

Date: 30 November 2023

Re: Follow-up on recommendations *Fly-away after compass malfunction*

Compliance with recommendations: Fly-away after compass malfunction

Publication date: 8 February 2023

1. About this report

On 11 April 2020, a team of four from the National Police intended to conduct a surveillance flight with an Unmanned Aircraft System (UAS) in The Hague's Zuiderpark (the Netherlands). The team, i.e. the crew, of this drone consisted of a licensed pilot, the payload operator, and two observers. The flight was conducted using a DJI Inspire 2 UAS with a camera as payload. Shortly after the pilot had allowed the unmanned aircraft (UA) to take off to check its controllability (post take-off check), the pilot lost control of the UA and the UA began to fly independently. This is called a fly-away. As the pilot tried to regain control, the UA flew over a line of trees, thereby blocking the line of sight between the Remote Controller (RC) and the UA, after which the connection between the UA and the RC was lost. The UA then flew uncontrolled over the city of The Hague. The UA initiated the automatic landing procedure after about 18 minutes due to a low battery level, but it was unable to complete the procedure. The aircraft hovered until insufficient battery power remained and subsequently crashed on a pavement in an urban area.

Shortly after take-off, the unmanned aircraft (UA) consistently did not respond to the pilot's input and eventually became uncontrollable due to an incorrectly calibrated compass. A loudspeaker had been used as payload on the previous flight. This payload had a different effect on the compass than the camera payload that was used during the incident flight. During flight preparations on the incident flight, the UAS software did not show a compass calibration warning, which is why the crew did not recalibrate the compass.

The procedures did not specify compass calibration after payload changes; the user relied on software instructions and in doing so complied with the UAS manufacturer's guidelines. This investigation showed that the software cannot in all cases detect an incorrectly calibrated compass. It is therefore advisable to manually start a compass calibration after a payload change to prevent unwanted non-conformities of the compass that could result in loss of control.

After the loss of control, the pilot activated the Return-To-Home (RTH) flight mode, which also depends on the compass. This was also in line with the procedures and guidelines of the UAS manufacturer. In some cases, it is better to switch to the A(ttitude) mode of this UAS as this mode does not depend on the compass. Switching to A mode is also advisable if the crew is unsure whether there is a compass malfunction because flying in A mode does not prevent automatic activation of the RTH mode.

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This investigation showed that there are clearly risks associated with using different payloads, which is why it is important that users are aware of these risks and take extra care when using different types of payloads.

Following the investigation, the Dutch Safety Board made two recommendations to Da-Jiang Innovations Science and Technology (DJI), the manufacturer of the UAS. DJI responded on 19 May 2023. The full response is available on the Safety Board's website.

2. General conclusion on compliance with the recommendations

DJI did not adequately comply with the recommendations or only did so partially. The purpose of the first recommendation was to improve the safety of the UAS by providing clarity to the users by way of reviewing the user manual. DJI's response does not indicate that this has been adequately done. As a result, the safety risks outlined in the report remain.

The second recommendation relates to DJI's cooperation in safety investigations and the information requested by operators. DJI stated its intention to improve this process internally, but the Dutch Safety Board has no indications that DJI's approach in this regard has changed or improved.

In evaluating the extent to which recommendations from aviation reports have been complied with, the Dutch Safety Board is bound by the assessment criteria of the European classification system, in line with EU Regulation No. 996/2010. These assessment criteria are quite strict and less intricate than the Board's own criteria for recommendations to sectors other than aviation. The European classifications with the corresponding assessment criteria are included at the bottom of this memorandum.

Recommendations to	(Core of) Recommendation	Compliance
DJI	1. Review the UAS user manual and safety guidelines based on the lessons learned from this occurrence	Inadequate
DJI	2. Ensure that safety investigation authorities and operators are provided with technical support and relevant information in a timely manner for the purpose of safety investigations related to UAS manufactured by DJI.	Partially adequate

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3. Compliance by recommendation

Recommendation 1

To Da-Jiang Innovations Science and Technology Co., Ltd. (DJI):

Review the UAS user manual and safety guidelines using the safety lessons learned from this incident, and clarify the following aspects:

- a. Actions in the case of controllability issues and when to use the RTH and A(ttitude) modes;
- b. in which cases the compass must be calibrated;
- c. the risks associated with flying with (different) payload types.

Response from DJI

Recommendation 1a:

In response to recommendation 1a, DJI indicated that the Inspire 2 user manual already provides detailed and clear information on using the Return-to-Home (RTH) and Attitude modes. The user manual explains three types of RTH: Smart RTH, Low Battery RTH and Failsafe RTH. However, only for Failsafe RTH is the user informed that RTH depends on the compass. DJI expanded the information on the Attitude mode in the June 2022 edition of the user manual: 'Active: Users toggle the flight mode switch to A mode. When an emergency situation occurs during flight, such as when the compass becomes unaligned or when the aircraft attitude is abnormal. If familiar with attitude mode, switch the flight mode to A mode, and control the aircraft to land in a safe place as soon as possible.'

Moreover, DJI points to the Disclaimer and Safety Guidelines of the Inspire 2: 'To avoid possible serious injury and property damage, observe the following rule: Land immediately when severe drifting occurs in flight, i.e., the aircraft does NOT fly in straight lines.'

Recommendation 1b:

DJI indicated that the Inspire 2 user manual already has a detailed description of calibration procedures (pages 62 and 63 of the manual). It also states that calibration is required when the status indicator of the UAS flashes red/orange (page 72).

Recommendation 1c:

DJI stated that according to safety guidelines, only payloads of its own brand should be used. The payloads of other manufacturers may cause malfunctions and compromise safety. The payload used in the fly-away case was not manufactured or certified by DJI. In its response, DJI points out that the Board states in its report that according to DJI's website the payload used is not suitable for the Inspire 2.

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Assessment of compliance

In accordance with the European classification, the follow-up to recommendation 1 as a whole and to the various parts of the recommendation are classified as inadequate. The recommendation has not been followed up on.

Explanation of the assessment

The core of recommendation 1 calls for a review of the UAS user manual and safety guidelines based on the lessons learned from this occurrence. DJI responded to the sub-recommendations, but disregarded the main recommendation that refers to the occurrence and thus the information in the report. This means that the main role of the user manual for users has not been adequately addressed and dealt with.

Recommendation 1a:

With regard to recommendation 1a, the user manual provides a description of how the different RTH modes work and under what circumstances the user is advised to switch to Attitude mode. The latter can be seen as an explanation to the user about cases where the controllability of the UAS is under threat. This should be stated more explicitly and merits a more prominent place in the manual.

The Dutch Safety Board feels that a clear reference point for action for the crew is lacking. The current manual assumes a reactive approach, but the option for proactive action is not really provided. Examples of choices for different modes in changing circumstances would be very helpful.

According to the user manual and safety guidelines, the P mode is the preferred flight mode. In some cases, particularly in the case of potential environmental disturbance factors, such as high-rise buildings, high voltage power lines or metal structures, it may be necessary to switch to A mode before the start of the flight. This eliminates dependence on the compass and GPS. Before starting the flight, it is therefore important to consider whether the P mode should be the preferred mode.

The current version of the user manual is also not sufficiently clear about how the A mode and RTH are related and which of the modes is preferred in which cases. The user manual now advises switching to A mode in the event of an odd UA route, while the safety guidebook advises landing.

DJI provides descriptions and warnings in a fragmented way. The information provided is divided between the user manual, the safety guidelines and DJI's website. A clearer and more complete description with reference points for action for the crew in the event of an emergency would improve safety.

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Recommendation 1b:

The calibration instructions in the user manual specify that “the compass only needs to be calibrated if the DJI GO 4 App or the status indicator signify that this is necessary”. This occurrence has shown that in some cases the GO 4 App does not send out a warning to calibrate, even though calibration is necessary. DJI also indicated in their own analysis (see report) that the occurrence could have been avoided by calibrating the compass after changing the payload, despite the lack of warnings. In general, it is conducive to the controllability of the UAS, and thus the safety of the flight, to calibrate the compass after a payload change. This therefore also applies if there are no warnings in the DJI GO 4 App. This notion has not been included in the user manual and safety guidelines.

Recommendation 1c:

The Dutch Safety Board maintains the underlying principle that new payloads must be developed together with the aircraft manufacturer so as to share information on the system operations and limitations and for equipment testing, for instance. It should not matter which party develops the payload. The risk of flying with different payload types is independent of whether the payload has been certified by DJI or not.

Aircraft control problems can also occur after a payload change where the payload installed was developed or certified by DJI. That was the case in this occurrence and it was the compass that was found to be incorrectly calibrated. The user manual and the safety guidelines do not make it sufficiently clear to the user that these risks are feasible and that they can occur both before and during flight operations.

Recommendation 2

To Da-Jiang Innovations Science and Technology Co., Ltd. (DJI):

Ensure that safety investigation authorities and operators are provided with technical support and relevant information in a timely manner for the purpose of safety investigations related to UAS manufactured by DJI.

Response from DJI

In its response to the second recommendation, DJI indicates that they have revised their internal procedures and have established a working group to provide the necessary support for investigations. They have committed themselves to providing information in a timely manner when requested to do so.

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Assessment of compliance

In accordance with the European classification, the follow-up to the recommendation is classified as partially adequate. They have expressed the intention to follow up on the recommendation, but the Board does not think it is very likely that they will do this.

Explanation of the assessment

The Dutch Safety Board has been unable to determine whether the new internal procedures and the working group that DJI agreed to put in place will provide sufficient and timely technical support and information to safety investigations.

It is good that the manufacturer is taking initiatives to improve participation in the investigation process, but it is important that participation in an investigation goes beyond responding to requests from state safety investigation authorities. The system in Appendix 13 of the International Civil Aviation Organization assumes an active role for the manufacturer as advisor to the accredited representative of the state of manufacture/state of design. In doing so, the manufacturer makes proposals or provides advice regarding the investigation and responds to questions and requests from the state safety investigation authority conducting the investigation. Moreover, many safety investigations will be carried out by the operators themselves, without involvement from a state safety investigation authority. Operators also require access to information and support to learn from occurrences.

The Dutch Safety Board also emphasizes the importance of being able to access validated event data to analyse the course of events leading to an incident with a UAS. DJI software used to analyse event data shows a limited number of parameters. In this investigation, the Dutch Safety Board was able to convert raw data into a readable format using third party software. This is no longer possible for newer DJI UAS models due to encryption. The Dutch Safety Board maintains the underlying principle that the UAS manufacturer provides the state safety investigation authority with information to decrypt raw data and convert it to a readable format. If this is not possible, then the UAS manufacturer should at least provide readable data or validate already converted flight data.

In 2020, the UK's Air Accidents Investigation Branch (AAIB) made a similar recommendation to DJI.¹ Although the AAIB indicated in its follow-up in 2021 that the recommendation had been adequately met by DJI, the Dutch Safety Board still ran into these problems in this investigation. This also applies to two other Dutch Safety Board investigations in which DJI's UAS played a role.²

Since the publication of the Dutch Safety Board's report, the Norwegian Safety Investigation Authority (NSIA) has also attempted to obtain data and support from DJI for a safety investigation. The Norwegian investigators had problems getting in touch with DJI. Based on this information and pending publication of NSIA's report, the Board tentatively concludes that this recommendation has been partially complied with. Experience will show to what extent DJI's commitments lead to the desired improvements.

¹ Dutch Safety Board, *Fly-away after compass malfunction*, 8 February 2023, p. 44

² Dutch Safety Board, *Quarterly Aviation Report Q3 2022*, and *Quarterly Aviation Report Q1 2021*

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Appendix 1: Aviation assessment criteria

For the assessment of the responses to the recommendations for the aviation sector, the Dutch Safety Board must use the guideline issued by ENCASIA concerning the EU regulation on investigation and prevention of accidents and incidents in civil aviation (Regulation (EU) no. 996/2010). ENCASIA is the European Network of Civil Aviation Safety Investigation Authorities. The classifications and associated assessment criteria are as follows:

Category	Guidance
Adequate	<p>The response clearly shows that the safety issue identified by the recommendation has been addressed.</p> <p>The response shows that there is a high probability the action will be taken in the future to address the safety issue or intent.</p> <p>The response may not meet the intent of the recommendation as written but does address the underlying safety issue or has been superseded by other evidence/action.</p>
Partially adequate	<p>The response goes some way to addressing the intent of the recommendation or safety issue in that some action is taking place, but there is:</p> <ul style="list-style-type: none"> • a likelihood the action may not take place, or • little or no likelihood of any further action by the addressee. •
Not adequate	<p>The recommendation response did not address the intent or safety issue, or the recommendation was rejected by the addressee and is not likely to be acted upon by them.</p>
Awaiting response	<p>Awaiting the first response from the addressee.</p>
Superseded	<p>The safety recommendation has been superseded.</p>

The recommendations, accompanying reactions and classifications are recorded in the European SRIS database (Safety Recommendations Information System), publicly available via <https://sris.jrc.ec.europa.eu/sris/public/>.