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Building a safer U-space: U-AGREE delivers enhanced risk models for drone operations

From mid-air encounters to the consequences of a drone impact on the ground, U-AGREE has delivered three enhanced risk models that provide a more realistic, data-driven understanding of the risks associated with unmanned aircraft operations.

Rome, 24 November 2026 – Every drone flight leaves a footprint beyond its flight path: it can interact with other airspace users, affect people and infrastructure on the ground, and introduce risks that vary considerably depending on where, how and under which conditions it flies. Understanding these interconnected dimensions is essential to integrating drones safely into Europe's aviation system.

The U-AGREE (U-space Air and Ground Risk Models Enhancement) project, funded by the SESAR Joint Undertaking under Horizon Europe and coordinated by Universitat Politècnica de València, has developed three enhanced risk models addressing three complementary dimensions of drone operations: air risk, ground risk and collision risk.
Building on the European Union's Specific Operations Risk Assessment (SORA) methodology, the models provide more detailed and quantitative approaches to identifying operational hazards, assessing their potential consequences and evaluating the effectiveness of risk mitigation measures.
Together, these models offer a more comprehensive understanding of the risks associated with increasingly complex unmanned aircraft operations.

Moving beyond traditional risk assessment

As the number and variety of aircraft operating at low altitude increase, assessing the likelihood and consequences of encounters between different airspace users becomes increasingly important.
The U-AGREE air risk model, developed with the contribution of the German Aerospace Center (DLR), introduces a more detailed assessment of potential encounters. Rather than focusing exclusively on interactions between drones and conventional manned aircraft, it considers

different combinations of airspace users, including drone-to-drone encounters, interactions involving electric vertical take-off and landing (eVTOL) aircraft, and wildlife strikes.

The model estimates the probability of an encounter using historical traffic data, dividing airspace into cells, and assigning risk levels according to the usual presence of different airspace users. It then assesses the potential severity of an encounter based on the characteristics of the aircraft or wildlife involved.

As **Dr Miguel Ángel Fas**, from **DLR**, explains:
"Calculating the probability of an encounter based on historical data allows for a more accurate estimation of the presence of other traffic along the route being evaluated, as it accounts for the specific timing of the flight: time of day, day of the year, day of the week, season, or any other temporal criteria that may reflect patterns in traffic activity in the area. Regarding severity, a table of potential harm associated with encounters between different airspace users allows us to specify the factors that determine the severity of an encounter—such as potential loss of life and economic costs—and their relative weights, as well as any mitigation measures that could reduce the severity of the consequences."

This more differentiated approach moves beyond the assumption that every encounter has the same potential consequences, allowing risk assessments to better reflect the aircraft involved and the operational environment.

Understanding what happens when a drone reaches the ground

Assessing the consequences of an accident is equally important. Ground risk modelling traditionally considers the likelihood of people being injured or killed following an uncontrolled impact. However, the actual consequences depend on several interacting factors, including aircraft characteristics, impact dynamics, population density and the protection offered by surrounding buildings.

U-AGREE's enhanced ground risk model, developed with the contribution of EuroUSC Italia, introduces more detailed methods to assess sheltering effectiveness and the influence of obstacles in urban environments.

Using Monte Carlo simulations, the model evaluates how likely an unmanned aircraft is to penetrate a building following an impact. It takes into account different aircraft characteristics,

impact conditions and building materials. The results show that, in typical Italian residential buildings, vulnerable elements, such as windows, play a decisive role in determining the probability of penetration, most of the remaining building structure generally provides effective protection against UAS impacts, even for aircraft with an MTOM exceeding 25 kg.

The model also examines how buildings and other structures can reduce the area potentially affected by a crash, distinguishing between fixed-wing and rotorcraft aircraft, whose impact behaviour differs.

As **Aurora Forcella**, Safety and Compliance Engineer at **EuroUSC Italia**, highlights:
"This study aimed to further advance the ground risk assessment methodology proposed in SORA 2.5 by exploring potential refinements and extensions. In particular, we developed a Monte Carlo-based simulation framework to provide a more realistic assessment of sheltering effects, with the long-term objective of supporting the application of this mitigation strategy to UAS with an MTOM exceeding 25 kg. In parallel, we investigated in greater depth the role of buildings in reducing the critical area and, consequently, the associated ground risk. Finally, to promote a more holistic approach to risk assessment, we proposed extending the analysis beyond traditional safety considerations to include environmental, economic, and reputational factors, thereby enabling a broader evaluation of the impacts associated with UAS operations."

In fact, importantly, the assessment goes beyond direct physical harm, introducing a structured evaluation of potential environmental, economic and reputational consequences associated with drone operations. This broader perspective provides a more comprehensive understanding of their impact on the communities and environments in which they take place.

Quantifying the risk of collisions between drones

A further essential element is understanding what happens when multiple unmanned aircraft operate within the same airspace.

The U-AGREE collision risk model uses realistic flight trajectories generated through a software-based flight simulator and Monte Carlo simulations to reproduce thousands of flight hours under different traffic conditions.

This approach makes it possible to examine how factors such as traffic density, aircraft behaviour, flight patterns and environmental conditions influence collision frequency.

The model also supports the assessment of tactical mitigation measures by simulating potential encounters, including conflicts and losses of separation. It therefore provides a basis for evaluating both safety performance and operational efficiency, including alert rates and the likelihood of false alarms.

Sandra Amarillo, U-space/UTM Research Engineer at the **Universitat Politècnica de València,** explains: “Collision risk in U-space does not depend only on how many drones are flying, but on how and where they fly. Our simulations show that when drones share routes and operating areas, encounters concentrate in ways that simple analytical models, which assume randomly distributed traffic, cannot capture. But knowing how often conflicts arise is not enough: we also need to know whether they can be detected and resolved in time during flight. That is why we combine two complementary models, one that reproduces realistic traffic over thousands of flight hours, and one that tests conflict resolution encounter by encounter, taking into account pilot reaction times, communication latencies and positioning errors. Together, they provide the basis for separation requirements that are neither too permissive nor too conservative.”

From risk assessment to safer U-space operations

The value of enhanced risk models lies in their practical application. U-AGREE has therefore put its modelling approach to the test through operational scenarios and simulation activities, assessing how risks can be reduced through U-space services and other mitigation measures. **Antonietta Perfetto**, project engineer at Engage srl, highlights the value of this approach: "Integrating the collision risk model into simulation made it possible to compare the same operational scenarios with and without U-space services, isolating the effect of each one as traffic increases. The Flight Authorisation Service stood out: by strategically deconflicting trajectories before take-off, it substantially reduced the risk of conflicts between drones. At the same time, the simulations showed that this benefit has to be balanced against access to the airspace, a trade-off that only an integrated approach can reveal.”

U-space is the European framework for managing drone traffic through digital services, enabling coordination between unmanned aircraft and other airspace users. Understanding how these services influence risk is essential to evaluating their contribution to safe and efficient operations.
By connecting risk estimates with the effectiveness of mitigation measures, the U-AGREE results provide a stronger evidence base for more consistent risk assessments and future digital

implementations of the risk assessment process. They also contribute to the development of more efficient operational approval processes while maintaining the safety levels required by European aviation regulations.

U-AGREE has received funding from the SESAR 3 Joint Undertaking under grant agreement No 101167187 under European Union's Horizon Europe research and innovation programme. The project consortium includes: Universitat Politècnica de València (UPV), CRIDA, Collins Aerospace, Cranfield University, DLR, ENAIRE, ENGage, EUROCONTROL, EuroUSC Italia and INECO.

CONTACTS	USEFUL LINKs
Project Coordinator Juan Vicente Balbastre Tejedor jbalbast@upv.edu.es **Communication and Dissemination Leader** Marilea Laviola marilea.laviola@eurousc-italia.it	www.u-agree.eu http://engagektn.eu/ LinkedIn Video