

DOTTORATO DI RICERCA IN INFRASTRUTTURE E TRASPORTI
SCHEMA PER L'AMMISSIONE AL II ANNO DI CORSO

Dottorando: Raducu DINU

Ciclo: XXXIV

Curriculum: 11042 Infrastrutture e Trasporti

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Argomento della ricerca:

Definition of a revised risk assessment model around Airports

SEZIONE A
Ricerca di Dottorato

1 – Acquisizione di conoscenze propedeutiche integrative (*contenuti appresi mediante frequenza di corsi, studio individuale, approfondimento del proprio bagaglio culturale, etc.*).

Land-use compatibility around (existing) airports becomes more and more challenging for all stakeholders as the air traffic and passengers volumes increase, but these elements also have direct consequences to the public in the vicinity of the runway. In order to acquire additional knowledge in this field, I have decided to participate to a project related to the development of the land side of one of the biggest airport in Canada. In fact, the project improves the road access to the main terminal and the parking lots, and is located in the Runway Protection Zone; as such, the project is related to the subject of the thesis, and in addition it allows me to be part of to the decision making process of the Airport Operator. Furthermore, I have attended to Envision credential training course organised by the Institute for Sustainable Infrastructure (ISI) as a prerequisite for Envision Sustainability Professional (<https://sustainableinfrastructure.org/envision/>). Finally, I am pursuing in-depth study of statistics analysis, in order to develop adequate knowledge to pursuit the preparation of the research thesis.

2 – Ricerca bibliografica svolta (*raccolta ed analisi di letteratura scientifica, con individuazione delle pubblicazioni maggiormente significative ai fini della ricerca proposta, per le quali si presenta in allegato una sintesi commentata.*).

The bibliographic research has covered the following scientific literature and applicable standards (the most significant and most recent ones are listed first):

- [1] Di Mascio P.; Loprencipe G. Risk analysis in the surrounding areas of one-runway airports: a methodology to preliminary calculus of PSZs dimensions. ARPN Journal of Engineering and Applied Sciences, pp.13641-13649, VOL. 11, NO. 23, December 2016
- [2] Di Mascio, P.; Loprencipe, G. Aeroporto Venezia/Tessera - Studio per la valutazione del rischio individuale contro terzi. Stato Futuro (2021), Sapienza Università di Roma, ENAC, February 2017
- [3] Di Mascio P.; Perta G.; Cantisani G.; Loprencipe G. The Public Safety Zones around Small and Medium Airports, Aerospace - Open Access Journal of Aeronautics and Astronautics 2018 <http://www.mdpi.com/2226-4310/5/2/46>
- [4] Cardi, A.; Di Mascio, P.; Di Vito, M.; Pandolfi, C.; Distribution of Air Accidents Around Runways, IIV - 5th International Congress - Sustainability of Road Infrastructures, SciVerse ScienceDirect, 2012

- [5] Moretti, L.; Cantasini, G.; Caro, S. Airport veer-off risk assessment: an Italian case study. ARPN Journal of Engineering and Applied Sciences, pp.900-912, VOL. 12, NO. 3, February 2017
- [6] Moretti, L.; Di Mascio, P.; Nichele, S.; Cokorilo, O. Runway veer-off accidents: Quantitative risk assessment and risk reduction measures. Safety Science Volume 104, Pages 157-163 April 2018
- [7] Attacalite, L.; Di Mascio, P.; Loprencipe, G.; Pandolfi, C.; Risk Assessment Around Airport, SIIV - 5th International Congress - Sustainability of Road Infrastructures, SciVerse ScienceDirect, 2012
- [8] ENAC Direzione Centrale Regolazione Aeroporti Policy di attuazione dell'art. 715 del codice della navigazione. Definizione della metodologia et della policy di attuazione del risk assessment. Jan. 2010
- [9] Runway protection zones (RPZ) risk assessment tool, Final Project Report ACRP 04-18, July 2016
http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_168_ContractorsFinalReport.pdf, consulted May 2019
- [10] Runway Protection Zones (RPZs) Risk Assessment Tool Users Guide, ACRP Research Report 168, Transportation Research Board, National Academy of Science, 2017.
- [11] Control of Development in Airport Public Safety Zones, Department of the Environment, Belfast, UK, 2007
- [12] Control of Development in Airport Public Safety Zones, DfT, Circular 01/2010. Department for Transport, London, UK, 2010
- [13] Evans, A. W., Foot, P. B. et al. Third Party Risk Near Airports and Public Safety Zone Policy. National Air Traffic Services Limited. R&D Report 9636. June 1997.
- [14] Public Safety Zones, Environmental Resources Management (ERM), DT &DoEHLG, Ireland, Feb.7, 2005
- [15] Cheung Y.S.; de Haij L.; de Jong R. Development of NLR third party risk model and its application in policy and decision-making for the airports in the Netherlands. National Aerospace Laboratory NLR, Report NLR-TP-2013-550, Amsterdam, Dec. 2013
- [16] Pikaar A.J.; Piers M.A.; Ale B. External risk around airports, National Aerospace Laboratory NLR, Report NLR-TP-2000-400, August 2000
- [17] FAA – Land Use Compatibility and Airports, a Guide for Effective Land Use Planning (https://www.faa.gov/airports/environmental/land_use/
https://www.faa.gov/about/office_org/headquarters_offices/apl/noise_emissions/planning_toolkit/media/III.B.pdf consulted on September 27, 2019)
- [18] FAA – Interim Guidance on Land Uses Within a Runway Protection Zone, Sept. 22, 2012, https://www.faa.gov/airports/planning_capacity/media/interimLandUseRPZGuidance.pdf
- [19] Transport Canada - Regulations Amending the Canadian Aviation Regulations (Aerodrome Work Consultations), effective January 1, 2017
<http://gazetteducanada.gc.ca/rp-pr/p2/2016/2016-10-19/html/sor-dors261-eng.html>, consulted on Oct. 20, 2019)
- [20] Airport Planning Manual - Land Use and Environmental Management, Doc.9184 /Part 2, ICAO, 3rd edition (2002) and 4th edition 2018
- [21] Analysis of Aircraft Overruns and Undershoots for Runway Safety Areas, ACRP Report 3, Transportation Research Board, National Academy of Science, 2008
- [22] Improved Models for Risk Assessment of Runway Safety Areas, ACRP Report 50, Transportation Research Board, National Academy of Science, 2011.
- [23] Using GIS for Collaborative Land Use Compatibility Planning Near Airports, ACRP Report 200, Transportation Research Board, National Academy of Science, 2019.
- [24] Advisory Circular (AC) 150/5300-13A Airport Design, FAA, Feb. 26, 2014

- [25] Development of a Runway Veer-Off Location Distribution Risk Assessment Model and Reporting Template, ACRP Research Report 107, Transportation Research Board, National Academy of Science, 2014.
- [26] Seung-Beom, Hong; Tukhtaev, Dilshod; DoHyun, K. An Application of the Risk Assessment Model for Runway End Safety Areas to a Specific Airport in Korea. International Journal of Control and Automation Vol. 9, No. 12, 2016, pp.287-298
- [27] Annual Aircraft Movements: Major Airports - NAV CANADA Towers and Flight Service Stations – 2018. Statistics Canada, <https://www150.statcan.gc.ca/n1/en/pub/51-004-x/51-004-x2019005-eng.pdf?st=yHRBm5aW>, consulted on October 20, 2019
- [28] Annual Aircraft Movements: Small airports - Airports without NAV CANADA Towers or Flight Service Stations, 2018 Statistics Canada, <https://www150.statcan.gc.ca/n1/pub/51-004-x/51-004-x2019007-eng.pdf>, consulted on October 20, 2019
- [29] Annual Aircraft Movements: Small airports - Airports without NAV CANADA Towers or Flight Service Stations, Statistics Canada, 2016 <https://www150.statcan.gc.ca/n1/pub/51-004-x/51-004-x2017015-eng.htm>, consulted on August 31, 2019
- [30] Annual Aircraft Movements: Major Airports - NAV CANADA Towers and Flight Service Stations – 2015. Statistics Canada, <https://www150.statcan.gc.ca/n1/pub/51-004-x/51-004-x2016011-eng.htm>
- [31] Airport Movement Statistics – Airports without Air Traffic Control Towers: Annual Report 2014. Statistics Canada, <https://www150.statcan.gc.ca/n1/en/pub/51-210-x/51-210-x2015001-eng.pdf?st=wQLOpRZj>
- [32] Air transportation occurrences in 2018, Transportation Safety Board of Canada, <http://www.tsb.gc.ca/eng/aviation/index.html>, updated on May 24, 2019
- [33] Aviation occurrence and aircraft data from January 2004, Transportation Safety Board of Canada, <http://www.tsb.gc.ca/eng/stats/aviation/data-2.html>, updated March 30, 2019

A summary of the findings in relation with the topic is presented in the Annex 1.

3 – Resoconto dello stato delle conoscenze relative alla tematica di ricerca *(breve sintesi del quadro scientifico di riferimento, in relazione alla tematica proposta: conoscenze consolidate e spunti per approfondimenti).*

The development and land-use around airports represents a subject of concern and interest for Airports Operators on one side and General Public, Business Communities and Local Authorities on the other side. This interest is further intensified by continuously increase of the air transportation (therefore by the need to expand the airport infrastructures) and by the fact that most of the airports are surrounded by already developed land. As such, in addition of existing regulations related to Noise Exposure or Airports' Obstacle Limitation Surfaces and Sectors – which ultimately limit the development of the land - **the risk assessment** of an Airport's Operations provides the means to validate the land use compatibility or even to restrict and control the activity outside, but in the vicinity of the Airport perimeter.

The definition or changes of the configuration of the Public Safety Zones (PSZ) and/or Runway Protection Zones (RPZ) and the risk assessment for these zones are at the interest of all stakeholders. As such, North America's approach is to have *a coordination between the parties* in order to achieve Land Use Compatibility with Airports (FAA) [17], or *to consult with stakeholders* before developing an airport or significantly changing an existing one (Transport Canada) [19].

In Europe, the approach in some countries (e.g. UK [11], [12], Ireland [14], Netherlands [16], etc.) is *to restrict and control the activity* within the PSZ, based on the maximum acceptable level of individual third-party risk.

Several zones are defined according to different threshold risks values of 1×10^{-4} (internal area), 1×10^{-5} (intermediate area) and 1×10^{-6} (external area) yearly. Italy's Civil Aviation authority (Ente Nazionale per l'Aviazione Civile - ENAC) has also defined the implementation policy for the risk assessment of the areas around airports, with similar threshold values [8].

A methodology to study the risk assessment is based on above mentioned studies (Netherlands and UK) and involves the creation of three models (as also indicated in the previous (3rd) edition of the International Civil Aviation Organisation (ICAO) Airport Planning Manual (2002) [20]), as follows:

- accident probability model;
- accident location (dispersion) model;
- accident consequence model.

Furthermore, the last (4th) revision of ICAO Airport Planning Manual (2018) indicates that specific methodologies can be used to define a dedicated zoning policy for land-use compatibility.

A summary of the scientific reference framework in relation with this topic, as per bibliographical research, is presented in the Annex 1.

Among the scientific reference, the models developed by the team of Sapienza University [7] (with ENAC and other collaborators) and the one developed under ACRP Project 04-18 and ACRP Report 168 (Runway Protection Zones (RPZs) Risk Assessment Tool) [10] have been further analysed.

The first element of analysis is the data collection of the accidents serving as historical database to define the accident location model. The database from ACRP Tool has accidents recorded from 1980 to 2009 and further expanded to 2014 (a total of 1066 events), while the database used in Sapienza model has records from 1996 to 2011 (a total of 813 events). However, ENAC further update an accident database to an extended records period, from 1996 and up to 2015 (a total of 1719 events, including small aircrafts with less than 5700 kg MTWA).

As such, a preliminary analysis of Sapienza accident probability model with the revised ENAC database confirms the model sensibility; therefore an adjustment of it might be operated (see Annex 2).

Furthermore, the accident database can be further updated until present day, in order to have more representative events for better accuracy or the proposed model. For instance, since 2016 and until end of August 2019, have occurred (only in Canada) a total of 842 accidents and 3228 incidents (average of 234 accidents and 832 incidents per year) with 149 fatalities, 99 + 4 (on ground/third-party) persons injured; even if the occurrences per million flights has a decreasing pattern [27] to [33] (see Annex 3).

Another element of analysis is a preliminary comparison of ACRP RPZ Tool and Sapienza Airport Risk Analysis (SARA) Software concluded for the same airport, with the output (iso-risk contours) presented in Annex 4. In this exercise, a particular attention has been given to ensure similar input data (number of annual movement, aircrafts fleet and runway use) between SARA and ACRP Risk Assessment Tool.

The result of the comparison, while presents similar shapes, returns some differences in the contours' values; as such it presents opportunity to in-depth analysis of these models, by understanding their limitations and/or by their possible adjustments and updates.

4 – Ricognizione delle attività in corso presso centri di ricerca nazionali ed internazionali (*inquadramento delle tendenze evolutive nello specifico ambito di ricerca, per quanto noto*).

The topic of the risk assessment, land-use and Runway Protection Zones has been identified by Federal Aviation Administration as an update to the Land Use Compatibility Advisory Circular [18], hence the evolutionary trend is towards RPZs based on risk assessment and accurate location-based data [23], such as iso-risk contours. Also, ENAC have been participating actively in this research field, in order to have adequate means to support its methodology to implement the risk assessment analysis.

5 – Definizione della Ricerca di Dottorato (*formulazione del Tema per la Tesi finale, con precisazione di: finalità, metodologia, fasi e tempi delle attività previste*).

Definition of a revised risk assessment model for Runway Protection Zones

The methodology will include:

- Revision/update of the accidents database according to project requirements, including ENAC database, and further on until 2019/2020.
- Review of existing models (SARA, ACRP, etc.) and comparison between the models' output.
- Update of SARA's probability model (updated database) in the first stage but with the same probability density distribution curves; further comparison with other models;
- Further analysis and evaluation of new probability distribution curves, including veer-off risks (for third-party / outside of airport perimeter);
- Sensibility analysis of the new model: large/small airport, variable traffic mix (majority of large commercial airplanes vs. majority of general aviation aircrafts);
- Production of the final report and documents

6 – Cronoprogramma (*seguire lo schema seguente*)

| n. | Attività | I Anno (consuntivo) | | | | II Anno | | | | III Anno | | | |
|----|--|---------------------|----|-----|----|---------|----|-----|----|----------|----|-----|----|
| | | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| 1 | Scientific Literature Research in the field of interest | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 2 | Update of the accident database | | | ■ | ■ | ■ | ■ | | | | | | |
| 3 | Review of existing models (SARA, ACRP) | | | ■ | ■ | ■ | ■ | | | | | | |
| 4 | Comparison of models' output | | | | | ■ | ■ | ■ | | | | | |
| 5 | Update SARA's probability model, revise distribution curves | | | | | ■ | ■ | ■ | ■ | | | | |
| 6 | Analysis of new probability distribution curves including veer-off risks | | | | | | | ■ | ■ | ■ | ■ | ■ | |
| 7 | Sensitivity analysis of the model | | | | | | | | | ■ | ■ | ■ | |
| 8 | Final report | | | | | | | | | | | ■ | ■ |

SEZIONE B

Attività di collaborazione e supporto; formazione ed acquisizione di capacità evolute

1 – Partecipazione alle attività di didattica presso la struttura di afferenza (*attività seminariale, supporto alla didattica frontale, preparazione di materiale didattico, collaborazione per ricevimento studenti, collaborazione allo svolgimento di tesi di laurea e stages*).

This activity is yet to be scheduled.

2 – Attività di formazione (*soggiorni presso strutture di didattica e ricerca in Italia e all'estero, corsi curriculari o speciali frequentati, partecipazione a seminari, convegni, workshop, etc.*).

The training activity includes attendance to the following courses at Sapienza University:

- 11 March 2019 - Paolo Delle Site - Stima di modelli logit e probit con dati best, worst, e best-worst.
- Valutazione multi-criteri di interventi sui sistemi di trasporto: la multi-attribute value theory.
- 18 March 2019- Giuseppe Cantisani, Paola Di Mascio - Risk analysis for transport infrastructures
- 25 March 2019 - Antonio Cappuccitti - Infrastrutture, Pianificazione e mitigazione delle vulnerabilità territoriali e urbane. Proposte di ricerca a partire da sperimentazioni esperite in Italia centrale.
- 3 April 2019 - Claudia Mattogno, Antonio Cappuccitti, Fabiola Fratini, Giuseppe Cantisani - Scenari per l'Europa.
- 10 April 2019 - Guido Gentile - Public Transportation Modelling in the era of ITS.
- 21 May 2019 - Giuseppe Loprencipe, Gianluca Dell'Acqua - Building Information Model
- 13 June 2019 - Laura Moretti, Antonio D'Andrea - Radiological Assessment of Construction Materials
- 24 June 2019 -Alberto Budoni - Infrastrutture e territorio: una visione bioregionale e transdisciplinare,
- 3 July 2019 - Stefano Ricci, Gabriele Malavasi - Tecnica della circolazione ferroviaria: principi e applicazioni a linee e nodi.
- 24 October 2019 (scheduled) - Paola di Mascio, Fabiola Fratini, Catherine Carré – Method and research; The Multiple Rs concept: urban regeneration for more sustainable mobility, land use and functions.

In addition, I have participated to Envision credential training course organised by the Institute for Sustainable Infrastructure (ISI) as a prerequisite for Envision Sustainability Professional (<https://sustainableinfrastructure.org/envision/>).

3 – Collaborazione a studi, ricerche, programmi strutturati (*contributi in PRIN, ricerche di Facoltà e di Ateneo, convenzioni, etc., con inquadramento del programma e specificazione dell'attività prestata*).

As a member of the Technical Committee C2 (Design and Operation of Safer Road Infrastructure) of the World Road Association (PIARC), cycle 2016-2019, I have contributed (including the final review and quality control) to the report 2019R26EN “Setting Credible Speed Limits – Case Studies Report”, which can be found at: <https://www.piarc.org/en/order-library/31347-en-Setting%20Credible%20Speed%20Limits%20- Case%20Studies%20Report>

Annex 1

Summary of finding Synthesis of the bibliographical research

Several third party risk calculation models based on the practice of quantitative risk assessment (QRA) have been developed and utilised in several countries, namely the British [11], [12], [13], Irish [14] and Dutch [15], [16] models. British and Dutch models consider certain limitation criteria, such as: medium and large airports (more than 150 000 movements per year), 90% of flights to “Western” standards, 70% precision approaches, general aviation (light aircrafts occurrences) excluded, etc. Accidents databases extend from 1979 to 1995 (respectively from 1980 to 1997). Irish model retained similar criteria as the British one, but also includes a separate model for light aircrafts.

All these models include three sub-models: accident probability model, location model and consequence model

The accident probability model retained by the British and Irish models is an empirical one, considering aircrafts with Maximum Takeoff Weight Authorised (MTWA) of 4 tonnes and plus (5.7 tonnes for the Dutch one).

One of the differences between British/Irish and the Dutch model resides in the accident localisation model: along the runway centerline for the formers versus the flight route for the latter. In all models, the risk assessment focuses on PSZ at each end of the airport's runway(s).

In the US, ACRP have recently developed a software tool “RPZ Risk Assessment Tool (RPZ_RAT)” [10], to help airport sponsors and airport planners to conduct risk assessment of the RPZ previously defined in FAA's Advisory Circular [24] and also the tool “Lateral Runway Safety Area Risk Analysis (LRSARA) based on a Runway veer-off location Distribution Risk Assessment Model and Reporting Template [22]. The accident database used for the latter model covers a period from 1982 to 2011 with close to 90% of the information retrieved from U.S. sources, the remaining 10% coming from ten countries with similar aviation accident rates.

Several studies have also been conducted by Sapienza University's researchers, with ENAC collaboration (for some of the studies). First, a study for the Distribution of Air Accidents around Runways [4] has been based on an updated database (15 years, from 1996 to 2011) and has been analyzed and presented with Sapienza University's tool Spatial Distribution of Aircraft Crashes SDAC. The study presents the distribution of accidents related to runway extension but also by aircraft categories, including general aviation (light aircrafts). Then, a standard individual calculation model has been developed derived from Irish model (the Probability Distributions Functions) and Dutch one (for the calculation of the Individual Risk) [7] in order to define PSZs. The model utilizes similar three sub models. The accident model has updated database, the accident distribution (geographical location) has two probability density distribution curves: Weibull distribution related to the Gaussian distribution (for overrun and landing) and Gamma distribution for take-off), while the accident consequences model will consider only third party individuals (on ground) in terms of severity of the destroyed area, in relation with the aircraft weight (and wingspan). This model has been implemented in SARAS (Sapienza Airport Risk Analysis Software), to calculate iso-risk contours.

Further studies have been developed based on SARAs model in order to define and validate PSZs (and model) for all single runway busiest Italian airports [1] for different traffic mix and three

categories of volumes (movements par year), and then to redefine the Risk Plans for small and medium airports [3] (less than 75,000 movement/year) according to risk analysis previously validated. The latter presents significant differences between the iso-risk developed contours and the risk plans in force, based on ICAO class of runway, differences that can overestimate the risk for small airport or underestimate the risk for airports in the inferior-medium range.

However, all the available models define the PSZs only on the runways thresholds.

Additional recent studies cover the assessment of veer-off risk of accidents, in an Italian Case Study [5] for an airport of 12,000 annual movements or Quantitative risk assessment and risk reduction measures [6]. In the first one the risk analysis methodology includes the frequency and the effect of the events. It is an empirical approach based on an extended world wide database (1946 – 2016). The model will consider the lateral probability distribution (path and final location of the aircraft, as offset from the runway centerline) and are combined with wind conditions. The damage quantification model is based on UK's Civil Aviation Authority (2014) and consistent with ICAO Annex 14, Vol. I Aerodromes, and considers the geotechnical characteristics of the strip area soil (expressed in CBR value). The study presents a three variables damage matrix: Human health (in the airplane), Mechanical consequences to the airplane, for a specific CBR value; and the risk of a veer-off event with iso-risk curves along the runway. Finally, the study proposes maximum levels of risk tolerances at the boundary of the Cleared and Grader Area (CGA) of the runway.

The second one presents a method to assess the probability and risk of a veer-off accident, considering its effect on the occupants. It identifies the causes and consequences (butterfly diagram of veer-off accidents, based on recent occurrences database (1980- 2016) and defines cumulative frequency classes and severity classes. It analyses the current level of veer-off risk for each type of ICAO runway code and presents a method to calculate the risk of the main landing gear departing beyond the CGA and for different CGA values. The study also presents the advantages in risk reduction by enlarging the CGA beyond the ICAO standard.

Annex 2

| Annual aircraft movements & accidents/incidents occurrences (Canada) | | | | | | |
|---|---------------------------------------|------------------|------------------|------------------|------------------|------------------|
| Description | 2014 | 2015 | 2016 | 2017 | 2018 | 5 yrs average |
| | Aircraft Movements¹ | | | | | |
| Major Airports - NAV CANADA Towers and Flight Service Stations | 5 437 047 | 5 458 399 | 5 469 664 | 5 561 754 | 5 741 330 | 5 533 639 |
| (Nr. of airports in survey) | 92 | 91 | 91 | 91 | 91 | |
| Small Airports - Airports without NAV CANADA Towers or Flight Service Stations | 637 901 | 626 934 | 609 205 | 639 936 | 618 837 | 626 563 |
| (Nr. of airports in survey) | 142 | 132 | 130 | 134 | 135 | |
| Total | 6 074 948 | 6 085 333 | 6 078 869 | 6 201 690 | 6 360 167 | 6 160 201 |
| Variation (yearly) | | 0,2% | -0,1% | 2,0% | 2,6% | |
| | Accidents & Incidents | | | | | |
| Accidents occurrence | 249 | 251 | 230 | 240 | 201 | 234,2 |
| Occurrence / million flights | 40,99 | 41,25 | 37,84 | 38,70 | 31,60 | 38,02 |
| Incidents ² occurrence | 741 | 789 | 833 | 939 | 860 | 832,4 |
| Occurrence / million flights | 121,98 | 129,66 | 137,03 | 151,41 | 135,22 | 135,13 |
| Total accidents & incidents | 990 | 1 040 | 1 063 | 1 179 | 1 061 | 1 067 |
| Total occurrences/flight | 1,63E-04 | 1,71E-04 | 1,75E-04 | 1,90E-04 | 1,67E-04 | 1,73E-04 |

Notes:

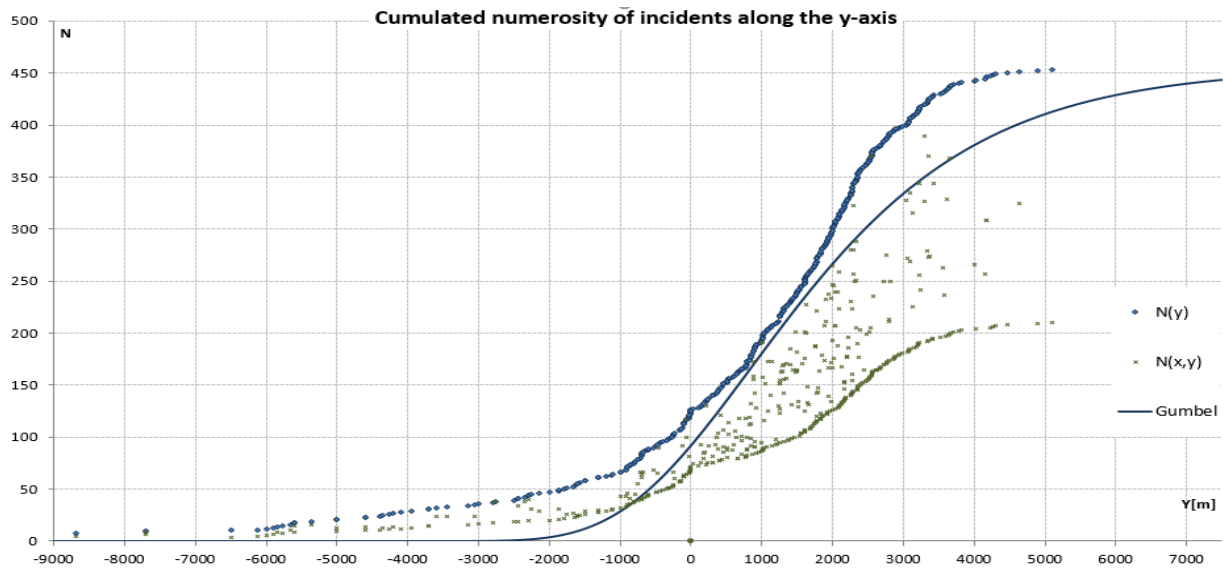
1. Data Sources: Statistics Canada and Transportation Safety Board of Canada (see bibliography for reference)
2. Incidents involving aircraft with a maximum certificated take-off weight greater than 2250 kg.

Annex 3

Extract from the preliminary analysis of the Sapienza location model:

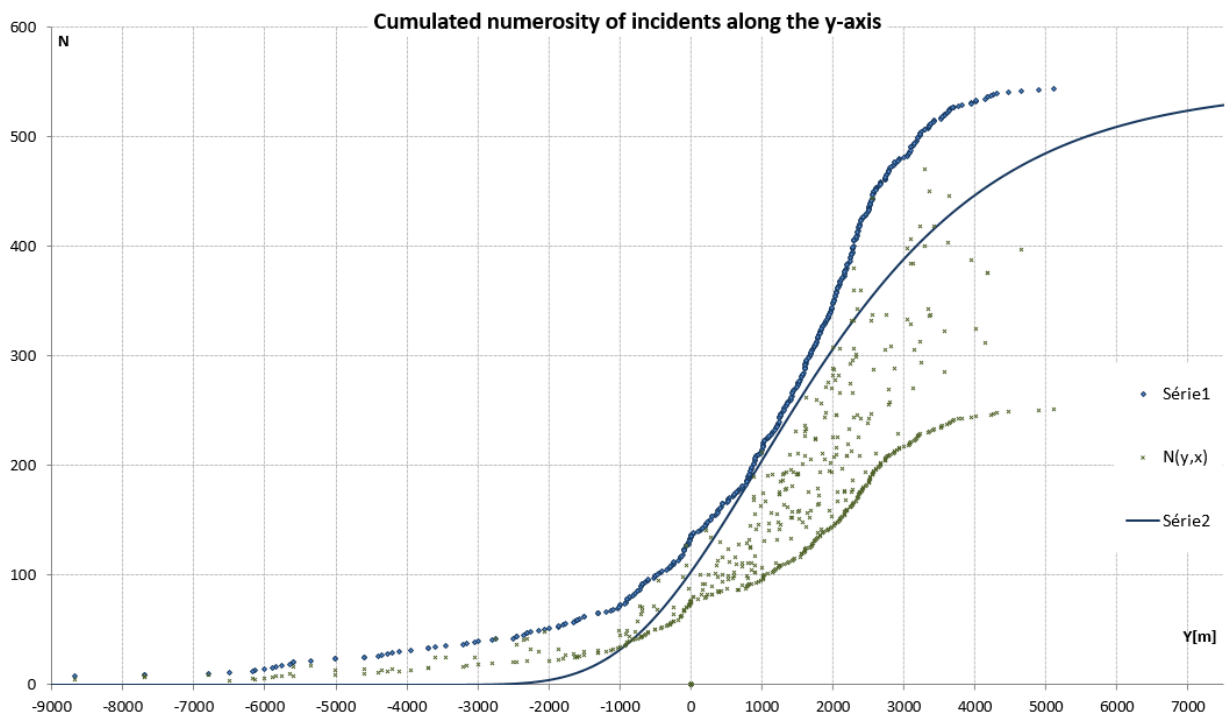
Gumbel distribution, location model (initial database, up to 2011)

Ex: $y = 1017,73$; $N(y) = 184,40$



Gumbel distribution (revised coefficients), location model (incl. ENAC database, up to 2016)

Ex: $y = 1015,36$; $N(y) = 206,12$

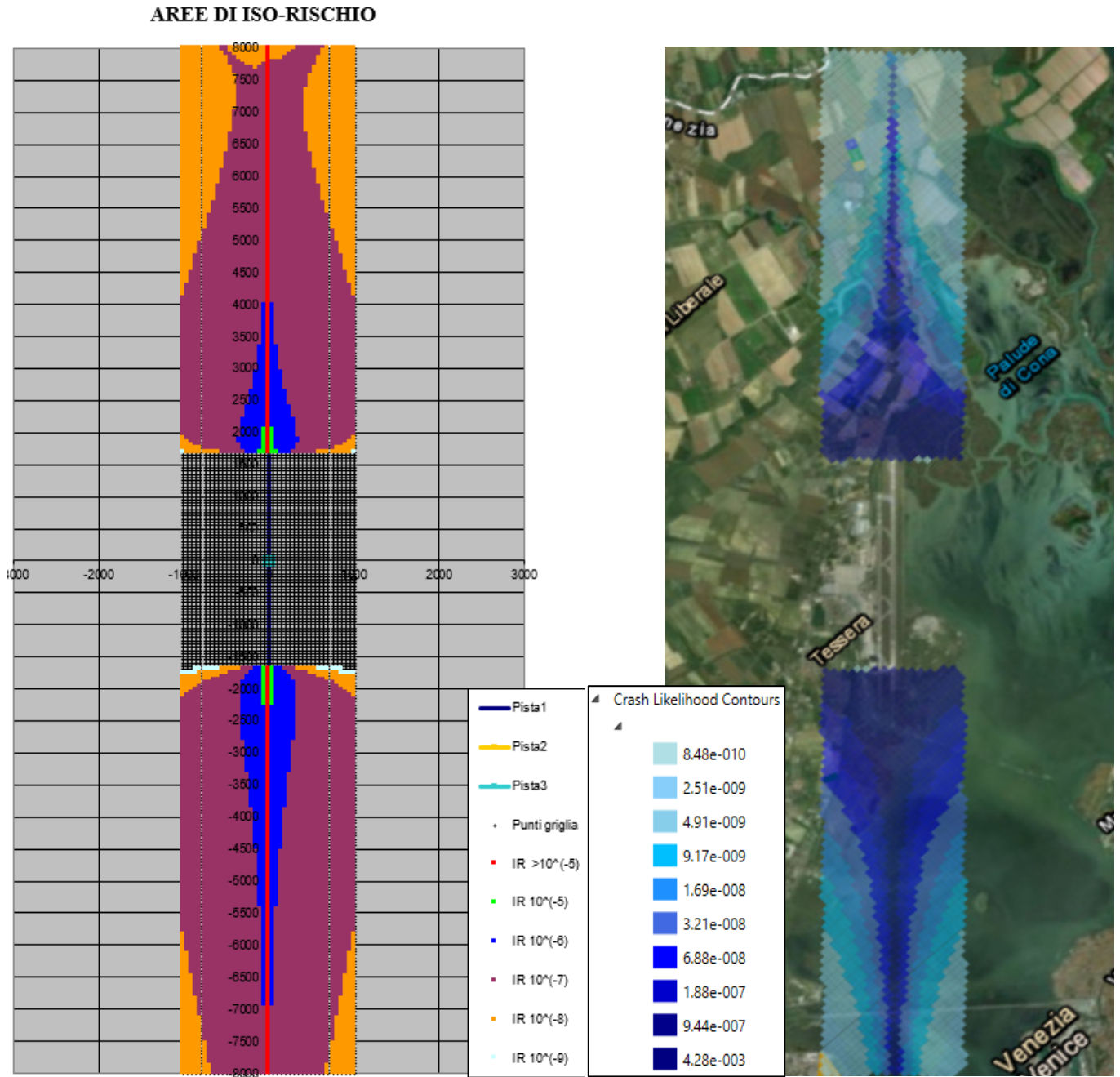


Annex 4

Output from the preliminary comparison analysis of the two risk assessment models:

SARA iso-risk contours (LIPZ)

ACRP RPZ Tool iso-risk contours (LIPZ)



SEZIONE C

Informazioni

(Tale sezione contiene le informazioni richieste alla fine ogni anno dall'Ufficio Dottorati)

- 1) Titolare di borsa erogata dalla Sapienza - Università di Roma.....SI NO
- 2) NazionalitàCANADESE
- 3) Dottorato in cotutelaSI NO
(se si indicare il cotutore: Ing. Costantino PANDOLFI (ENAC))
- 4) Dottorato con doppio titoloSI NO
- 5) Borsa con finanziamento esternoSI NO
- 6) Università di provenienza
- 7) Numero di mensilità di ricerca spese in una struttura di ricerca estera
- 8) Finanziamenti all'interno di reti internazionali di formazione alla ricerca ..SI NO
- 9) Pubblicazioni e altri prodotti degli ultimi 3 anni

***Per le aree bibliometriche.** Articoli pubblicati su riviste peer-reviewed internazionali (ed eventualmente proceedings per le aree che accettano) con impact factor (indicizzate WoS) o indicizzate Scopus.*

***Per le aree non bibliometriche.** Prodotti editoriali pubblicati dai dottorandi come Monografie dotate di ISBN e/o pubblicazioni in riviste di fascia A (o prodotti editoriali equivalenti ammessi dalla VQR).*