SSM
Scuola Superiore Meridionale

MERC PhD Project Proposal

Title of the research project

Engineering of airport operations risk analysis

Keywords

Reliability, complex systems, aircraft dynamics, air traffic management, infrastructure, combustion science, industrial risk.

Supervisors

Supervisor 1 (I. Iervolino, iunio.iervolino@unina.it, http://wpage.unina.it/iuniervo, risk analysis)

Supervisor 2 (E. Salzano, ernesto.salzano@unibo.it, https://www.unibo.it/sitoweb/ernesto.salzano, industrial risk)

Supervisor 3 (D. Accardo, domenico.accardo@unina.it, https://www.docenti.unina.it/domenico.accardo, Aircraft dynamics)

Project description

Airport facilities are complex systems, with operations determining risk with the airport area as well as the surroundings. Such risks are primarily determined by the hazards related to air traffic (e.g., taxi, landing and take-off) and the chance of crashes and can be aggravated by storage or treatment of hazardous substances in the area of interest (i.e., domino effects). In fact, accidents leading to crash may include fuel fires and explosions, but also trigger domino effects such as industrial accidents, possibly amplifying adverse consequences.
International standards increasingly require that feasibility and design studies for airport facilities building and/or upgrade include quantitative assessment of the effects of the routine operations on the area surrounding the planned installation.
In some countries such analyses are mandatory and the targets for which the effects need to be evaluated often include: cultural heritage, natural habitat, as well as human comfort and health.
Quantitative risk analysis for airport facilities is the topic of the PhD. Program proposed, where a probabilistic framework to evaluate the annual fatality risk for airports and surrounding area, already established by the advisors in a preliminary form (see Iervolino et al., 2019).

Relevance to the MERC PhD Program

It has been discussed that airport facilities are complex civil infrastructure; several kinds of risks are connected to. One possible rick metric for quantitative assessment is the individual risk (IR), that is the unit-time fatality risk for an individual continuously exposed in the airport area and surroundings (De Waal et al., 2015).
Therefore, the methodology for the risk assessment should contemplate the tools and procedures to compute the annual expected number of accidents that result in fatality for each point in the area surrounding the airport.
Three causes contribute to the evaluation of IR: (i) direct aircraft impact, (ii) heat radiation produced by the burning of fuel possibly released in the crash; (iii) heat radiation or intoxication because the crash involves industrial facilities storing or treating relevant amounts of hazardous materials.
Consequently, the risk analysis requires competencies mainly from three fields: (a) stochastic modelling for uncertainty management and probabilistic evaluation; (b) aeronautical engineering for the modeling of aircraft operations and dynamics that may result in an accident and, finally, (c) chemical engineering for the combustion modeling and for the analysis of cascading effects on industrial targets (also called domino in the following), as well as for the evaluation of health consequences.

An important task to be fulfilled while developing the proposed risk assessment method is the evaluation of aircraft dynamical behaviour in case of failure during landing or take-off manoeuvres in proximity of an airport. Even if a large amount of statistical data is available, it does not allow to cover the required levels of risk to be considered with a significant accuracy. In addition, statistical models permit to estimate just the geographical distribution of crash risk. They do not allow to assess the typical levels of impact velocity that are required to estimate the consequences of crash in terms of risk of explosion and the extent of debris distribution. Moreover, specific procedures are needed to include new aircraft models and configurations. For this reason, advanced flight simulation tools can be determined to generate effective risk distribution charts. They can exploit assessed simulation models that are based on aircraft performance data bases that have been developed and tested by worldwide aeronautical authorities, such as the Base of Aircraft Data developed by EUROCONTROL.

The simulation of accidental jet-fuel combustion in the atmosphere is a matter of complexity and far to be fully understood (Pio et al., 2019). Indeed, the detailed description of the fire or the explosion of jet-fuel requires key parameters that identify the homogeneous and heterogeneous rate of combustion, the formation of soot, the flame extinction phenomena, the gasification and pyrolysis phenomena and other minor mechanisms. Detailed chemistry is needed in order to implement the full kinetic models in computational fluid dynamic, which allows for the 3D analysis of the jet-fuel accident. The phenomena of jet fuel fire and explosion can produce an escalation (domino effects) of the consequences due to interactions with critical infrastructures and more specifically with industrial plants falling under the so-called Seveso Directive, even if non-Seveso industrial systems can also present critical issues. The assessment of the domino effects falls within the topic of industrial risk engineering (Cozzani & Salzano, 2004) and allows to define the accidental scenarios triggered by the plane crash and the related consequences in the analysed domain.

Key references

Iervolino I., Accardo D., Tirri A.E., Pio G., Salzano E. (2019) Quantitative risk analysis for the Amerigo Vespucci (Florence, Italy) airport including domino effects. Safety Science, 113: 472–489.

De Waal, J. A., Muntendam-Bos, A. G., & Roest, J. P. A. (2015). Production induced subsidence and seismicity in the Groningen gas field–can it be managed?. Proceedings of the International Association of Hydrological Sciences, 372, 129-139.

Pio, G., Carboni, M., Salzano, E., Realistic aviation fuel chemistry in computational fluid dynamics (2019) Fuel, 254, 115676.

Cozzani, V., Salzano, E., The quantitative assessment of domino effects caused by overpressure: Part I. Probit models (2004) Journal of Hazardous Materials, 107, 67-80.

Joint supervision arrangements

Meetings with the first advisor will occur at least on a weekly basis, daily, if needed.

For the development of aircraft dynamics simulation in condition of failure when flying in proximity of airports: a bi-monthly meeting with prof. Domenico Accardo and Claudia Conte.

For the jet-fuel fire and explosion assessment and numerical modeling, and the implementation in computational fluid dynamics (CFD): a monthly meeting with prof. Ernesto Salzano and Gianmaria Pio

Location and length of the study period abroad (min 12 months)

It may be that some industrial partners will be involved; e.g., Ente Nazionale Aviazione Civile (ENAV) and Italian association of airport managing companies (ASSOAEROPORTI).

If needed, a 12 month research period can be carried out at Imperial College, London UK. The student can be tutored by prof. Professor Washington Yotto Ochieng, Head of the Centre for Transport Studies and Chair of Positioning and Navigation Systems in the Department of Civil and Environmental Engineering.

Any other useful information

E.g. involvement of stakeholders, industrial partners, other research institutions etc, funded research projects related to the proposed activity etc

If needed, a cooperation with the National Research Council (CNR) of Italy, Istituto di Scienze e Tecnologie per l'Energia e la Mobilità Sostenibili (STEMS) (Prof. Ernesto Salzano as research associate, dr. Valeria Di Sarli as senior researcher) is possible for the CFD development.