IV. CRD table of comments, responses and resulting text

(General Comments) -

comment	*3* comment by: *EuroUSC Italia*
	The supporting excel file does not compute the critical area correctly. In particular the input about "UA capable of gliding (Yes = 1) (No = 0)" in "summary calculation sheet" is not correctly taken into account. This is apparently due to an error in cell E22 of "summary calculation sheet".
response	Thank you for your comment. Your comment is accepted. The comment is correct and cell "E22" has been corrected accordingly.

comment	8 comment by: Drone Architect (Jon Verbeke)
	The overall way of naming convention for parameters, lack of definition, graphical representation, units and way of writing the formulas in standard mathematical format is far below standard.
response	Thank you for your comment. Your comment is accepted. The document has been updated improving its readability.

comment	9 comment by: Drone Architect (Jon Verbeke)
	The (Excel) tool is far below standards with respect to non-uniform naming convention for parameters, lack of units and no access to the formulas used within the tool to verify their correctness
response	Thank you for your comment. Your comment is noted. The Excel tool follows Annex F's naming convention, and includes the units of measure. The formulas used to calculate the outputs of the tool are exposed in the guidance document published together with the excel tool.

comment	*17* comment by: *Drone Architect (Jon Verbeke)*
	This proposal should be reviewed, adapted and then a new public consulation period should be provided so that we can properly review the proposal. In its current form, with all its shortcomings and lack of supporting evidence, this is not posible.
response	Thank you for your comment Your comment is noted. The models are based on Jarus model. Furthermore, the high impact angle model has been developed based on available literature and engineering judgement. A simulation (from Qinetiq) has also been made for High impact model.

comment	*18* comment by: *AOPA Sweden* AOPA Sweden The calculation seems to be very thorough with all the mathematical formulas and it should be clear the magnitude of the risks of accidents when a drone crash. We are not clear though about the practical use of the formulas. Of course it is good to know what risk you are taking on the ground in case a drone crash nearby. But nevertheless it is difficult for a person on the ground to have time to take shelter when a drone is about to crash. So we are not sure about the practical impact and use of these guidelines. Hopefully it will lead to measures taken to improve safety and to minimize future accidents. What AOPA miss in these guidelines is an aproach to improve safety in the air; so to avoid incidents and accidents involving drones and manned airplanes. AOPA represent all general aviation in the world and we are concerned about the risks of collusions in the air between planes and drones. For example means of communication between vehicles operating in the same area is an object worth studying for EASA. Best regards AOPA Sweden Fredrik Brandel
response	Thank you for your comment, your comment is noted. The purpose of these guidelines is to provide a way to assess the area where a person standing would be expected to be impacted by the UA during or after a loss of control event, and thus the area where a fatality is expected to occur if a person were within it. They are not proposing ways to mitigate the risk in case of an impact, but they are focused on assessing such risk. Also, the purpose of the guidelines is limited to the risk on the ground, the air risk is out of the scope of this document. In regard of the consequences of a UAS impacting a manned aircraft, EASA recently published the following study: https://www.easa.europa.eu/en/research-projects/vulnerability-manned-aircraft-drone-strikes

comment	*19* comment by: *S.PIZZIOL* As a general comment, this GM may be not conservative: AC value is linked to the Loss of Control (LOC) definition. The LOC definition as in SORA 2.5 (annex F, C.1): Adverse operating conditions + Human Error (even the controlled flight into terrain CFIT) + Any failure condition on the UAS + Deterioration of the external systems.

	The model proposed here does not consider all the adverse operating conditions. It seems the LOC condition considered here for both the high impact angle and the Jarus model is only the loss of propulsion. For instance, for the high impact angle model, why the CFIT is neglected? An UAS for which cutting the engines will indeed fall vertically may be also capable of a CFIT with a small impact angle. That approximation is not conservative as a CFIT may happen with far bigger AC. The same is true for the UAS for which the JARUS model is applied, as the impact angles defined here (i.e. 10 deg or 35 deg) may be in some cases under conservative (e.g. in case of a "nominal landing" triggered by accident on the wrong landing site? In the case of a CFIT?). Since the approach presented here is not always conservative, a limit on the SAIL level of applicability of this GM may be appropriate.
response	Thank you for your comment, your comment is partially accepted. It has been clarified that the critical area definition is the one in SORA Annex I, the same is valid for LOC. Controlled flight into terrain performed with the goal of reducing the critical area may be considered as an M2 mitigation and assessed accordingly. The proposed guidelines are intended to be used in SORA Step #2, and the models are intended to provide an assessment of an intrinsic characteristic of the drone (its critical area), without considering any means applied to reduce the effects of impacts with the ground, which should be assessed separately. As the critical area is an intrinsic characteristic of the UA, it is not linked with its SAIL as it would remain the same independently of the level of risk of the operation.

comment	21	comment by: S.PIZZIOL
	A comment on the subject: "SUBJECT : SORA Step #2 – Intrinsic ground risk class" It seems that the document refers to step#2 of SORA 2.5 (see table 1 with references to max characteristic dimensions 20m and 40m). If it's the case the reference to the actual SORA version could be explicit.	
response	Thank you for your comment, your comment is accepted. These guidelines are applicable to both SORA 2.0 and SORA 2.5. The main change in the ground risk assessment between the two versions is the transition from qualitative to quantitative indicators of the population density. However, the mathematical model driving the assessment of the iGRC remains the one defined in Annex F for both versions of SORA.	

comment	*38*	comment by: *Schiebel LUC Organisation*
	For better readability please add page numbers, table, figure and equation captions.	

response	Thank you for your comment, your comment is accepted.

comment	*47* comment by: *Drone Industry Association Switzerland*
	Whether it is caused by the tool or the model, important discrepancies are observed in corner cases. For example, when using 1.00 m and 1.01 m, the tool provides values respectively below and above 8 m2, thus leading to important jumps in the critical area. This seems incorrect mathematically and forces a strict limitation to 1.00 m. Please review it. (page 6) We note as well that the JARUS model and the High impact Angle Model give very different results for rather similar use cases which could lead a UA with slightly higher impact angle than 60° and one with slightly lower impact angle than 60° to be treated in complete different ways while having very similar behavior. Finally, we note discrepancies in the use of the safety factors (page 7) when close to 0.2 kJ. If our interpretations are correct, please assess how to make a more homogeneous model and ensure the good implementation in the tool. We have the feeling that the continuity between the limimts of certain intervals is not assured.
response	Thank you for your comment, your comment is partially accepted. The reason of the discrepancy between drones which have a characteristic dimension of <1m and >=1m in the JARUS model is that the slide portion of the critical area is neglected if the drone is smaller that 1m due to its limited size, but it is then considered when it is bigger than 1m, and this may cause some relevant difference in the critical area size for corner cases. As the guidelines reflect the JARUS model, the formulas and assumptions remain, however the calculation of the safety factor has been updated and it is homogeneous from 2.3 to 7 according to the formula shown in the guidelines.

comment	*57* comment by: *Schiebel LUC Organisation*
	The font, font size and other charactersitics of the equations are not consistent. some examples: • Page 6: some equations and parameters are italic and have different font type without consistency • Page 7: the equation on page 7 is bold and has larger font size • Page 9: some equations and parameters are italic and have different font type without consistency Besides each equation needs to be captioned for better readability.
response	Thank you for your comment, your comment is accepted

comment	*70* comment by: *UK CAA*

Commenter: UKCAA

Page No: 1

Paragraph No: SUBJECT

Comment:
UK CAA believes it is unclear whether the proposed guidelines apply to SORA 2.0 or 2.5

Justification:
Clarity required on the proposed guidelines and whether they apply to SORA 2.0 or 2.5.

response

Thank you for your comment, your comment is accepted. The guidelines are applicable to both SORA 2.0 and SORA 2.5. The main change in the ground risk assessment between the two versions is the transition from qualitative to quantitative indicators of the population density. However, the mathematical model driving the assessment of the iGRC remains the one defined in Annex F for both versions of SORA.

comment

72 comment by: *UK CAA*

Commenter: UK CAA

Page No: (Excel spreadsheet) ca_calculator.xlsx

Paragraph No: iGRC Annex F tab

Comment:
The critical area values do not match those in SORA 2.5 Annex F.

Justification:
UK CAA believes the values should be identical to those in SORA 2.5 Annex F.

Proposed Text:
Use the values in SORA 2.5 Annex F.

response

Thank you for your comment, your comment is accepted. All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F V2.5.

comment

74 comment by: *Adrien B*

Clarify (in the tool and in the document) the speed to consider among the following possibilities :

- Maximum speed (limited by FCS - hard limit or operator set limit)
- Design/typical cruise speed (eg. max endurance speed)
- Vno (maximum structural cruising speed)

response Thank you for your comment, your comment is accepted. The tool will clearly state to include maximum speed for rotorcraft/multirotors and cruise speed for the other types of UA.

comment *86* comment by: *DGAC FR*

	Theme	Reference	Page	Commentary	Resolution
DGAC	**General**	Entire document		In order to provide relevant comments, it would be appreciable to have the excel file password to be able to see how the calculations are performed. We are especially interested in the impact angle calculation.	NA

response Thank you for your comment, your comment is noted. All the formulas used to assess the critical areas, including the assessment of the impact angle, have been included in the guidelines. The calculator will not be published in the form of an excel file but directly in the IAM Hub, the Excel file was published only for the purpose of the consultation.

comment *87* comment by: *DGAC FR*

	Theme	Reference	Page	Commentary	Resolution
DGAC	**General**	Entire document		We understood that the validity of the models was verified by simulations. However, these simulations were apparently based on an arbitrary value for the terminal speed and friction coefficient. In order to check the realism of these simulations and the validity of the models, it would have been interesting to perform tests to determine the real terminal speed and friction coefficient of a small multirotor UAS	NA

response	Thank you for your comment. Your comment is noted. The values for the terminal speed and friction coefficient are not arbitrary. The value of friction coefficient comes from Jarus- Annex F. (V2.5) and the terminal speed is calculated also with the formula of terminal speed of Annex F (V2.5). Once we have more experience with some cases the models could be reviewed and updated if need is.

comment	*89*	comment by: *UAV DACH AC*
	Title and Scope: plural of aircraft is aircraft (not aircrafts)	
response	Thank you for your comment, your comment is accepted The document has been corrected accordingly.	

comment	*94*	comment by: *UAV DACH AC*
	References, validation data, spread, statistical evidence is missing. The document by itself is insufficient. If NAWCAD is used: note the large spread in NAWCAD data, averaged values accounting for small fraction of the population, see there, No. 139-143.	
response	Thank you for your comment, your comment is Noted. Simulations on a DJI Inspire have been used to validate second added model.	

comment	*103*	comment by: *UAV DACH AC*
	Quality of equations is poor; use equation editor instead of text; add numbers to equations	
response	Thank you for your comment, your comment is accepted The document has been updated improving its readability.	

comment	*110*	comment by: *Drone Alliance Europe*
	DAE appreciates EASA's effort in soliciting public input on their guidelines proposal for the calculation of the UA critical area; DAE has no significant concerns or objections to the proposed 'high impact angle model'. However, in light of JARUS's ongoing fine-tuning of Annex F numbers, DAE recommends aligning the current proposal with the eventual finalised figures from JARUS prior to the formal publication of the guidelines.	
response	Thank you for your comment, your comment is accepted All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.	

comment	*111*	comment by: *FOCA (Switzerland)*

	Many thanks for the opportunity to comment. We have no comments on specific points, but would like to ask you to please consider waiting for all the updates still pending in JARUS SORA 2.5 before the final publication of the tool. As the document is due to be finalised in the coming months, it would ensure that the approaches are harmonised. Thank you very much for taking note.
response	Thank you for your comment, your comment is accepted. All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.

comment	*117* comment by: *Federal Aviation Administration*
	FAA comment: Consider dropping the "s" on the end of the words "aircraft" and "rotorcraft." These nouns can be both singular and plural.
response	Thank you for your comment, your comment is accepted The document has been corrected accordingly.

comment	*148* comment by: *Federal Aviation Administration*
	FAA comment: Recommend conducting tests of the various failure modes of the drone and determine the critical area. This approach would provide two advantages, namely if the critical area is smaller than what this analysis shows, it reduces the risk associated with the operation (and thus allows for more operations). The second is if the critical area is larger than what this analysis shows, than it removes the uncertainty (and perhaps liability) associated with the first order approach provided here. There are some fundamental limitations on how this analysis is being done. For example, the model chosen is a 1D model, but multi-rotors are inherently unstable and their flight path will be erratic (i.e. their flight path will not follow a straight line). Things like drag coefficient and drag reference area will change in time with respect to speed, and vehicle orientation. Note that the case described in the document, the complete loss of power is unlikely to be a worst case scenario of a multi-rotor crash. Worse would be when the vehicle loses control of some of its rotors, and still tries to maintain attitude. This case is much more likely, and with the vehicle still powered, has a much higher energy state than a vehicle without power. Also note that things like bounce and splatter can be deadly, as these vehicles can hurl sharpnel on impact with the ground.
response	Thank you for your comment. Your comment is noted. There was a simulation done by Qinetiq and the results have been used to calibrate the model. Testing critical area would also require making a lot of assumptions on the probabilities of different failure modes, flight speeds and altitudes. All of these would affect the impact dynamics and angles not to mention the ground hardness and slope angle. Eventually, some amount of uncertainty and simplifications of analysis would need to be accepted.

comment	*149* comment by: *Federal Aviation Administration*

	FAA comment: The scope of this document and its associated JARUS SORA document do not appear to specify the weight -based classification of aircraft such as Parts 23, 27, 29, 25, Light Sport Aircraft (LSA), etc. Do you plan to specify this?
response	Thank you for your comment, your comment is noted. The weight of the aircraft is one of the variables in the formulas to be used to calculate the critical areas, both in the JARUS and High impact angle models.

comment	150 comment by: Federal Aviation Administration FAA comment: Crash dynamics of an aircraft (xx.562) is a much more complicated Multiphysics phenomena that requires repeated experimental validation and verification from the FAA/DOD funded Centers of Excellence (COEs) like National Institute for Aviation Research (NIAR) which has been actively leading meaningful and applied research work to support FAA Type Certification projects. NIAR is working closely with FAA's CSTA for Crashdynamics, SAE SEAT Committee, EUROCAE WG, among others to formulate the Multiphysics phenomena. EASA may want to join with SAE SEAT Committee (and companion EUROCAE WG), NIAR, among others to solve this problem.
response	Thank you for your comment, your comment is noted. The models proposed are a possible way to describe the area resulting from the impact of a UA with the ground, and are based on conservative assumptions. To substantiate the model, a finite element simulation on a test case has been conducted and the model was refined according to its result.

Section 1 - Background and Introduction p. 2

comment	*5* comment by: *Ciconia* The critical area as defined in the text: "It is the sum….impacted by the UA during or after a loss of control event". In the new era, where drones, AAM and others becomes more and more common way of transportation, the risk of platform loss by aerial accident becomes more and more eminent. A mid air collision, between these platforms, can cause large enough debris, who may fatality hit persons on the ground – therefore **the probability calculation of platform malfunction should include the probability to mid air collision and not only mulfunction.** As an outcome of mid air collision, the number of the fatal debris is higher – for example: engines, large structural rods, drone goods etc. **Therefore, even if the critical area is the same, the probability to be fatally hit is increasing**
response	Noted. It is correct that a mid-air collision may produce debris which pose a risk for the people on ground, however the scope of these guidelines is limited to assess the area resulting from the impact of a UA with the ground, with the goal of providing additional information that may be used when

	performing the ground risk assessment in Step#2 of SORA. Additional risk are not whithin the scope of these guidelines and therefore not assessed by the proposed models.

comment	*40* comment by: *Schiebel LUC Organisation* "*The following assumptions should be satisfied to obtain a realistic representation of the critical area using with the ballistic model:*" Sentence is not clear, consider revising (omitting "with" ccould be an option).
response	Accepted. The document has been corrected according to this comments.

comment	*48* comment by: *Drone Industry Association Switzerland* Section 1 mentions that these guidelines are not addressing the calculation of the critical area resulting from the application of an M2 mitigation. Would it be possible to use those guidelines however in the context of a Type 3 mitigation according to the MoC M2 since the reduction of critical area together with the reduction of lethality may represent a 90% risk reduction while the reduction of critical area alone may in many cases not be sufficient to reduce the GRC in the context of the SORA Step #2.
response	Noted. The applicability of these guidelines are SORA Step#2. The application of an M2 mitigation to reduce the lethality of the UAS may also vary the way an UAS impact on the ground, and this may invalidate some of the assumptions of the guidelines and make the proposed models not applicable anymore. Therefore, these guidelines may not be automatically applied in the context of a Type 3 M2 mitigations, as further considerations/assessments may be needed.

comment	*77* comment by: *Adrien B* As this GRC reduction is linked with the UAS design, it may be subject to EASA verification (as enhanced containment). What is EASA position ? Is this computation tool planned to be recognize as an AMC ?
response	Noted. The plan for this tool is currently for it to remain a guideline.

comment	*78* comment by: *Adrien B* This guidelines helps to substantiate a GRC mitigation based on passive/intrinsec design. Thus, it should be allowed to use it for reduction of final adjacent area GRC.
response	Noted. The information collected when calculating the critical area may be used also for the containment assessment.

comment	*79* comment by: *Adrien B*

	This guidelines help to substantiate a GRC mitigation based on passive/intrinsec design. As per SORA step #3 and released MOC, M2 type 1 could be demonstrate with a passive design (no mitigation means to be activated). As a result, this assessment of the real critical area and reduction of the GRC should be part of SORA step #3.
response	Thank you for your comment. Your comment is rejected. The guidelines proposed do not take into account passive design/mitigations. As an example, using the proposed models a frangible UAS with certain technical specifications (characteristic dimension,mass, speed...) would get the same critical area of a non-frangible drone with the same specifications. If using these guideline it is demonstrated that the critical area of an UA is smaller than the value associated to its characteristic dimension, this information should be used when assessing the iGRC in Step#2.

comment	118 comment by: Federal Aviation Administration FAA comment: Suggest removing the word "with" from the sentence that reads: "The following assumptions should be satisfied to obtain a realistic representation of the critical area using with the ballistic model"
response	Thank you for your comment. Your comment is rejected accepted.

comment	*119* comment by: *Federal Aviation Administration* FAA comment: Recommend changing "fatality" to "casualty" in the definition given for the Critical Area of the UA.
response	Thank you for your comment. Your comment is rejected. The definition of critical area is taken from SORA's Annex F, so in order to keep consistency the same wording is used.

comment	120 comment by: Federal Aviation Administration FAA comment: Recommend adding other assumptions used in this model (e.g., no malfunction turns, no winds), or clarifying why only two assumptions are presented.
response	Thank you for your comment. Your comment is rejected. In order to keep consistency wth SORA Annex F, the absence of wind/malfunction turns etc. are not among the assumptions as the models are assumed to be conservative enough to cover also those cases.

comment	*121* comment by: *Federal Aviation Administration* FAA comment: Consider including other possible causes leading to a ground collision, other than "during or after a loss of control event."
response	Thank you for your comment. Your comment is accepted. The text has been updated removing loss of control and stating that the critical area is resulting from an impact with the ground.

comment	122 comment by: Federal Aviation Administration FAA comment: Recommend clarifying the use of the word "conservative" in the context of the sentence: "... as the critical area resulting from this kind of crash is bigger, and therefore more conservative, compared to other crash scenarios." Why would a bigger area of impact be considered more conservative?
response	Thank you for your comment. Your comment is accepted. The wording has been updated so to clarify that a bigger critical area leads to a bigger iGRC.

comment	123 comment by: Federal Aviation Administration FAA comment: Recommend clarifying the use of the word "gliding" in the context of the sentence: "The UA should not be capable of gliding."
response	Thank you for your comment. Your comment is partially accepted. To improve clarity, it has been specified that in order to utilise the high impact angle model for the assessment of the critical area, an UA should be a rotorcraft or a multirotor.

Chapter 1: General p. 2

comment	*22* comment by: *S.PIZZIOL* Since the so called "JARUS Model" is strongly inspired by the critical area model used by JARUS but it's not totally identical to it (for instance, the Obstacle reduction in this GM is set to 1, i.e. no obstacle reduction is applied), it the name "Jarus Model" may be misleading. We propose to change this name, for instance for "Low angle of impact model".
response	Thank you for your comment. Your comment is noted. However, all the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.

comment	*23* comment by: *S.PIZZIOL* It is said: *"These guidelines are not addressing the calculation of the critical area resulting from the application of an M2 mitigation (SORA Step #3), but refer to the critical area to be expected from the impact with the terrain of an UA with no ground risk mitigations applied (SORA Step #2)."*

The reason for not considering the M2 type 1 is clear: not taking credit twice for the CA reduction. What is not so clear is why M2 type 2 should not be considered, as it can indeed decrease the lethality while on the other hand increase the Critical Area.
In that second case considering the effect of the M2 mitigation is the conservative evaluation.

It could be appropriate to ask the UAS designer to verify that the application of their M2 mitigation does not increase their Critical Area before applying this GM.

response Thank you for your comment. Your comment is noted. The goal of an M2 mitigation is to decrease the risk to uninvolved persons of one or more order of magnitudes starting from the ground risk class assessed in Step#2.

comment *71* comment by: *UK CAA*

Commenter: UK CAA
Page No: 4

Paragraph No: 3

Comment:
'Table 1' does not match what is in SORA 2.5 Annex F for a 40m dimension.

Justification:
UK CAA believes the values should be identical to those in SORA 2.5 Annex F.

Proposed Text:
Amend the critical area from 80,000 to 43,331

response Thank you for your comment. Your comment is accepted. All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.

comment *112* comment by: *LHD*

Please clarify since the beginning which SORA edition (2.0, 2.5) should be considered for each part of the guideline.

response Thank you for your comment. Your comment is accepted. These guideline are applicable to both SORA 2.0 and SORA 2.5. The main change in the ground risk assessment between the two versions is the transition from qualitative to quantitative indicators of the population density. However, the mathematical model driving the assessment of the iGRC remains the one defined in Annex F for both versions of SORA

Chapter 2: Overview of the scenarios p. 3

comment	*41* comment by: *Schiebel LUC Organisation* *1. Gliding capability of the UA;* *2. Impact angle.* Specify the second condition: 2. Impact angle. (> 60° or <60°)
response	Thank you for your comment. Your comment is accepted. The wording has been updated according to this comment.

comment	*42* comment by: *Schiebel LUC Organisation* In the Block Diagram on page pdf page 4, please refer to the excel file "ca_calculator_04072023_for_release_rounded.xlsm" is, because calculation of impact angle is necessary to come to a decision.
response	Thank you for your comment. Your comment is partially accepted. The sentence above the flowchart has been updated so to clarify that the selection of the applicable model, therefore also the evaluation of the impact angle, is performed by the tool.

comment	*92* comment by: *UAV DACH AC* It is difficult to understand the intention of the document. Maybe a simplification of the language is possible? E.g. In these guidelines [multiple?] --> "In this guideline, two models are proposed to obtain a critical area of an UA in case of a loss of control event. Each model adresses a different scenario:"
response	Thank you for your comment. Your comment is accepted. Text revised according to this comment.

comment	*93* comment by: *UAV DACH AC* There is ony one flowchart following: "The following flowcharts gives a" -> "The following flowchart gives a"
response	Thank you for your comment. Your comment is accepted. Text revised according to this comment.

comment	*114* comment by: *LHD* The proposed models of calculation have been subjected to any validation activity to demonstrate the real behaviour of UAS under those conditions? It is encouraged the action to validate the models with real data. Are EASA/MS CAAs going to provide evidence on that validation?

response

Thank you for your comment. Your comment is noted. We took the model begin the Jarus model and the high impact angle has been developed following paper and engineering assessment. Once more experience is acquired the model could be adapted (if needed)

comment

126 comment by: *Federal Aviation Administration*

FAA comment: Regarding the first bullet point under "impact scenarios," please describe another condition if the UA is not capable of "gliding."

response

Thank you for your comment. Your comment is accepted. For clarity purposes, the word "gliding" has been removed and it has been clarified that in order to use the high impact angle model the UAS should be a rotorcraft or a multirotor.

comment

127 comment by: Federal Aviation Administration

FAA comment: Recommend to clarify Item 1, "Gliding capability of the UA," given that previous text has inferred that the UA is incapable of gliding.

response

Thank you for your comment. Your comment is accepted. The text is being rephrased and it refers to the two conditions on which the selection of the applicable model is based.

comment

128 comment by: *Federal Aviation Administration*

FAA comment: Recommend clarifying the distinctions being made between loss of power and loss of control. Typically, loss of power automatically mean loss of control, but NOT vice versa. The technical distinction between loss of power and loss of control has significant importance.

response

Thank you for your comment. Your comment is accepted. The bullet points have been rephrased removing the reference to loss of control, and just describing the scenarios which the models are describing.

Section 2: Definitions p. 3

comment

76 comment by: *Adrien B*

Please provide guidance on how to assess if a UA is capable of gliding or not.

response

Thank you for your comment. Your comment is accepted. To improve clarity, it has been specified that in order to utilise the high impact angle model for the assessment of the critical area, an UA should be a rotorcraft or a multirotor.

comment

91 comment by: *UAV DACH AC*

Critical Area: "It is the sum of all areas on the ground where a person standing would be expected to be impacted by the UA during or after a loss of control event, and thus the area where a fatality is expected to occur if a person were within it" -
(1) add for clarification: the critical area includes the debris zone, flagration area or splash pattern
(2) for better understanding, proposed to change to "It is the sum of all areas on the ground where a person will be fatally injured by the UA during or after a loss of control event"

response

Thank you for your comment. Your comment is accepted. The critical area definition has been updated by referring to the one given in SORA Annex I.

comment *124* comment by: *Federal Aviation Administration*

FAA comment: Regarding the definition of "Impact angle," recommend changing "terrain" to "person" or "life." "Impact" is not just with terrain but with any object, structure, or person, the latter of which is the most critical as it applies to the iGRC.

response

Thank you for your comment. Your comment is rejected. It is correct that the impact may be with any object, however in the models presented in the guideline the impact angle is intended with the terrain.

comment *125* comment by: *Federal Aviation Administration*

FAA comment: Regarding the definition of "High Impact Angle model," consider providing scientific evidence supporting the use of a 60-degree angle, and consider whether angles such as 59, 55, or 50 degrees may also be relevant. In an event of loss of control, it is not easy to ascertain the impact angle with expected accuracy, the paper does not identify the basis for the impact angle.

response

Thank you for your comment. Your comment is accepted. In the explanation of the high impact angle model has been added a clarification on the fact that the 60 degree value has been chosen to keep consistency with Annex F.

Chapter 3: Critical Area and intrinsic Ground Risk Class p. 4

comment *6* comment by: *Ciconia*

Critical Area - **Not all areas alike.** Though the probability to hit the ground is straight forward, not all outcomes are the same – meaning: the outcome of a crash depends of course on people density on the ground but also and importance of the structures on the ground. Hospitals, chapels, kindergarten are not as industrial area – Therefore, it is recommended to add, in addition to the critical area, the "**Area Importance Score**" – This way, large platform, could fly over large critical area with low area score (small damage probability), and may be, small platform (with medium critical area) will not be allowed to fly over high score areas (high damage probability)

response	Thank you for your comment. Your comment is noted. The proposed guideline describes two models to assess the size of the critical area, and in order to cover a wide range of use cases and be usable without requiring a case-by-case adaptation, conservative assumptions are made so to cover the vast majority of the possible outcomes. Critical structures and infrastructures (prisons, powerplants, etc.) are protected by geozones which prevent unauthorised drones to overfly them, while other structures in which a large number of people may be inside, are taken into account when assessing the risk of the operation as they increase the iGRC.

comment	*24* comment by: *S.PIZZIOL* Probable Typo: "UASQ"-->UAS?
response	Thank you for your comment. Your comment is accepted.

comment	*43* comment by: *Schiebel LUC Organisation* The abbreviation "UASQ" in the first bullet point on page 4 needs to be defined.
response	Thank you for your comment. Your comment is accepted.

comment	*44* comment by: *Schiebel LUC Organisation* In the second bullet point on page 4, the parameters "light weight and low cruise speed" need to be quantitatively defined.
response	Thank you for your comment. Your comment is rejected. Those bullet points are meant to provide a qualitative example of the cases which may benefit the most when comparing the critical area assessed according to the proposed guideline against the critical area which is assigned to them according to Table 1. A quantitative assessment on the weight and speed needed to obtain credit in SORA Step#2 depend on the specific UA and operation.

comment	*73* comment by: *Adrien B* Consolidate how to evaluate the max UAS characteristics dimension for the following UAS : • fixed wing with multirotor for VTOL capability, • balloon with rigid envelope, • balloon with textile envelope
response	Thank you for your comment. Your comment is accepted. A reference to SORA Annex I, in which is provided the definition of characteristic dimension, has been included in the document (page 1).

comment	80	comment by: *Adrien B*
	Consider the appropriate relation between this guidelines and the *Optional JARUS Model Trade-offs* proposed in SORA 2.5 consultation. To me, GRC resulting from this guidelines or any optional trade-off model should be coherent.	
response	Thank you for your comment. Your comment is accepted. All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.	

comment	82	comment by: *DroneUp*
	Regarding the paragraph that starts with "The table above, taken from SORA 2.5 Annex F,..." - Which table? Can you be specific? I don't find a table in Annex F with the 80,000 m^2 critical area, but rather one that has 43,300 m^2.	
response	Thank you for your comment. Your comment is accepted. All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.	

comment	95	comment by: *UAV DACH AC*
	"Among the factors ... Critical area value." The semantics are wrong and very complicated - propose "The size of the critical area is one factor to define the instrinsic ground risk class (iGRC). A critical area value is associated with each threshold of maximum characteristic dimension given in the iGRC table (Table 1)."	
response	Thank you for your comment. Your comment is accepted. The text has been reworded similarly to what has been proposed in the comment.	

comment	96	comment by: *UAV DACH AC*
	"Table 1" add description "Table 1 - Critical area values"; similarly for al other tables	
response	Thank you for your comment. Your comment is accepted. The document has been updated accordingly.	

comment	97	comment by: *UAV DACH AC*
	"The table above, taken from SORA 2.5 Annex F" - cannot find this table in SORA 2.5 Annex F, ed 0.3 dated 8.11.2022; Tables 15 and 19 look similar but have a different value for 40m (last column = 43300 instead of 80000)	
response	Thank you for your comment. Your comment is accepted. All the values and assumptions in this deliverable have been aligned with the ones included in the final version of Annex F.	

comment | 129 comment by: *Federal Aviation Administration*

FAA comment: In table 1, please clarify what (m) and (m^2) represent and how those variables are determined. Does (m^2) = m squared? Does (m) represent mass?

response | Thank you for your comment. Your comment is accepted. The term "m" in Table 1 indicates "meters" and "m^2" indicates "square meters".

comment | 130 comment by: *Federal Aviation Administration*

FAA comment: In Table 2, if 8 m is approx. 25 ft, then >8 m should be approx. >25 ft.

response | Thank you for your comment. Your comment is noted. The comment is correct however Table 2 is a screenshot from the EU drone regulation, therefore cannot be modified for this guideline.

comment | 131 comment by: *Federal Aviation Administration*

FAA comment: Recommend to title the tables in the "Example" section.

response | Thank you for your comment. Your comment is agreed. The titles have been inlcuded in the tables.

comment | 132 comment by: *Federal Aviation Administration*

FAA comment: Recommend revising the sentence to more clearly convey the meaning: "Using these guidelines, the applicant may calculate the critical area of the UA used in its operations and compare it with the content of Table 1." The intent of this sentence is not clear as to where the applicant may do the calculation in different ways and then compare against Table 1.

response | Thank you for your comment. Your comment is agreed. The sentence has been clarified making reference to the EASA Critical Area assessment tool.

Chapter 4: the JARUS Model for calculation of Critical area p. 5

comment | 2 comment by: *EuroUSC Italia*

Current text: The angle for ≤1m UAS is set to 35° and all larger UAS use an angle of 10°

Comment: setting a hard limit at 1m dimension creates distortions in the model. In fact for a UAS with characteristic dimension of 1.01m, 15m/s of cruise speed and 1.5kg of MTOM, using an angle of 10°, the critical area is around 10m^2. For a UAS of 0.99m, using an angle of 35°, the crtical area is

around 5m^2. The differnce is significant and would result in a different iGRC for two UAS which differ only for 2cm. The use of 35° impact angle for UAS < 1 is justified in Annex F as follow: "angle of impact is 35 degrees (corresponding to cruise velocity), as this category contains a significant amount of multi rotors and these smaller aircraft would have higher wing loading and thus a steeper glide angle".
To avoid model distorsion, the applicant should be allowed to use a value of the impact angle that is different from the ones proposed by the model, if this can be substantiated with experimental data.

Proposed text: Impact angle should be set based on experimental data. If such data is not available the impact angle is set to 35° for multicopters ≤1m while for all other UAS it is set to 10°.

response

Thank you for your comment. Your comment is noted. The critical area assessment tool reflects accurately the " Critical Area Jarus model" latest' developments and assumptions. Therefore, your suggestions cannot be implemented in this Assessment tool. An alternative is proposed and can be used if certain conditions are met, see the high impact model assessment of critical areal (further details in the guidance material and in the tool itself).
Lastly, the assessment tool and guidance have now been updated following the latest reviews coming from Jarus for the Jarus critical rea assessment model.

comment

4 comment by: *AERODRON*

Good afternoon,

as to concern the methods used to calculate the critical area for gliding UAS we have noticed a logical mistake in the proximity of AUS having a wing span of 1 meter.

I am posting the following results for three different UAS, sharing the same MTOM (1.5 KG) the same cruise speed (15.5 m/s) and the same flight altitude (80 meters), but differing on wingspan.

UAS 1:

- wingspan: 99 cm
- MTOM: 1.5 Kg
- Speed: 15.5 m/s
- altitude: 80 m
- Critical Area: 5.08 m2

UAS 2:

- wingspan: 100 cm
- MTOM: 1.5 Kg
- Speed: 15.5 m/s
- altitude: 80 m
- Critical Area: 5.12 m2

UAS 3:

- wingspan: 101 cm
- MTOM: 1.5 Kg
- Speed: 15.5 m/s
- altitude: 80 m
- Critical Area: 10.47 m2

As you can see there is an increase of just 0.04 m2 when passing from a wingspan of 99 cm to a wingspan of 100 cm, but there is an increase of 5.35 m2 when passing from a wingspan of 100 cm to a wingspan of 101 cm.

We are aware that a lenght of 100 cm represents the limit of utilization of one formula in the place of the other, but from a logical point of view it is not acceptable.

Further neither the speed nor the MTOM affect the result of calculation. Considering the following UAS:

UAS 4:

- wingspan: 101 cm
- MTOM: 0.1 Kg
- Speed: 1 m/s
- altitude: 80 m
- Critical Area: 10.47 m2

as far as concern this last UAS, it has the same critical area of UAS 3, but with a MTOM of just 0.1 Kg and a speed of 1 m/s, even in this case from a logical point of view it is not acceptable.

Eventually we are considering an unreal situation for the last UAS.

UAS 5:

- wingspan: 1.00001 m
- MTOM: 0.01 Kg
- Speed: 1 m/s
- altitude: 1 m
- Critical Area: 10.40 m2

In this last example we are considering an UAS with a MTOM of 10 g, flying at an altitude of 1 meter with a velocity of 1 m/s and the critical area is basically the same as UAS 4 and UAS 3.

The aim of this document is to demonstrate that a certain UAS despite its dimensions can fall under a specific column to get the appropriate GRCi, but for gliding UAS with a wingspan of about 1 meter it is impossible to drop the value of the critical area under 10.4 m2 to get the value below 8 m2, as a result this document is not usable.

We hope you can modify your spreadsheet taking into account our observations, we find it a very valuable resource but in order to be utilized it needs to be more realistic and accurate.

Best regards

response

Thank you for your comment. Your comment is noted. The Jarus model has discontinuities and it is a limitation. The assessment tool has incorporated the formulas of Jarus model as per task sheet.

comment | *7* | comment by: *Ciconia*

It is important to note that the AAM ecosystem is very young, and also a near accident with people will adversely affect the ecosystem growth – so the probability may be low, but it is imperative not to trust only the **statistics rather to try and prevent any accident**

response

Thank you for your comment. Your comment is noted. The two models are taken from Jarus and available, once more data is acquired the model could be adapted (if needed)

comment | *11* | comment by: *Drone Architect (Jon Verbeke)*

Lethal limb KE limit = 290, but not mentioned why this value is chosen. Is this value then also true for kinetic energy impact in general regarding lethality reduction measures in M2?

response	Thank you for your comment. You comment is noted. The value of the KE follows the assumptions of the Jarus model before mitigations. M2 mitigations uses other values for the kinetic energy since the assumptions for M2 are different.

comment	*25* comment by: *S.PIZZIOL* General comment on Chapter 4: the formulas are difficult to read because of the chosen format.
response	Thank you for your comment. Your comment is agreed. The formulas format have been reviewed.

comment	*26* comment by: *S.PIZZIOL* A clarification on the "JARUS model" presented here. It is not clear if the parameter values provided here are prescriptive (Obstacle reduction =1, Theta = 10deg/35dec, etc.) or just provided as an example to explain the JARUS model. In the former case, the hypothesis behind the chosen values could be explicitly provided. In the latter case, it could be enough to provide a reference to the relevant JARUS documentation. PS in the first case "perscriptive model", it could be nice to have the final formula to be used with only the UAV parameters to be inserted.
response	Thank you for your comment. Your comment is noted. Please refer to the reply from comment 2. Furthermore, the excel tool gives the possibility to calculate the Jarus model critical area by giving the maximum characteric dimension, MTOM and maximum cruise speed.

comment	*27* comment by: *S.PIZZIOL* Probable typo: "AC = 2 rD (dglide) + 0.5*π rD2" --> AC = 2 [rD (dglide) + 0.5*π rD2] or AC = 2 rD (dglide) + π rD2
response	Thank you for your comment. Your comment is accepted. The Jarus formulas have been reviewed. In addition, coordination with Jarus has also been done to use the latest updates

comment | 28 | comment by: *S.PIZZIOL*

Which are the values of rperson and hperson? The same found in JARUS documentation? Since the model is recalled here, why not recall also their values here?

response | Thank you for your comment. Your comment is partially accepted. For the Jarus model fully follow the latest updates of done by Jarus in term of model and value of parameters. The Table 5 has been updated to include all values of the parameters. (rperson=0.3, hperson=1.8)

comment | 29 | comment by: *S.PIZZIOL*

Probable typo ?

Vnon_letal = sqrt (K_non_letal) / m

-->

Vnon_letal = sqrt (**2** * K_non_letal / m**)**

response | Thank you for your comment. Your comment is accepted. The Jarus formulas have been reviewed. In addition, coordination with Jarus has also been done to use the latest updates

comment | 37 | comment by: *S.PIZZIOL*

As a general comment, this GM may guide the UAV designers for a better estimate of the impact angles, it's a shame that the impact angles for the JARUS model are provided (i.e. 10 deg or 35 deg) with little explanation.

A UAV designer could more precisely estimate the impact angle if the hypothesis behind the model were explicit. Those values correspond to which condition :

- A glide with engines off at theroetical maximum glide ratio ?
- A glide with engines off and autopilot detcting it and still actioning the control surfaces ?
- A glide with engines off and autopilot **not** detcting it and still actioning the control surfaces ?
- A nominal landing (in the wrong landing site) ?
- Other?

response | Thank you for your comment. Your comment is noted. It has been added a sentence in the guideline specifying that the constants in the JARUS model, such as the impact angle, are the ones used in Annex F. Further details on the JARUS model may be found in Annex F.

comment | 46 | comment by: *Schiebel LUC Organisation*

If "rperson" and "hperson" which are defined in the first and second bullets on page 6 are constants, then their values need to be specified.

response | Thank you for your comment. Your comment is accepted. The Table 5 has been updated to include the values of parameters.

comment | 49 | comment by: *Drone Industry Association Switzerland*

For UAS smaller than 1 m, it seems that the obstacle reduction factor was assumed as 0.5 unconsistently on both terms of the equation. Could you clarify what is the assumption of the obstacle reduction factor here or where the obstacle reduction factor is in the case of 1 m?

response | Thank you for comment. Your comment is noted. The obstacle reduction applies for UA between 1 and 8 meters according to Jarus model. The updated assumptions of Jarus are defined in Annex F and its corresponding revisions, for more detailed information please refer to Annex F document. However, the general idea is to say that when an UA crashes it could impact obstacles (for example houses, building) which would lead to a reduction of the critical area.

comment | 50 | comment by: *Drone Industry Association Switzerland*

Areas overlap of the impact area and the slide and glide areas seem not to be accounted. Could you clarify?

response | Thank you for comment. Your comment is noted. The formulas of the Jarus model have been used without changes. However, the Dglide is the surface around a person at the impact on the ground, Dslide is calculated after impact and a buffer.

comment | 53 | comment by: *THALES AVIONICS*

Could you please precise the value of each constant (e.g obstacle reduction; Rperson; Hperson;...) as mentionned in AnnexF .

response | Thank you for your comment. Your comment is accepted. The Table 5 has been updated to include the values of parameters.

comment | 54 | comment by: *THALES AVIONICS*

	In footnote, it could be interesting to precise that the operator can decide if he wants to use the generic value of the guidelines or its own impact angle; same for 'Cg' or 'e' .
response	Thank you for comment. Your comment is rejected. The assessment critical rea tool does not foresee the possibility. The Jarus model uses the same impact angle (35°). Please refer to Chapter 4 for further guidance.

comment	*55* comment by: *THALES AVIONICS*
	Typo error: factor 2 is missing for the computation of Vnon lethal. . Annex F refers to 2K_non_lethal. More sense while referring to kinetic energy formula (KE= 1/2 m v²)
response	Thank you for your comment. Yor comment is accepted. The formula has been updated accordingly.

comment	*58* comment by: *Schiebel LUC Organisation*
	Does Cgg in the third bullet on page 6 correspond to C_g * g? If so please correct.
response	Thank you for your comment. Your comment is rejected. The multiplication signs have been omitted for readability reason. We have used Annex F notation.

comment	*75* comment by: *Adrien B*
	The absence of consideration of fuel damage (battery or thermal) within the critical area is surprising. Several models exist to assess this fuel area (eg. CRASH LETHALITY MODEL by John A. Ball, Michael Knott, Dr. David Burken 6 June 2012). At least a record of this simplification seems necessary.
response	The critical area assessment using Jarus model follows all assumptions of Annex F. For the justification about the consideration and variables used please refer to Annex F.

comment	*84* comment by: *DroneUp*
	"Jarus" in the first paragraph should be all in caps.
response	Thank you for your comment. It is accepted. The text has been updated.

comment	*99* comment by: *UAV DACH AC*

	"Annex F introduces the simple critical area formula applicable for UAS sizes above 20m" - this refers to the UA size not the UAS
response	Thank you for your comment. It is accepted. The text has been updated.

comment	*100* comment by: *UAV DACH AC* Formula on page 6: Assuming that AC is the critical area: this should be made clear
response	Thank you for your comment. It is accepted. The text has been updated.

comment	*102* comment by: *UAV DACH AC* in "rD= ..." "w is the wing span (UAS CD)", should be "w is the Characteristic Dimension (wing span, rotor diameter, max dimension from tip to tip for multicopters)", to include other than fixed wing, see also prEN4709-001
response	thank you for your comment. Your comment is noted. For the Jarus model, the formula of the rD is the one of Jarus Annex F as well as its assumptions. For high impact angle, the model uses the rotor diameter to calculate the rD. See step 3 of high impact angle model.

comment	*104* comment by: *UAV DACH AC* "Vglide = Vmax.cruise*0.65": Vmax.cruise is not the speed at impact; use Vmax.impact instead (need to determine what this would be however) if I assume a UA < 1m wingspan, MTOM 2 kg that travels at 25 m/s, with a assumed CD = 0.08; if I calculate correctly, at an unpowered decent the UA will become faster and not slower. So I am not sure if this is a good simplifications.
response	Thank you for your comment. Your comment is partially accepted. The latest version of Annex F does not use the Vglide, and the model has been updated accordingly.

comment	*105* comment by: *UAV DACH AC* V.non_lethal: wrong citation from JARUS Annex F Eq. (31): square root must include full fraction (=sqr(K_non_lethal/m))
response	Thank you for your comment. It is accepted. The text has been updated.

comment	*133* comment by: *Federal Aviation Administration* FAA comment: Recommend variable/formula be defined by slide alone. It was already presented in this model that UA are incapable of gliding.

response

Thank you for your comment. Your comment is noted. The critical area assessment using Jarus model follows all assumptions of Annex F.

comment

134 comment by: *Federal Aviation Administration*

FAA comment: Recommend to number the equations and to provide definitions of key variables ahead.

response

Thank you for you comment. Your comment is accepted. The definitons of key varibles have been updated. Please refer to table 5.

comment

135 comment by: *Federal Aviation Administration*

FAA comment: Please define MTOM. Typically Maximum Take-Off Weight (MTOW) is used in determining criticality as it applies to kinetic energy or like formulas.

response

Thank you for your comment. Your comment is accepted. Please refer to Sora Annex I for definitions list

comment

136 comment by: *Federal Aviation Administration*

FAA comment: Please define "AC." Multiple formulas are provided, and not every formula can = AC.

response

Thank you for your comment. Your comment is accepted. The text has been updated accordingly.

comment

137 comment by: *Federal Aviation Administration*

FAA comment: Recommend providing technical/scientific backing for the determination of 35 and 10 degress. Note that tan(35deg) ~ 0.7 and tan(10deg) ~ 0.176; their inverses are 1.43 and 5.67, respectively.

response

Thank o for your comment. Your comment is noted. For the Jarus model, the critical area assessment uses all assumptions and scientific justification of Jarus Annex F . Please refer to Annex F for further guidance.

Chapter 5: Overview of the High Impact Angle Model p. 7

comment

10 comment by: *Drone Architect (Jon Verbeke)*

The Advisory circular FAA AC-431.35-1 was titled "Expected Casualty Calculations for Commercial Space Launch and Re-Entry Missions" and has been retracted in 2013 for another method by the FAA. The document itself cannot be downloaded anymore. So no possibility to investigate the supporting evidence of the proposed methods.

response

Thank you for your comment. Your comment is noted. The advisory circular may be found at this link: https://www.govinfo.gov/content/pkg/GOVPUB-TD4-PURL-LPS111342/pdf/GOVPUB-TD4-PURL-LPS111342.pdf

comment

30 comment by: *S.PIZZIOL*

Step 3: For the high angle model the erquation is ��������=��������*����*�������������.

It seems the dglide term is being neglected, if it's the case it is worth to state it explicitly.

NB It could be at worst of around 1m (for 60deg).

response

Thank you for your comment. Your comment is noted. The glide portion of the critical area is neglected in the high impact angle model, as it was assessed that being the impact angle so high, the glide portion of the critical area is small enough that it can be considered as already included in the area included in the circle defined by the high impact angle model.

comment

51 comment by: *Drone Industry Association Switzerland*

While we welcome the introduction of a high impact angle model appropriate for multicopters which form currently more than 90% of drone operations, we can't help notice that the model is based on a advisory circular of the FAA relating to commercial space launch and reentry mission risk of fatality. Therefore the safety factor is based on the kinetic energy coming from the terminal velocity which space mission will achieve in such contexts. However for multirotors, most missions take place at lower level airspace and will in most cases never have the time to actually reach the terminal velocity with a fall from such low altitudes. We suggest adding the possibility for operators operating at lower altitudes to account for the potential kinetic energy (mgh instead). Similarly, we suggest adding the possibility for applicants to use empirical or other analytical models.

response

Thank you for your comment. Your comment is noted. The FAA circular has been utilised for the purpose of these guidelines only limited to the part which describes the critical area resulting from debris falling vertically at its terminal velocity to the ground. The safety factor formula has been taken by a military regulation which is now referenced in the document. It has been assumed that a drone falling vertically would reach its terminal velocity as this is the worst case scenario. Assessing the critical area requires making a lot of assumptions on the probabilities of different failure modes, flight speeds and altitudes. All of these would affect the impact dynamics and angles not to mention the ground hardness and slope angle, therefore we opted to make some conservative assumptions in order to make the model more robust.

comment	*52* comment by: *Drone Industry Association Switzerland* The table shown on page 8 with it's formulas leads to Safety Factors below 2 for UAS with a Kinetic energy between 0.2 and roughly 5 kJ. Therefore the Figure shown above the table does not actually represent the table in question. We suggest to re-visit the formula and the figure to identify where this inconsistency arises and clarify how the Safety Factor for UAS between 0.2 kJ and 5 kJ can be calculated.
response	Thank you for your comment. Your comment is accepted. The graph and formulas have been corrected.

comment	*56* comment by: *Schiebel LUC Organisation* What does Vno on page 7 stand for? Moreover, it is not used anywhere else in the document.
response	Thank you for your comment. It is accepted. Vno is defined in Annex F and the definition has been included in Annex 1 Impact angle (maximum structurally safe cruise speed = max cruise speed)

comment	*59* comment by: *Schiebel LUC Organisation* Impact angle must be clearly indicated in the figure on page 7, to prevent misunderstandings.
response	Thank you for your comment. Your comment is accepted. The text has been updated. , the impact angle has been indicated in the figure

comment	*60* comment by: *Schiebel LUC Organisation* The following sentence on page 8 is not clear and needs to be revised as well as "deliverable 2 team" needs to be explianed: *"The lower limit of the safety factor was increased from 1.1 to 2 by the Deliverable 2 team to account for the 60-degree impact angle (rounded function in the tool) increasing the impacted area over a 90-degree impact angle."*
response	Thank you for your comment. Your comment is accepted. The text has been reviewed for clarification. Furthermore, for your reference, the deliverable 2 team, made reference to the Authorities sub-group within the task force.

comment	*61* comment by: *Schiebel LUC Organisation*

On page 8, E_k is denoted as E_tot and F_s is denoted as k in the safety factor graph which is inconsistent with the give safety factor equation in the table below. Update required.

response

Thank you for your comment. Your comment is accepted. The same notation has been used for coherence.

comment

62 comment by: *Schiebel LUC Organisation*

$F_s = 1.4 * E_k(kj)^{0.2}$

On page 8, unit of the E_k should be removed from the safety factor equation.The unit is already mentioned in the E_k column of the corresponding safety factor rable.

Proposed version: $F_s = 1.4 * E_k^{0.2}$

response

Thank you for your comment. Your comment is accepted. The changes have been done in the model. The values of the safety factor range from 2.3 until 7. Please refer to new guidelines of high impact angle model

comment

63 comment by: *Schiebel LUC Organisation*

Lower limit and upper limit of the safety factor (2 and 7 respectively) can not be obtained with the equation when the limit kinetic energy values (i.e. 0.2 kJ and 4000 kJ) are used as stated in the table.

Instead following values obtained:

lower limit ~ 1.02
upper limit ~ 7,35

response

Thank you for your comment. Your comment is accepted. The table 6 Safety Factor calculation has been also reviewed and the FS value have been adapted following the results of the simulation done by Qinetiqs.

comment

64 comment by: *Schiebel LUC Organisation*

On page to in the safety factor table, ≤ sign for lower limit needs to be replaced with < as it is also used to denote acceptable interval.

response

Thank you for your comment. Your comment is accepted. The table has been updated to reflect the correct interval, see table 6- safety factor calculation.

comment

85 comment by: *DroneUp*

	Regarding the graph of the Safety Factor - the 200J seems to be mislabeled. Check this in the spreadsheet version as well. The formula seems correct, but the graphical depiction in both the GM and the spreadsheet could use a look.
response	Thank you for your comment. Your comment is accepted. The graph and formulas have been corrected.

comment	*106* comment by: *UAV DACH AC* Three symbols (E_tot, E_k, $E_{k.terminal}$) are used for the same Parameter. Consolidate
response	Thank you for your comment. Your comment is accepted. The parameters nomenclature has been updated.

comment	*107* comment by: *UAV DACH AC* "Terminal velocity was chosen for the calculation because SORA method should assume the worst credible case impact in the iGRC calculation." Calculating the energy from the kinetic energy is not worst case but physics; transfer of energy to the "other part" is a different thing, i.e. how much of the energy is dissipated by the UA (by deformation) or the "other party" (ground, person); The assumption seems to be that the energy is dissipated by absorption by the "other party" in case of a person, and by defragmetation of the UA on ground. This is very worst case and may be aplicable for a projectile. The method should allow for UA specific solutions. Chosing terminal velocity is worst case and correct, though.
response	Thank you for your comment. Your comment is noted. The terminal velocity is only considered for the high impact angle model and in accordance with the available literature (with conservative assumptions)

comment	*108* comment by: *UAV DACH AC* Terminal velocity can only be achieved with enough height above ground; Cd and A (definition for A missing; better use A*Cd = drag surface) depends on orientation (of fuselage) during descent (high for post-stall, low for head on). This may be too simplistic. See prEN4709-001, 5.2.1.2.1.1
response	Thank you for your comment. Your comment is noted. Agreed the assumptions and model are simple. However, the intent is to estimate a credible worst case impact and to not require extremely complex analysis to get to that estimate.

comment	*113* comment by: *LHD* Please note that the FAA advisory Circular (FAA AC-431.35-1) reference considered as input model has been removed by FAA and substitued by Flight

Safety Analysis Handbook Rev. 1.0. This last updated model is considered more conservative with respect to the one used in this document as for instance takes into account also area related to UAS explosion. Has this been taken into account by EASA? A proportional approach based on increasing conservativism for increasing SAIL level could be considered?

response

Thank you for your comment. Your comment is noted. The FAA circular has been utilised for the purpose of these guidelines only limited to the part which describes the critical area resulting from debris falling vertically at its terminal velocity to the ground. The safety factor formula has been taken by a military regulation which is now referenced in the document. The Safety analysis handbook has been considered during the comments resolution, however the critical area calculation model presented has not been found suitable for the use cases addressed by the guidelines. A digital simulation has been conducted in order to verify the correctness of the high impact angle model, which results were aligned with the model.

comment *116* comment by: *Airbus Helicopters*

Clarification of the coverage of the safety factor	Does the safety factor includes the debris ejection following the impact on the ground of a turning main rotor (autorotation)?

response

Thank you for your comment. Your comment is noted. The safety factor model and equation are defined in table 6 Safety factor calculation, it is based on the kinetic energy assessment and is assumed to cover the different scenarios.

comment *138* comment by: *Federal Aviation Administration*

FAA comment: Regarding Step 2, please clarify the fourth sentence. Does the iteration end on the ground or when it impacts an object, in this case a person?

response

Thank you for your comment. Your comment is accepted. The iteration ends when the UA touches the ground.

comment *139* comment by: *Federal Aviation Administration*

FAA comment: Regarding Step 2, in the sixth sentence, should calculation use Maximum Velocity instead of Maximum Cruise Speed? Where cruise speed is a constant, velocity can reach terminal calculations when force of air (drag) equals force of gravity (google).

response

Not accepted. The model uses the max cruise speed because speed because it is the only information available at the beginning of the iteration when the UA start its descent

comment	*140* comment by: *Federal Aviation Administration* FAA comment: Recommend to provide a title for what would be Figure 3.
response	Thank you for your comment. Your comment is accepted, the proposal has been incorporated.

comment	*141* comment by: *Federal Aviation Administration* FAA comment: Recommend to title the "Safety factor" table/figure.
response	Thank you for your comment. Your comment is accepted. The proposal has been incorporated.

comment	*142* comment by: *Federal Aviation Administration* FAA comment: The text references FAA Advisory Circular 431.35-1, Expected Casualty for Commercial Space Launch and Re-Entry Missions. This Advisory Circular applies to those vehicles which are licensed as Commercial Space Vehicles and their applicable operations, and it cannot be used to support UAS methodologies not so identified and/or licensed.
response	Thank you for your comment. Your comment is noted. The FAA circular has been utilised for the purpose of these guidelines only limited to the part which describes the critical area resulting from debris falling vertically at its terminal velocity to the ground. The safety factor formula has been taken by a military regulation which is now referenced in the document.

comment	*143* comment by: *Federal Aviation Administration* FAA comment: Regarding the sentence: "Terminal velocity is calculated by the equations below using assumptions aligned with Annex F ballistic descent calculations," please confirm that "ballistic descent calculations" are applicable to UAS in this safety factor. Ballistic flight refers to projectiles where initial speed and initial angle, among additional precise values are known/determined.
response	Thank you for your comment. Your comment is accepted. Ballistic descent assumptions are not relevant for the calculation of the terminal velocity, therefore the reference to them is removed.

ANNEX 1: Impact angle - mathematical model p. 9

comment	*1* comment by: *Wolfgang Riegelmayer* Attachment #1

It is on Digital organisation principle of air space for ATM/ANS service operation in real-time for any flight manoeuvres considering sovereignty and local conditions,
to be handled for SES, intra FABs and inner FABs using so called “Platonic(/s)” bodies in 3 dimensional (horizontal&vertical) gapless coverage and flexible enough (prolongable, flattened, trajectory volume resolutions) for minimal overlapping.

The most advantageous one as the segmenting pattern of different aerial layers is the **Icosaeder,**
corresponding to reliable omnidirectional Radio fields with possible Frequencies reuse in certain distances,
and capable for automated Handover procedures and sophisticated Roaming interface known form Cellular surface mobility.
(Within each Icosaeder so called Golden Rectangles (3) are applicable e.G. Geo Fancing for SES border control.)

For further you may count on me.

Best

W. Rm.

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response — Thank you for your comment. Your comment is noted.

comment — *12* — comment by: *Drone Architect (Jon Verbeke)*

Annex 1 formulas of V horizontal (t) en V vertical (t) seem wrong to me. The units don't match. I think the delta t should be in the numerator, not the denominator. Probably they did the simulation with delta t = 1 second and thus haven't discovered their flaw as this coincidentally doesn't have an effect for that specific value. It would be completely different if they used a more refined delta t = 0.01 seconds interval.

response — Thank you for your comment. Your comment is accepted. The formula has been reviewed accordingly.

comment — *31* — comment by: *S.PIZZIOL*

Wind is taken into account for the maximum forward speed? Please clarify

response	Thank you for your comment. Your comment is not. The maximum forward speed should be defined in the same way as in Sora step 2.

comment	*32* comment by: *S.PIZZIOL* *"(when the vertical distance is equal to the minus initial Vertical distance)"* The sentence is not clear. Please clarify.
response	Thank you for your comment. Your comment is accepted. the sentence has been reviewed.

comment	*33* comment by: *S.PIZZIOL* "Vertical distance (t) = Vertical distance (t-1) + Vertical distance (t-1) * Δ t" The iteration should be on a discrete index, like "i" or "j" for instance. Apart from that, there is probably another typo in the formula: Vertical distance (i+1) = vertical distance (i) + **vertical speed** (i)*Δ t
response	Partially agreed. There was a typo in the formula of the vertical distance and it has been reviewed. The path of the iteration is indeed discrete, it is Δt (= t-(t-1)) and the index is, one instant of the time.

comment	*34* comment by: *S.PIZZIOL* "V horizontal(t) = (V horizontal (t−1) + Drag force Horizontal (t−1))/(m∗ Δ t)" There is probably a typo in the formula as speed (m/s) cannot be added to a force (N). There is probably a second typo as Drag sould decrease the speed and so have opposite sign.
response	Thank you for your comment. Your comment is accepted, there was a typo, the formula has been reviewed.

comment	*35* comment by: *S.PIZZIOL*
	V vertical (t)=V vertical (t−1)−(g−Drag force Vertical (t−1))/(m∗Δ t). There is probably a typo in the formula as speed (m/s) cannot be added to an acceleration (m/s2) and to a force (N). There is probably a second typo as Drag sould decrease the speed and so have opposite sign. Since the sign of g is opposite to that of V, V_vertical sign is positve upward, isn't it ? So, since the UAV is falling, V_vertical is always negative ?
response	Thank you for your comment. Your comment is accepted, there was a typo, the formula has been reviewed.

comment	*36* comment by: *S.PIZZIOL*
	Beause of the number of typos at the begnning of this section, later comments on the section are based on "suppositions" on the correct format of equations and definitions. Please consider a further stage for comments, since the understanding of the section was difficult.
response	Thank you for your comment. Your comment is noted. The comments have been addressed when justified.

comment	*65* comment by: *Schiebel LUC Organisation*
	On page 9, "initial vartical distance(t)" is not function of time, rather an initial value. Could be corrected by replacing (t) with (t=0).
response	Thank you for your comment. Your comment is accepted. The changes have been done in the model.

comment	*66* comment by: *Schiebel LUC Organisation*
	On page 9, units of the following equation do not match. Vertical distance (t) = Vertical distance (t-1) + Vertical distance (t-1) * Δ t [meter] = [meter] + [meter]*[time]
response	Thank you for your comment. Your comment is accepted. The formula has been reviewed accordingly.

comment	*67* comment by: *Schiebel LUC Organisation*

	On page 9 and page 10, units of the following equations do not match:
response	Thank you for your comment. Your comment is accepted. The formula has been reviewed accordingly.

comment	*68* comment by: *Schiebel LUC Organisation*
	There is a possible typo in the following equation on page 9. "masse" to be replaced with "mass" m = UA masse
response	Thank you for your comment. Your comment is accepted. The typo has been corrected.

comment	*69* comment by: *Schiebel LUC Organisation*
	On page 9, in the following equation: Drag Force (t−1)=0.5* ϱ* Speed vector (t−1) ²*ref area* Cd • speed should not be called as vector. • ref area is denoted as A in $V_{terminal}$ equation. Same notation should be used for consistency.
response	Thank you for your comment. Your comment is accepted. The formula has been reviewed for consistency.

comment	*88* comment by: *DGAC FR*

	Theme	Reference	Page	Commentary	Resolution
DGAC	**General**	Annex 1	9-10	The equations proposed in Annex 1 for the definition of the horizontal speed V horizontal (t) and vertical speed V vertical (t) do not seem homogeneous: a speed plus a force divided by a mass multiplied by a time is not dimensionally consistent and not equal to a speed.	NA

response Thank you for your comment. Your comment is accepted. The formulas have been reviewed accordingly.

comment *109* comment by: *UAV DACH AC*

What is the aim and scope of Annex 1? Cd=0.8 means that the method relies on this value or is this value a parameter chosen for illustration? The value of Cd depends on the "trimmed condition" during descent; as per Annex F: "For most objects, the drag coefficient is between 0.2 (quite low) and 1.2 (quite high)." = 0.7+/-0.5 = 0.7+/-70%

response Thank you for your comment. Your comment is noted. The values of the parameters come from Annex F and is a constant in the model. The 0.8 selection comment also from Annex F assumptions.

comment *115* comment by: *LHD*

Attachment #2

Although the basic criteria for the impact angle mathematical model are evaluated as correct, please consider the attachment for a clearer exposition which could help the reader.

response Thank you for your comment. Your comment is accepted. The exposition of the models has been reviewed for improve readability.

comment *144* comment by: *Federal Aviation Administration*

	FAA comment: Where (t) or height (m) is subjective and varies, is the formula in this model assuming (m) to be while operating at maximum altitude? Where a failure could occur at any altitude while operating, is this formula applicable?
response	Thank you for your comment. Your comment is noted. The assumption in the ballistic impact model is that the drone has a minimum altitude (t or m) above which it is flying at maximum speed. So while the altitude measurement might be subjective or not entirely accurate, it is also assumed that always flying at maximum speed is a very conservative assumption. Therefore, most flights could still be conservatively assumed to impact at a higher than 60 degree impact angle.

comment	*145* comment by: *Federal Aviation Administration* FAA comment: Regarding the definition of V horizontal, the units being used are incompatible and should be revised. The entire equation can be fixed as: Vhz(t) = Vhz(t-1)-(Drag/m)(t-1)* Delta t Note that sign of the Drag is opposite to the traveling direction. *There are other similar issues after such.
response	Thank you for your comment. Your comment is accepted. The formula has been reviewed accordingly.

comment	*146* comment by: *Federal Aviation Administration* FAA comment: Please check derivations for Vertical distance, V horizontal, and V vertical equations. Note that units do not match (e.g., velocities added to force). Vertical distance is always zero if the equation shown. Recommend to rederive equations and start from first principles and include a free body diagram explaining the coordinate systems in more detail.
response	Thank you for your comment. Your comment is accepted. The formulas have been reviewed and the proposed diagram explaining the coordinate systems included accordingly.

comment	*147* comment by: *Federal Aviation Administration* FAA comment: The induction is done by using Euler's method. This method is good for illustrative purposes but it can propagate a lot of error and be problematic when trying to use it to quantify risk. Suggest using another method such as Runge-Kutta-Fehlberg method to reduce the potential for errors.
response	Thank you for your comment. Your comment is noted. Others models may exist with different assumption and limitations . The model used serves the purpose to estimate the impact angle and make a decision on the model to apply either Jarus model or High impact angle.

comment | 13 | comment by: *Drone Architect (Jon Verbeke)*

The calculation tool uses the "Minimum operational flight altitude AGL". It is not defined what exactly this means. I suppose for a parachute equipped drone this will be the minimum deployment altitude, but for others, it might as well be 1m. Or should it state the "Maximum operational flight altitude AGL" as the highest altitude will lead to the highest terminal velocity (although a smaller critical area due to the higher impact angle)...

response | Thank you for your comment. Your comment is accepted. The definition has been added in the guidelines as the minimum operational flight altitude is the limitation in the operation manual outside takeoff and landing.

comment | 14 | comment by: *Drone Architect (Jon Verbeke)*

The calculation tool: The Safety factor for High impact angle model depends on the terminal velocity which depends on its cross sectional area (for drag force estimation). This parameter is not present as an input value in the tool. Or are you supposed to fill in the terminal velocity in the "Maximum speed / Cruise speed Vno"? Even then, it does not affect the safety factor. Apparently only the "UAS characteristic dimension" and mass seem to affect it and this doesn't make sense nor is in alignment with the formulas in the PDF.

response | Thank you for your comment. Your comment is accepted. An explanation on how the cross sectional area is calculated has been included in the guideline.

comment | 15 | comment by: *Drone Architect (Jon Verbeke)*

The calculation tool: Coefficient of Restitution "CoR" has the wrong symbol, in PDF it is "e".

response | Thank you for your comment. Your comment is accepted. The coefficient of restitution nomenclature has been updated.

comment | 16 | comment by: *Drone Architect (Jon Verbeke)*

The calculation tool : Obstacle reduction is 0.6, but not clear why. See earlier remark

response | Thank you for your comment. Your comment is noted. The values of the parameters are those of Jarus model (latest update)

comment | 81 | comment by: *Adrien B*

"It should be defined if / how to exchange with JARUS"
This point seems to be not adressed.

response	Thank you for your comment. Your comment is accepted. EASA and Jarus will coordinate to use the latest parameters values and updates of models (if needeed).

Appendix A
Attachments

Bild 3.15 Icosaeder - extract from my last book.jpeg
Attachment #1 to comment #1

ImpactAngle_MathematicalModel.pdf
Attachment #2 to comment #115
