.

5. Digital twin for helicopter engine diagnostic and repair system

We are looking for effective diagnostic tools for maintenance to optimize maintenance and anticipate downtime based on experience. Indeed, reactive problem solving is relatively expensive given the variety of configurations in service. In addition, the strength of helicopter engine manufacturers lies in the competence of their human operators and the growing volume of data collected from flight and maintenance records. The aim of this project is to provide support to MRO (Maintenance, Repair and Overhaul) teams, to help them in their daily activities, using digital twins (DTs) from the fleet of engines in service. How would design such DTs for diagnosing failure and helping maintenance personnel to explore "what-if" possibilities? Who are the stakeholders? What kind of AI technology would you choose and implement?

Since we will have to use experience feedback from the potential users, we will try to capitalize human interactions with the system to learn with respect to deviations to expected trends. This is a topic of reinforcement learning.

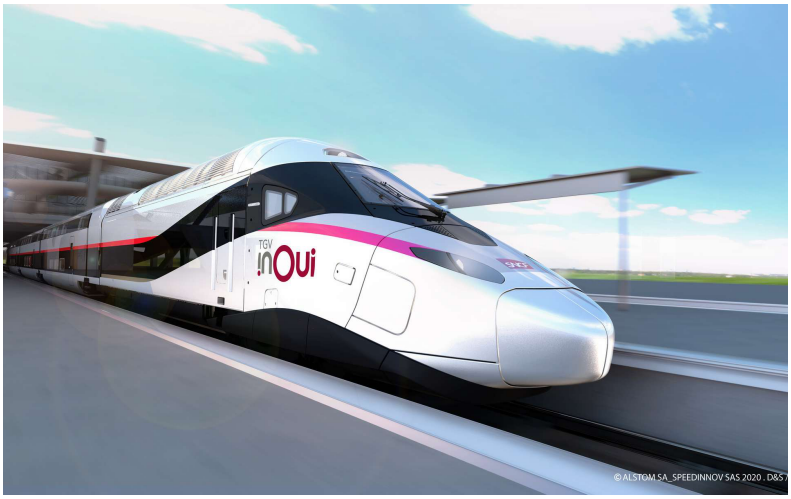


6. Offshore oil-&-gas platform telerobotic system

How can we replace safely, efficiently, and comfortably human inspection of and restart an oil platform by a robotic equivalent remotely managed? Whenever uninhabited well platforms require an emergency shutdown, the intervention of a multi-trade team of 7/8 people, to carry out the actions required locally to restart the platform. The personnel must establish a lack of danger by meeting X standards. Therefore, how an inspection robot can be used to perform a check (verify the integrity of the platform) and restart the platform remotely? Research questions are the following: (1) situation awareness; (2) acceptability; and (3) decision making.

Potential solutions should involve knowledge elicitation from subject matter experts in the form of procedural scenarios (i.e., task descriptions and analysis) and declarative scenarios (i.e., functional, and structural descriptions and analysis). The first set of scenarios will describe what exists today with field workers. The second set of scenarios will describe what could be done using robots remotely managed. these two sets of scenarios should be compared with respect to principles and criteria to be defined.

7. Model-Based-HSI in rail systems



We would like to make trains more autonomous, using sensors, radars, artificial intelligence and HSI. We want to anticipate the train of the future (2040-2050). Will to create trains assisted by smarter systems involving artificial and human intelligence (that results in difficult function allocation and tangibility issues). Operational efficiency will depend on the right integration of heterogeneous systems. We are looking for the expansion of use contexts, which requires new analysis processes, situation awareness functions, decision-making support and action taking procedures, leading to new emerging human roles. At the same time, connectivity increases, and huge amounts of information must be processed. Since actors' roles change, workplaces will also change. Consequently, resulting human factors must be studied.

The following questions should be better formulated and further answered: what is the scope of the system to be considered? What elements do we need to integrate into the cockpit to manage the system safely, efficiently, and comfortably? What methodology for the design of a good human-autonomy teaming? What are the rules of coordination between people and these new machines? How to create a human-machine symbiosis where the machine assists the human operator in his new role of system manager and where a true relationship of trust is established? How to integrate a new philosophy while maintaining the current principles of authority? How to free humans from repetitive and basic tasks? What is the right level of information for the people involved? How can we reduce the cognitive load of people involved and increase their situation awareness? How can we optimize physical and figurative tangibility, as well as ultimately trust and collaboration.

Time schedule

There are three types of events in the Daily Schedule below:

L_n: Lecture number n (**presence to all lectures is mandatory**)
C_p: Industrial Case number p (real-world cases will be given by professional experts)
E_r: Exam number r (E_1 consists in answering 20 straightforward questions in one hour; documents are allowed, but if you consult them, you may not have enough time to finish – advise is "be present at all classes"; E_2 consists in presenting your project facing an evaluation committee; E_3 consists in writing a synthesis of your project results)

Time	Mon 4 Apr	Wed 13 Apr	Thu 14 Apr	Wed 20 Apr	Thu 21 Apr	Fri 22 Apr	Mon 2 May	Tue 3 May	Thu 5 May
Morning									
08:00:-08:15	L1: Intro		C1: Product			L16: Risk		C5: NPP-1	
08:15-08:30	HSI -1		Nature/Life			Taking		SOH	
08:30-08:45			Harmonization						
08:45-09:00	GAB		GAB & GF			GAB		GAB & BL	
09:00-09:15	Pause		Pause			L17: Life		Pause	
09:15-09:30	L2: Intro		L8: Practical			Critical		C6: NPP-2	
09:30-09:45	HSI -2		Complexity			Systems		SOH	
09:45-10:00			Analysis			GAB			
10:00-10:15	GAB		GAB					GAB & BL	
10:15-10:30	Pause							Pause	
10:30-10:45	L3: Kick-off				L14: HSI		L18 Scenario	E1: 20Q1H	
10:45-11:00	Projects				Ingescape		Based	Exam	
11:00-11:15					Fundamentals		Design	Mid-term	
11:15-11:30	GAB et al.				GAB & SV		GAB & DM	GAB	
11:30-11:45					Pause		Pause		
11:45-12:00					L15: HSI		L19: PRODEC		
12:00-12:15					Ingescape				
12:15-12:30					Exercise				
12:30-12:45					GAB & SV		GAB		
Afternoon									
14:00-14:15		L4: Cockpit	L9: Design	L13: UX					E2 (05/04)
14:15-14:30		Design	Thinking						Projects
14:30-14:45									Defenses
14:45-15:00		GAB	GAB	GAB					
15:00-15:15		Pause	Pause	Pause					
15:15-15:30		L5: ODM	L10: GEM	C2: Oil&Gas					
15:30-15:45				Telerobotics					
15:45-16:00									
16:00-16:15		GAB	GAB	GAB & ÉD					
16:15-16:30		Pause	Pause	Pause					
16:30-16:45		L6: SCE	L11: HSI	C3: MMT					
16:45-17:00			INNOMED	MOHICAN					
17:00-17:15									
17:15-17:30		GAB	GAB	GAB & CM					
17:30-17:45		L7: SCAF	L12: GEM	C4: Nuclear					
17:45-18:00			Your	Submarine					E3 (12/04)
18:00-18:15			solution	Experience					Projects
18:15-18:30		GAB	GAB	GAB & LL					Reports

References

Boy, G.A. (2021). *Design for Flexibility*. Springer Nature, Switzerland (https://www.springer.com/gp/book/9783030763909).

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

Boy, G.A. (2013). *Orchestrating Human-Centered Design*. Springer, U.K. (https://www.springer.com/gp/book/9781447143383).

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Boy, G.A. (1998). *Cognitive Function Analysis*. Greenwood/Ablex, CT, USA (https://www.amazon.com/s?k=9781567503777&i=stripbooks&linkCode=qs).

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