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NR	Name of the organisation commenting	Section, table, figure	Page					
1	*TCCA* *NAC Structures*	Cover page	1	At page 3 item 1.1, It is said that the purpose "of the CM it to provide specific guidelines" and at page 5 item 3.1 it is said "CM is to provide guidance", but at cover page it is said" CM are provided for i**nformation purposes only**"	May be to rewrite or eliminate phrase to avoid misleading of CM goal as complementary data for AMC and GM.	Recommended	Noted	The statement on the coverpage contains the following 2 important points: 1. CMs are intended to provide guidance on a particular subject and, as non-binding material, may provide complementary information and guidance for compliance demonstration with current standards. *2.* Certification Memoranda are provided for information purposes only and must not be misconstrued as formally adopted Acceptable Means of Compliance (AMC) or as Guidance Material (GM). Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements and do not constitute any legal obligation. This CM contains 'guidance' but not 'Guidance Material' which can be used by an applicant to better understand EASA's interpretation of CSs requirements and the associated AMC but should be used for information purposes and is in no way binding. Therefore the statements in item 1.1. and 3.1 are both correct.
2	*TCCA* *NAC Structures*	3.1	6	The phrase "This CM should be only used to assess PDR events in the framework of CAW" could be moved to Section 1.1 Purpose and Scope.	To move the phrase to section 1.1 to clarify up front the goal for use this CM.	Not requested	Accepted	Section 1.1. is modified.

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3	*TCCA, NAC engineering*	3.2 Scenario 1	p.6/25 and sub	TCCA considers engineering judgement, possibly supported by analysis where appropriate, would be the most appropriate way to determine in a conservative manner the potential damage due to detached parts. It is questionable whether reliable values of *"P (damage by PDR in case X)"* – the probability of a detached part hitting the rotorcraft - could be determined in other than the most obvious cases, e.g. part falling well clear of the rotorcraft. In particular where there could be dependencies on flight conditions and airflow, the assessment should conservatively assume that the part could hit the rotorcraft. There is also a concern with the CM's proposed use statistical analysis of in-service data to determine the trajectory of the detached part and/or damage to the impacted area. It is difficult to foresee a situation where there would be sufficient in-service events to provide a statistically significant dataset for such a determination. There would also be too much potential variation in the individual operational circumstances of these events to determine representative worst case damage (location and severity) based on these few events only.	Recommend removing from the proposed CM specific allowances under scenario 1 for use of statical analysis of in-service data to determine trajectories and/or damage severity. There should also be clearer focus on qualitative, engineering judgement based assessment, instead of probability analysis.	Recommended	Partially Accepted	The concern is technically shared. It is not in the intent to foster the positive bias based on previous events with low criticality outcome. Statistical analysis refers to trajectory determination. Related potential damage is not intended to be based on in-service data. The statistical analysis is intended as part of the engineering assessment based for example on a normal distribution of detachment angles and speeds. Among all the possible trajectories the ones with the highest potential for damages shall be identified and cumulative probabilities calculated. Example: Loss of Passenger Door Observed occurrence level (all type of events/criticality): P1 [FH^-1] Cumulative probability of critical events (from Statistical analysis of trajectories)=P2 [adimensional, <<1] Estimated rate of critical events= P1*P2 The idea is to determine an estimation of critical outcome linked to a specific type of occurrence even if so far it has not yet happened. The consideration on the statistically relevant experience is also shared. The observed occurrence level becomes statistically relevant when the number of cumulated FH is significant. This is the reason for mentioning mature fleets as our source of data for the examples. The text has been improved to clarify the intent. Added sentences: *"Statistical analysis refers to trajectory determination and related potential damage is not intended to be based on in-service data.* *The statistical analysis is intended as part of the engineering assessment based, for example, on a normal distribution of detachment angles and speeds. Among all the possible trajectories the ones with the highest potential for damages shall be identified and cumulative probabilities calculated. The aim is to determine a robust rationale for the selected trajectories.* *Qualitative considerations are also acceptable to establish the "most likely" trajectory."* *"The observed occurrence level becomes statistically relevant when the number of cumulated FH is significant."*

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4	*TCCA, NAC engineering*	3.3 Scenario 2A	p.12/25 and sub	TCCA concurs the risk to people on ground due to PDR is relevant. It is unclear, however, how the CAW process could take into account the population density in the risk assessment, given that there is no instrinsic limitation as part of the approved design on where the product can be used. In the absence of specific limitations in the RFM, one would have to assume the worst case (i.e. flying over high density population areas) as part of the risk assessment. On this basis, it is unclear how a lower density population area could be used as assumption in the risk assessment. Unlike UAS applications, where the ConOps inherently includes the planned operations, and the geographical context into which these operations occur, there is no such control or constraint on a certified rotorcraft as part of the product approval.	Recommend removing from the proposed CM references to lower population density, and driving the assessment of risk for people on ground to use the highest expected population density only.	Recommended	Noted	Population density is a value that may change significantly when comparing a crowded megacity to a rural/remote area. The reference values proposed have to be considered as ordinal averages (rank). These values are considered indeed to be conservative. As this is a key value for the risk assessment, using the highest expected population density, that is extra-conservative may, lead to an over-estimation of the risks. We need to consider the evidence that so far, no case of severe injury to people on the ground has been reported to EASA (if the special case of NHEC is put aside) also in the presence of several hundreds of PDR. The Table on Page 14 is an attempt to explain this rationale and therefore it won't be removed. The sentence below suggests however to use the higher population density: *"Conservatively, and in the absence of further analysis, the Applicant should select a probability of injuring people on the ground of 1*10-5"* At this stage it is worth to leave the door open for further analysis that could be proposed by the applicants, where all assumptions (i.e. population density, shelding, impact area) have to be evaluated by the Agency.
5	*TCCA, NAC engineering*	3.3.1 Scenario 2A	p.13/25	There is no information or reference on how the kinetic energy limits for CAT/HAZ/MAJ were determines. In particular, there is no correlation provided between these threshold, and either the Abbreviated Injury Scale (AIS) or the Head Injury Criterion (HIC) - which seem to be the broadly accepted metrics in this area.	EASA is requested to clarify how the proposed kinetic energy limits were defined, and how they relate to Abbreviated Injury Scale (AIS) or the Head Injury Criterion (HIC) criteria.	Requested	Partially Accepted	Detailed relation with AIS and HIC is provided in the Annex 1 of this CRD. Considering that such level of detail is not useful for the user of the CM, such information will not be included. However, a sentence has been added in the text: *"The different kinetic energy thresholds correlate with the energy associated to Abbreviated Injury Scale (AIS) and Head Injury Criterion (HIC) for skull fracture by blunt object."*
6	*TCCA, NAC Continuing Airworthiness*	3.2.1 Severity	9	In the first paragraph on page 9, when addressing whether emergency landing is possible, it is not clear if the CM considers the possible flight regime that the rotorcraft can be operating in that will make successful emergency landing questionable. E.g. for Category B rotorcraft where footnote 3 classifies unscheduled landing (autorotation) to be a possible emergency landing, it is not clear if the CM considers that Category B rotorcraft can be operating in the avoid region of the H-V diagram during the PDR event where an emergency landing is needed but successful autorotation is not assured.	It is suggested that EASA clarify the criteria of classifying Category B rotorcraft emergency landing as HAZARDOUS.	Recommended	Not Accepted	HAZARDOUS classification is coherent with the definition of unscheduled landing in an emergency (i.e., unsuccessful autorotation resulting in injuries). When the PDR occurs inside the H-V avoid region the combined effect of reduced performance and PDR direct/indirect consequences may drive the classification to CATASTROPHIC. A default classification is not possible. The CM is focussed therefore on the outcome and not specifically on the flight phase in which the PDR occurs. The worst possible flight phase where the PDR is likely to occur, should be considered in the evaluation. Note 3 of the CM is proposed only to highlight that the applicable definition of "continued safe flight and landing" is different for CAT A and CAT B rotorcraft. A default classification is not given in the CM as the assessment of the PDR may lead to different classifications.

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7	*TCCA* *NAC Structures*	Figure 2	24	There is no IF decision rule (Yes or No) at "identify other mitigation means" green box to direct to "AD" or "CA under DOA" red boxes.	To include it unless it is applicable for both scenarios.	Recommended	Noted	It is applicable for both
8	*TCCA* *NAC Structures*	Figure 3	25	There is no IF decision rule (Yes or No) at "identify other mitigation means" green box to direct to "AD" or "CA under DOA" red boxes.	To include it unless it is applicable for both scenarios.	Recommended	Noted	It is applicable for both
9	*TCCA Aircraft Certification*	Section 3.2.1 and Annex 1		The draft CM covers NHEC (and not HEC) scenarios, but Section 3.2.1 and Annex 1 includes HEC terms and scenarios. Is this intended?	Clarify the intention and adjust the text accordingly	Requested	Partially Accepted	HEC scenario has been removed from Annex 1. The CM covers NHEC operations but the HEC definition in Section 3.2.1 is retained for a different purpose: to support the classification making the comparison "risk of death of external occupants" vs "risk of death of third party on ground".
10	*Airbus Helicopters*	3.2.2	10	*"If a non-compliance to the certification basis is at the origin of the PDR, the probability of PDR event should be set to 1. "* AH understanding that the justification to set probability to 1 is that there is a direct cause-effect relationship between the identified non-compliance to the certification basis and a PDR event. Here 'direct' means there is no need of additional contributing factor to explain a PDR event. In addition, no matter if this was the actual root cause of the PDR event – as soon as a direct cause-effect is established between a non-compliance to certification basis and a PDR event, the probability of the PDR event shall be set to 1. If AH understanding is correct, following sentence will be for AH more accurate: "If a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1." From AH opinion, following case is a typical case where the probability of the PDR event should be set to 1: actual limit	Replace: *"If a non-compliance to the certification basis is at the origin of the PDR, the probability of PDR event should be set to 1. "* by: *"If a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1."*	Requested	Partially Accepted	EASA shares the interpretation given by AH, however the concept of "a non-compliance to the certification basis can explain solely a PDR event" may be misleading. The text retained for the final version of the CM is: *"If a non-compliance to the certification basis can be a direct cause for a PDR event, the probability of PDR event should be set to 1."*

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				loads of the broken part are found to be finally not sustained in the whole flight envelop.				
11	*Airbus Helicopters*	3.2.3	11	*"If a failure occurs as a result of a non-compliance with the Certification Basis, the probability of a PDR event is automatically set to 1."* Same comment than previous comments see page 10	Replace: *"If a failure occurs as a result of a non-compliance with the Certification Basis, the probability of a PDR event is automatically set to 1. "* by: *"If a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1."*	Requested	Partially Accepted	EASA shares the interpretation given by AH, however the concept of a non-compliance to the certification basis can explain solely a PDR event" may be misleading. The text retained for the final version of the CM is: *"If a non-compliance to the certification basis can be a direct cause for a PDR event, the probability of PDR event should be set to 1."*
12	*Airbus Helicopters*	3.2.3	11	*"The combined probability in this case can be used to discuss the corrective action plan."* Question: In case of a non-compliance to the certification can explain solely a PDR event and if the detached part meets the energetic criteria > 100J, the scenario will be by default classified CAT / 10-5/FH. According to AMC part 21, Agency may decide in such situation to immediately ground the fleet if an immediate protective/corrective measure cannot be put in force rapidly. AH understanding of previous sentences of the certification memo is that TCH will have to act anyway with the adequate level of urgency and with no delay with respect to what is achievable. But AH understands also that the observed occurrence in service may be considered in the discussion with the Agency to justify a non-grounding of the fleet if unfortunately, no very immediate action can be put in force rapidly.	Replace *"The combined probability in this case can be used to discuss the corrective action plan."* By *"The combined probability in this case can be used to discuss the corrective action plan possibly considering also the observed occurrence."*	Requested	Not Accepted	The compliance time definition is part of the corrective action plan. As such, in the frame of the discussion, all elements have to be considered to determine a decision. GM to 21.A.3B (d) (4) provides sufficient guidance on this subject. There is no need to include them (partially) in this CM. The numerical method proposed in the GM is a rational 'departure point' for a discussion that is far more complex and may still need to be tempered by non-numerical considerations.
13	*Airbus Helicopters*	3.3	12	*"Rotorcraft are operated more often than large aeroplanes above congested areas and their type of operations requires the*	Remove the sentence *"Rotorcraft are operated more often than large aeroplanes above congested areas and their type*	Requested	Not Accepted	The example provided by AH is not pertinent to address the risk of PDR. Approach and departing routes in proximity of congested area are designed to minimize the hazard to 3rd parties and properties on

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				assistance of people on the ground. In this context," The aim of this sentence is not understood and seems not necessary for the Agency to develop its position in the certification memorandum which is anyway well justified. In addition, it seems to finger point helicopter operations as representing a higher danger for people on ground than large aeroplanes operations. And if it is somehow the aim of the sentence, it seems to AH to be more a judgment than a demonstrated fact. Indeed if a rotorcraft pilot will operate a more important part of its mission than a large aeroplane pilot above congested areas, from the perspective of someone on ground living in some part of congested area (the ones that are routes for airports but which are covering a lot of km²) are much more often over flown by large aeroplanes than rotorcrafts (since the flight hours accumulated yearly by large aeroplanes are much more higher than the ones accumulated by helicopters).	*of operations requires the assistance of people on the ground. In this context,"* which is not necessary for the Agency to develop its position and could be a bit controversial.			ground. For the inhabited portion of the overflown area a higher risk is noted. Aeroplane operations are scheduled, and the fly-over time of an individual a/c is relatively small. On the contrary rotorcraft may perform multiple drills on the same area and there are practically no restrictions for the area to be over-flown. An example is the traffic over NYC. The part of the sentence dealing with the assistance of people on the ground is linked to NHEC loading/unloading phase and does not need further explanation. The intent is not to identify rotorcraft as more dangerous but simply to identify the higher operational capability and explaining the need to develop the proposed methodology and scope.
14	*Airbus Helicopters*	3.3.3.1	14	*"If a non-compliance to the certification basis is the origin of the PDR, the probability of PDR event should be set to 1."* Same comment than previous comments see page 10	Replace: *"If a non-compliance to the certification basis is the origin of the PDR, the probability of PDR event should be set to 1."* by: *"If a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1."*	Requested	Partially Accepted	EASA shares the interpretation given by AH, however the concept of a "non-compliance to the certification basis can explain solely a PDR event" may be misleading. The text retained for the final version of the CM is: *"If a non-compliance to the certification basis can be a direct cause for a PDR event, the probability of PDR event should be set to 1."*

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15	*Airbus Helicopters*	3.3.4	15	*"However, when the PDR event is caused by a design deficiency, the occurrence level should be set to 1 […]"* Same comment than previous comments see page 10	Replace: *"However, when the PDR event is caused by a design deficiency, the occurrence level should be set to 1 […]"* by: *"However, if a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1 […]"*	Requested	Partially Accepted	EASA shares the interpretation given by AH, however the concept of a non-compliance to the certification basis can explain solely a PDR event" may be misleading. The text retained for the final version of the CM is: *"However, if a non-compliance to the certification basis can be a direct cause for a PDR event, the probability of PDR event should be set to 1."*
16	*Airbus Helicopters*	3.4	16	*"For the lower system, it is usually not possible to estimate a failure rate because a quantitative safety assessment is not available. A conservative value should then be used:* *P (lower system failure) ≥ 10-3 per FH8* *In this case, the P (lower system failure) prevails, bringing the P (loss of NHEC) to the same order of magnitude."* Question: is the Agency considering rulemaking to address the PDR event related to the lower system?	Question only	Not requested	Noted	For the time being no RMT is considered on lower systems. Under the current regulatory framework, the Competent Authority for Air Operations is requested to determine the conditions for obtaining an operational approval.
17	*Airbus Helicopters*	Annex 1	19-20	4 times *"EASA's involvement is necessary in all cases."* The certification memorandum provides the adequate guidance to identify the PDR event to be classified as unsafe or potentially unsafe. In that respect, it is not understood why EASA involvement would be necessary for PDR event classified according to the proposed methodology as not unsafe.	Replace the sentence *"EASA's involvement is necessary in all cases."* By *"EASA's involvement is necessary for unsafe or potentially unsafe condition"*	Requested	Accepted	
18	*Airbus Helicopters*	Annex 1	19	*"If there is a non-compliance with the certification basis of structure and*	Replace:	Requested	Partially Accepted	EASA shares the interpretation given by AH, however the concept of a non-compliance to the certification basis can explain solely a PDR event" may be misleading.

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				mechanical parts the probability is set to 1" Same comment than previous comments see page 10	*"If there is a non-compliance with the certification basis of structure and mechanical parts the probability is set to 1"* by: *"If a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1."*			The text retained for the final version of the CM is: *"If a non-compliance to the certification basis can be a direct cause for a PDR event, the probability of PDR event should be set to 1."*
19	*Airbus Helicopters*	Annex 1	20	2 times *"If there is a non-compliance with the CS for structure and mechanical parts the probability is set to 1"* Same comment than previous comments see page 10	Replace: *"If there is a non-compliance with the CS for structure and mechanical parts the probability is set to 1"* by: *"If a non-compliance to the certification basis can explain solely a PDR event, the probability of PDR event should be set to 1."*	Requested	Partially Accepted	EASA shares the interpretation given by AH, however the concept of a non-compliance to the certification basis can explain solely a PDR event" may be misleading. The text retained for the final version of the CM is: *"If a non-compliance to the certification basis can be a direct cause for a PDR event, the probability of PDR event should be set to 1."*

ANNEX 1

HIC is a recognized aviation sandard for seat certification. Ref AC 21-22, AC 25.562

The HIC limit of 1000 is applicable to solid head impact of an occupant with any aircraft interior feature. It comes from the assessment of a potential skull fracture from localized impacts against a hard surface. HIC tests are conducted with an ATD (typically Hybrid II or III). The HIC value depends on the selection of impact duration (this limit is most useful with pulse interval not greater than 0.05 s) and the time history of the recorded head dummy acceleration during such interval. The test method aims at obtaining a given impulse shape. In this context a HIC value of 1000 is associated with a certain probability of life-threatening (head) injury.

The type of impact and the methodology used for HIC calculation and limit values do not fit the possible human harm scenarios due to a falling object.

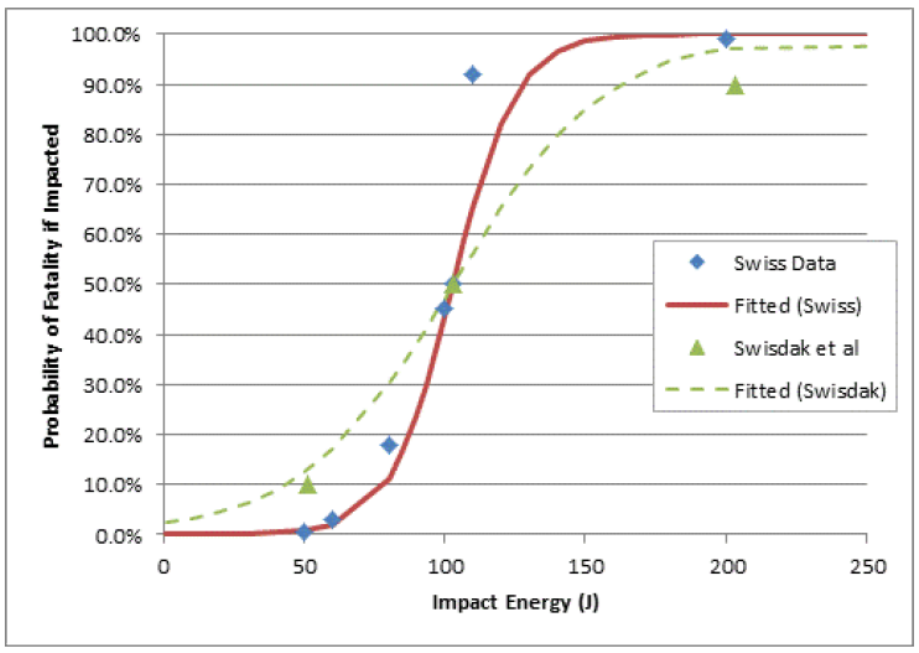
There is no consolidated aviation guidance/std on how to address this specific risk on third parties although initiatives are monitored in the field of Unmanned Aircraft Systems Rulemaking (i.e., ASSURE UAS task force, Task A14: UAS Ground Collision Severity Evaluation 2017-2019). A not exhaustive list of injuries and fatalities that had occurred due to UAS malfunctions and operator errors suggests focussing on head injury and neck injury.

This CM aims at providing a usable guidance for classification. Therefore, the intent of the authors is to give a simple tool for the determination of risk level (ref. A. Shelley 7-4-2016, International journal of Aviation, Aeronautics, and Aerospace, “A Model of Human Harm from a Falling Unmanned Aircraft: Implications for UAS Regulation”).

By considering a statistical approach to describe the probability of Fatality Given Impact the following distribution is assumed.

$$P(fatality \mid impact) = \frac{1}{1 + e^{-k(E_{imp} - E_0)}}$$

Different studies (Henderson, 2010- Swisdak et al., 2007) converge on the definition of Eo= 100 J and K=0.009. The fatality probability of 50% has been considered adequate to trigger the highest severity of a PDR outcome.



In the literature there are attempts to correlate kinetic energy at impact with HIC values and Abbreviated Injury Score (AIS) at least for skull fractures.

AIS is an ordinal severity scale:

AIS code	Injury Level	Fatality Range
0	No injury	0.0 %
1	Minor	0.0 - 0.1 %
2	Moderate	0.1 - 0.4 %
3	Serious	0.8 - 2.1 %
4	Severe	7.9 - 10.6 %
5	Critical	53.1 - 58.4 %
6	Maximum	Virtually unsurvivable

For Example, from a Payne and Patel (2001) study a proposed range for "Blunt Object Skull Fractures" is provided in terms of equivalent HIC and Equivalent AIS.

Force Required for Skull Fracture Caused by Blunt Object, Payne and Patel (2001).

Injury Level	Tolerance Level (kN)	Equivalent HIC	Equivalent AIS
0–1 No Skull Fracture	< 2.2	< 500	
2 Minor Depressed Skull Fracture	2.2–5.5	500–900	2
3 Major Depressed Skull Fracture	> 5.5	900–1800	3
4 Severe Life-Endangering Fracture	> 5.5	> 1800	4/5*

Source: http://www.eurailsafe.net/subsites/operas/HTML/Section3/Section3.3frm.htm. A severe life-endangering fracture is assessed by the authors of the OPERAS study as "potentially non-survivable with over 50% probability of an AIS 4 head injury".

It is noted that the effect of an object dropping on to the top or back of the skull may differ from the effect of a frontal impact, so the use of the scale shown in the Table above for potential skull fractures caused by blunt objects falling from the sky may not be exhaustive.

The threshold between AIS 3 and AIS 4/5 can be assumed to occur at 11kN based on empirical evidence collected in the referenced studies.

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With a simplified approach the kinetic energy is assumed to be dissipated as the object comes to rest, so the average impact force *F* is:

$$F = E_{imp} / d$$

By taking an average value for *d*=0.009m (i.e., 9mm) the kinetic energy at the impact is derived.

Assumed Relationship between Impact Energy and Skull Fracture Severity.

Outcome	Impact Force (kJ)	Impact Energy Threshold (J)	AIS Injury Severity
No Skull Fracture			0
Minor Depressed Skull Fracture	2.2	19.8	2
Major Depressed Skull Fracture	5.5	49.5	3
Severe Life-Endangering Fracture	11	99	4

It is noted that Skull Fracture is however only one of the possible injuries associated to falling objects.

In conclusion:

- The use of HIC limits as viable predictor for injury in impact from falling objects is still under debate (ref ASSURE research), so until there is a clear consensus EASA has decided to use the kinetic energy criteria to define the potential severity, towards a simple conservative approach.
- Correlation between the injury levels at the basis of AIS and kinetic energy at impact have been considered and adapted to define proportionality in the expected severity (qualitative scale).

Based on the above considerations and in order to avoid confusion among applicants HIC values and AIS ordinals were not quoted in the CM.