U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

August 18, 2015

Exemption No. 11373A
Regulatory Docket No. FAA−2015−0060

Mr. Richard Bowden Dobbins
The Dobbins Company
3827 Cliff Crest Drive
Smyrna, GA 30080

Dear Mr. Dobbins:

This letter is to inform you that we have granted your petition for an amendment. It explains the basis for our decision, describes its effect, and lists any changes to the original conditions and limitations.

By letter dated May 27, 2015, you petitioned the Federal Aviation Administration (FAA) for an amendment to your current exemption. That exemption from §§ 61.23(a) and (c), 61.101(e)(4) and (5), 61.113(a), 61.315(a), 91.7(a), 91.119(c), 91.121, 91.151(a)(1), 91.405(a), 91.407(a)(1), 91.409(a)(1) and (2), and 91.417(a) and (b) of Title 14, Code of Federal Regulations (14 CFR) allows the petitioner to operate a UAS to perform aerial data collection. You requested an amendment to add the SenseFly eXom.

In your petition, you indicate that there has been no change in the conditions and reasons relative to public interest and safety that were the basis for granting the original exemption.

The FAA has determined that good cause exists for not publishing a summary of the petition in the Federal Register because the requested amendment to the exemption would not set a precedent, and any delay in acting on this petition would be detrimental to the petitioner. The unmanned aircraft authorized in the original grant are comparable in type, size, weight, speed and operating capabilities to those in this petition.

Airworthiness Certification

In accordance with the statutory criteria provided in Section 333 of Public Law 112−95 in reference to 49 U.S.C. § 44704, and in consideration of the size, weight, speed, and limited operating area associated with the aircraft and its operation, the Secretary of Transportation has determined that this aircraft meets the conditions of Section 333. Therefore, the FAA finds that relief from 14 CFR part 21, C*ertification procedures for products and parts,*

Subpart H—Airworthiness Certificates, and any associated noise certification and testing requirements of part 36, is not necessary.

Our Decision

The FAA has determined that the justification for the issuance of Exemption No. 11373 remains valid and is in the public interest. Therefore, under the authority contained in 49 U.S.C. 106(f), 40113, and 44701, delegated to me by the Administrator, the operator is granted an amendment to add new aircraft to its UAS operations.

The operator shall add this amendment to its original exemption.

Conditions and Limitations

All conditions and limitations within Grant of Exemption No. 11373 remain in effect except as follows. Condition No. 1 has been updated to reflect the additional aircraft.

Failure to comply with any of the conditions and limitations of this grant of exemption will be grounds for the immediate suspension or rescission of this exemption.

1. Operations authorized by this grant of exemption are limited to the DJI Phantom 2, DJI Phantom 2 Vision, and SenseFly eXom when weighing less than 55 pounds including payload. Proposed operations of any other aircraft will require a new petition or a petition to amend this exemption.

This exemption terminates on April 30, 2017, unless sooner superseded or rescinded.

Sincerely,

/s/
John S. Duncan
Director, Flight Standards Service

May 27, 2015

United States Department of Transportation
Federal Aviation Administration
800 Independence Ave, SW
Washington, DC 20591

RE: Petition for Amendment of existing Section 333 Exemption for use of additional aircraft.

To whom it may concern:

Good day. My firm has recently been granted a Section 333 exemption and issued a COA for using UAS for the collection of aerial data. Per this letter of request, I seek an amendment to our existing 333 to allow the use of an additional aircraft that is of the same type, size and aerodynamic characteristics of the aircraft our existing 333 was granted for. The following will be included in this request: Name & information of Petitioner; Executive Summary; Reasons for the Requested Amendment; Public Good; Description of UAV to be Deployed; Description of Intended Commercial Operations and Operating Parameters. Also attached is a copy of the existing 333 & COA and Extended User's Manual for the subject UAS.

PERSONAL INFORMATION

Name	Richard Bowden Dobbins (**hereafter referred to as "Petitioner"**)
Company	The Dobbins Company
Address	3827 Cliff Crest Dr.
	Smyrna, Georgia 30080
	404-451-1595
	rick@dobbinscompany.com

Current 333 Information

Section 333 Exemption No. 11373
Regulatory Docket No. FAA-2015-0060

EXECUTIVE SUMMARY

On April 17, 2015, the FAA granted The Dobbins Company a Section 333 rule exemption and a Small UAS Operations 200 feet and below for Commercial Purposes COA for the purposes of aerial data collection. A copy of the 333 and COA are made part of this request for review of the details of issuance. This COA allows the use of a DJI Phantom 2 UAS. The petitioner seeks an amendment to the existing 333 to allow, in addition to the Phantom 2, the use of a SenseFly eXom quadcopter. The eXom is similar in many regards to the Phantom 2 in size, weight and

aerodynamics. However, the eXom is designed mainly for the purpose of aerial mapping and infrastructure inspections such as bridges, cell phone towers, industrial complexes, etc. As explained in detail below, the eXom is far more technologically advanced than the Phantom 2 as it has many built in sensors to facilitate its tasks. It is also a much more expensive platform. Current cost of the eXom is around $45,000 as compared to the $1500 for the Phantom 2. The intended uses of the eXom will not require flight above 200 feet and all requirements of the existing COA will be complied with. The eXom is unique in today's UAS marketplace as it is the only available UAS built specifically for low altitude infrastructure inspection and mapping. Granting this amendment will allow this new technology to be used in many industries and provide significant safety improvements and cost savings to these businesses. The public good will is well served by allowing this amendment to be issued.

REASON OF REQUESTED AMENDMENT

The eXom is manufactured by SenseFly. SenseFly is a subsidiary of Parrot Company. Founded in 1994, Parrot creates, develops and markets, in addition to UAS, advanced consumer technology products for Smartphones and tablets. Parrot also offers the most extensive range of hands-free communication systems on the market for cars. Its globally recognized expertise in the fields of mobile connectivity and multimedia around Smartphones has positioned Parrot as a key player of in-car infotainment.

SenseFly develops and produces aerial imaging drones for professional applications. These safe, ultra-light and easy to use UAS are highly automated data collection tools and employed by customers around the world in fields such as surveying, agriculture, GIS, industrial inspection, mining and humanitarian aid. SenseFly was founded in 2009 by a team of robotics researchers and quickly became the industry leader in mapping drones. Today they continue to lead the way in developing situationally aware systems that help professionals make better decisions. SenseFly is a world leader in manufacturing drones for industrial applications. All of their products utilize state of the art technology and have exceptional safety records.

SenseFly's newest UAS, the eXom, is a quadcopter made specifically for industrial infrastructure inspections and aerial mapping of small (<100 acres) tracts of land for agriculture, mining, construction, etc. The eXom is built with many sensors that allow it to get close to structures and maintain a safe distance in order to properly collect both optical and thermal imaging. The eXom can even bump up against structures without causing damage to the aircraft or the structure.

The Dobbins Company intends to use this UAS for low altitude infrastructure inspections and mapping. All operations will be conducted under 200 feet in altitude and will always remain under VLOS control.

PUBLIC GOOD

The new technology offered by the eXom will allow up close inspection of bridges, towers and other hard to reach industrial facilities by the remote use of a UAS. Not only will this result in significant cost savings for business, but it is much safer to inspect these types of structures remotely by UAV. An example are cell phone towers. The eXom, with its wide array of sensors can easily inspect and produce 3D maps of a tower for civil engineers to review on the ground. The current method of inspecting a cell tower entails having technicians climb the tower to

inspect components. Many climbing deaths occur each year. The eXom can eliminate the need to climb towers on a regular basis and significantly cut down the injury rate of inspecting these structures. Bridge inspections are another public good. There are over 600,000 bridges in America today and they need inspecting on a regular basis. However, this is currently difficult and requires many man-hours to conduct. The eXom can inspect a bridge with its optical and thermal cameras in a small fraction of the time it currently takes to perform these tasks. Railroads, DOTs and other government agencies are seen as prime candidates for using our UAS bridge inspection services. Granting this amendment to the Petitioner would allow him to provide this service. Further, the small UAS being utilized in this application will pose no threat to the public given its small size and lack of combustible fuel when compared to larger manned aircraft. The operation of this UAS will minimize ecological damage and promote economic growth by providing information to businesses & individuals in the metro Atlanta, north Georgia and beyond.

DESCRIPTION OF UAV TO BE DEPLOYED UNDER REQUESTED AMENDMENT

The eXom is a quadcopter similar in size and weight to the currently approved Phantom 2. The following are its specifications:

AIRFRAME

Weight	3.7lbs
Dimensions	31.5"x22.1"x6.8"
Max Airspeed	27MPH
Max Climb	23 Ft/Sec
Max Wind Component	22 MPH
Operating temperature	-10 to 40C
Nominal Endurance Time	Approx. 22 min.
Material	Carbon Structure & composite parts
Battery	3-cell 8500mAh LiPo
Propulsion	4 Electric Brushless Motors

SENSORS

Main Camera-Stills	38MP
Main Camera-Video	HD (1280x720 Px)
Thermal Camera	80x60 Px
NavCam Video	640x480Px
Ultrasonic Sensors (x6) range	20 Ft

COMMUNICATIONS

Ground Modem	
Range	1.2 miles
Frequency	2.4 GHz & 5 GHz ISM bands
Streams	MiMo 2x2 with spatial Diversity
Transmission Mode	OFDM or DSSS
Radiated Power	Up to 630 mW
Antennas	Dual Omnidirectional

Security	WPA Encryption
Remote Control	
Frequency	2.4 GHz
Range	0.5 miles

SOFTWARE

The eXom comes with two software packages – eMotion X and Postflight Terra 3D. The eMotion is the software that controls the UAS where the Postflight is for rendering images on the ground. eMotion X gives operators interactivity with the eXom and provides telemetry. eMotion also allows operators the ability to have enhanced manual control or strict manual control. There are many safety features with eMotion such as system monitors, malfunction alerts and safety alerts. eMotion allows for the construction of a geofence where the UAS will return to Home if it crosses the fence parameters. And along with its GPS capabilities, the eXom has the capability of Return to Home or Land Immediately in case of emergency or catastrophic failure.

PREFLIGHT

The petitioner will always follow procedures outlined in the UAS operator's manual as to proper preflight inspection of all hardware, software, environment and any other factors needed to ensure a safe flight. As well as comply with the existing COA.

DESCRIPTION OF INTENDED COMMERCIAL OPERATIONS WITH ADDITIONAL UAS

Petitioner intends to solicit work for aerial infrastructure inspections from tower operators, railroads, DOTs, construction contractors, mining operators, etc. This work will always be conducted with the permission of the property owner or their respective agent. Flight operations will be restricted to flights directly over the property that has granted permission. Given the type of work being targeted here, the Petitioner does not foresee any instance where the UAS would be flown over any crowds or assemblages of people in an open-air environment. If in fact there is any job that does entail flights over crowds, petitioner will elect not to make said flight. Safety will always be the primary concern regarding any flight at any time.

UAS OPERATING PARAMETERS

The UAS being deployed in this amendment requests can fly at a speed of approximately 25 knots. However, given the intended use describe here, this speed will never be necessary. Much slower speeds are preferred to collect the imaging material needed.

Although the UAS being deployed has an approximate control link distance of 1.5 miles, this is much more than VLOS will allow. Petitioner agrees never to fly UAS outside of VLOS.

Petitioner will only fly UAS during the day in VMC conditions. Given the petitioner agrees to never fly higher than 200 feet AGL, distance from clouds should not be a factor if flown in VMC conditions.

Petitioner agrees to use a Visual Observer (VO) during all operations. The VO will be used to help assure VLOS at all times.

The UAS will not operate within 5 nautical miles of an airport reference point as denoted on a current FAA published aeronautical chart without permission from the airport manager.

The UAS being deployed with this amendment request has the capability of using GPS signals to return to its initial point of take off if connection with the radio control link is lost.

The petitioner agrees to yield right of way to all manned aviation activities at all times.

CLOSING

The Petitioner believes that amendment to our existing 333 exemption is warranted given Petitioner's background as a Private Pilot, the nature of the type of UAS flights that will be undertaken, the size & weight of the UAS being deployed, the safety precautions to the general public and the NAS the Petitioner intends to adhere to, the positive environmental impact the flight operations would have compared to manned fuel consuming missions and the economic benefit the Petitioner's business would have in this new area of aviation.

Thank you for your review of this matter. Please feel free to contact me at any time with any questions regarding this matter.

Respectfully submitted,

Richard Bowden Dobbins

US Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

April 17, 2015

Exemption No. 11373
Regulatory Docket No. FAA–2015–0060

Mr. Richard Bowden Dobbins
The Dobbins Company
3827 Cliff Crest Drive
Smyrna, GA 30080

Dear Mr. Dobbins:

This letter is to inform you that we have granted your request for exemption. It transmits our decision, explains its basis, and gives you the conditions and limitations of the exemption, including the date it ends.

The Basis for Our Decision

By letter dated January 12, 2015, you petitioned the Federal Aviation Administration (FAA) on behalf of The Dobbins Company (hereinafter petitioner or operator) for an exemption. The exemption would allow the petitioner to operate an unmanned aircraft system (UAS) to conduct real estate inspections.

See Appendix A for the petition submitted to the FAA describing the proposed operations and the regulations that the petitioner seeks an exemption.

The FAA has determined that good cause exists for not publishing a summary of the petition in the Federal Register because the requested exemption would not set a precedent, and any delay in acting on this petition would be detrimental to the petitioner.

Airworthiness Certification

The UAS proposed by the petitioner are the DJI Phantom 2 and DJI Phantom 2 Vision.

In accordance with the statutory criteria provided in Section 333 of Public Law 112–95 in reference to 49 U.S.C. § 44704, and in consideration of the size, weight, speed, and limited operating area associated with the aircraft and its operation, the Secretary of Transportation has determined that this aircraft meets the conditions of Section 333. Therefore, the FAA finds that the relief from 14 CFR part 21, *Certification procedures for products and parts, Subpart H—Airworthiness Certificates*, and any associated noise certification and testing requirements of part 36, is not necessary.

The Basis for Our Decision

You have requested to use a UAS for aerial data collection. The FAA has issued grants of exemption in circumstances similar in all material respects to those presented in your petition. In Grants of Exemption Nos. 11062 to Astraeus Aerial (*see* Docket No. FAA–2014–0352), 11109 to Clayco, Inc. (*see* Docket No. FAA–2014–0507), 11112 to VDOS Global, LLC (*see* Docket No. FAA–2014–0382), and 11213 to Aeryon Labs, Inc. (*see* Docket No. FAA–2014–0642), the FAA found that the enhanced safety achieved using an unmanned aircraft (UA) with the specifications described by the petitioner and carrying no passengers or crew, rather than a manned aircraft of significantly greater proportions, carrying crew in addition to flammable fuel, gives the FAA good cause to find that the UAS operation enabled by this exemption is in the public interest.

Having reviewed your reasons for requesting an exemption, I find that—

- They are similar in all material respects to relief previously requested in Grant of Exemption Nos. 11062, 11109, 11112, and 11213;
- The reasons stated by the FAA for granting Exemption Nos. 11062, 11109, 11112, and 11213 also apply to the situation you present; and
- A grant of exemption is in the public interest.

Our Decision

In consideration of the foregoing, I find that a grant of exemption is in the public interest. Therefore, pursuant to the authority contained in 49 U.S.C. 106(f), 40113, and 44701, delegated to me by the Administrator, The Dobbins Company is granted an exemption from 14 CFR §§ 61.23(a) and (c), 61.101(e)(4) and (5), 61.113(a), 61.315(a), 91.7(a), 91.119(c), 91.121, 91.151(a)(1), 91.405(a), 91.407(a)(1), 91.409(a)(1) and (2), and 91.417(a) and (b), to the extent necessary to allow the petitioner to operate a UAS to perform aerial data collection. This exemption is subject to the conditions and limitations listed below.

Conditions and Limitations

In this grant of exemption, The Dobbins Company is hereafter referred to as the operator.

Failure to comply with any of the conditions and limitations of this grant of exemption will be grounds for the immediate suspension or rescission of this exemption.

1. Operations authorized by this grant of exemption are limited to the DJI Phantom 2 and DJI Phantom 2 Vision when weighing less than 55 pounds including payload. Proposed operations of any other aircraft will require a new petition or a petition to amend this exemption.

2. Operations for the purpose of closed-set motion picture and television filming are not permitted.

3. The UA may not be operated at a speed exceeding 87 knots (100 miles per hour). The exemption holder may use either groundspeed or calibrated airspeed to determine compliance with the 87 knot speed restriction. In no case will the UA be operated at airspeeds greater than the maximum UA operating airspeed recommended by the aircraft manufacturer.

4. The UA must be operated at an altitude of no more than 400 feet above ground level (AGL). Altitude must be reported in feet AGL.

5. The UA must be operated within visual line of sight (VLOS) of the PIC at all times. This requires the PIC to be able to use human vision unaided by any device other than corrective lenses, as specified on the PIC's FAA-issued airman medical certificate or U.S. driver's license.

6. All operations must utilize a visual observer (VO). The UA must be operated within the visual line of sight (VLOS) of the PIC and VO at all times. The VO may be used to satisfy the VLOS requirement as long as the PIC always maintains VLOS capability. The VO and PIC must be able to communicate verbally at all times; electronic messaging or texting is not permitted during flight operations. The PIC must be designated before the flight and cannot transfer his or her designation for the duration of the flight. The PIC must ensure that the VO can perform the duties required of the VO.

7. This exemption and all documents needed to operate the UAS and conduct its operations in accordance with the conditions and limitations stated in this grant of exemption, are hereinafter referred to as the operating documents. The operating documents must be accessible during UAS operations and made available to the Administrator upon request. If a discrepancy exists between the conditions and limitations in this exemption and the procedures outlined in the operating documents, the conditions and limitations herein take precedence and must be followed. Otherwise, the operator must follow the procedures as outlined in its operating documents. The operator may update or revise its operating documents. It is the operator's responsibility to track such revisions and present updated and revised

documents to the Administrator or any law enforcement official upon request. The operator must also present updated and revised documents if it petitions for extension or amendment to this grant of exemption. If the operator determines that any update or revision would affect the basis upon which the FAA granted this exemption, then the operator must petition for an amendment to its grant of exemption. The FAA's UAS Integration Office (AFS-80) may be contacted if questions arise regarding updates or revisions to the operating documents.

8. Any UAS that has undergone maintenance or alterations that affect the UAS operation or flight characteristics, e.g. replacement of a flight critical component, must undergo a functional test flight prior to conducting further operations under this exemption. Functional test flights may only be conducted by a PIC with a VO and must remain at least 500 feet from other people. The functional test flight must be conducted in such a manner so as to not pose an undue hazard to persons and property.

9. The operator is responsible for maintaining and inspecting the UAS to ensure that it is in a condition for safe operation.

10. Prior to each flight, the PIC must conduct a pre-flight inspection and determine the UAS is in a condition for safe flight. The pre-flight inspection must account for all potential discrepancies, e.g. inoperable components, items, or equipment. If the inspection reveals a condition that affects the safe operation of the UAS, the aircraft is prohibited from operating until the necessary maintenance has been performed and the UAS is found to be in a condition for safe flight.

11. The operator must follow the UAS manufacturer's maintenance, overhaul, replacement, inspection, and life limit requirements for the aircraft and aircraft components.

12. Each UAS operated under this exemption must comply with all manufacturer safety bulletins.

13. Under this grant of exemption, a PIC must hold either an airline transport, commercial, private, recreational, or sport pilot certificate. The PIC must also hold a current FAA airman medical certificate or a valid U.S. driver's license issued by a state, the District of Colombia, Puerto Rico, a territory, a possession, or the Federal government. The PIC must also meet the flight review requirements specified in 14 CFR § 61.56 in an aircraft in which the PIC is rated on his or her pilot certificate.

14. The operator may not permit any PIC to operate unless the PIC demonstrates the ability to safely operate the UAS in a manner consistent with how the UAS will be operated under this exemption, including evasive and emergency maneuvers and maintaining appropriate distances from persons, vessels, vehicles and structures. PIC qualification flight hours and currency must be logged in a manner consistent with

14 CFR § 61.51(b). Flights for the purposes of training the operator's PICs and VOs (training, proficiency, and experience-building) and determining the PIC's ability to safely operate the UAS in a manner consistent with how the UAS will be operated under this exemption are permitted under the terms of this exemption. However, training operations may only be conducted during dedicated training sessions. During training, proficiency, and experience-building flights, all persons not essential for flight operations are considered nonparticipants, and the PIC must operate the UA with appropriate distance from nonparticipants in accordance with 14 CFR § 91.119.

15. UAS operations may not be conducted during night, as defined in 14 CFR § 1.1. All operations must be conducted under visual meteorological conditions (VMC). Flights under special visual flight rules (SVFR) are not authorized.

16. The UA may not operate within 5 nautical miles of an airport reference point (ARP) as denoted in the current FAA Airport/Facility Directory (AFD) or for airports not denoted with an ARP, the center of the airport symbol as denoted on the current FAA-published aeronautical chart, unless a letter of agreement with that airport's management is obtained or otherwise permitted by a COA issued to the exemption holder. The letter of agreement with the airport management must be made available to the Administrator or any law enforcement official upon request.

17. The UA may not be operated less than 500 feet below or less than 2,000 feet horizontally from a cloud or when visibility is less than 3 statute miles from the PIC.

18. If the UAS loses communications or loses its GPS signal, the UA must return to a pre-determined location within the private or controlled-access property.

19. The PIC must abort the flight in the event of unpredicted obstacles or emergencies.

20. The PIC is prohibited from beginning a flight unless (considering wind and forecast weather conditions) there is enough available power for the UA to conduct the intended operation and to operate after that for at least five minutes or with the reserve power recommended by the manufacturer if greater.

21. Air Traffic Organization (ATO) Certificate of Waiver or Authorization (COA). All operations shall be conducted in accordance with an ATO-issued COA. The exemption holder may apply for a new or amended COA if it intends to conduct operations that cannot be conducted under the terms of the attached COA.

22. All aircraft operated in accordance with this exemption must be identified by serial number, registered in accordance with 14 CFR part 47, and have identification (N-Number) markings in accordance with 14 CFR part 45, Subpart C. Markings must be as large as practicable.

23. Documents used by the operator to ensure the safe operation and flight of the UAS and any documents required under 14 CFR §§ 91.9 and 91.203 must be available to the PIC at the Ground Control Station of the UAS any time the aircraft is operating. These documents must be made available to the Administrator or any law enforcement official upon request.

24. The UA must remain clear and give way to all manned aviation operations and activities at all times.

25. The UAS may not be operated by the PIC from any moving device or vehicle.

26. All Flight operations must be conducted at least 500 feet from all nonparticipating persons, vessels, vehicles, and structures unless:
    a. Barriers or structures are present that sufficiently protect nonparticipating persons from the UA and/or debris in the event of an accident. The operator must ensure that nonparticipating persons remain under such protection. If a situation arises where nonparticipating persons leave such protection and are within 500 feet of the UA, flight operations must cease immediately in a manner ensuring the safety of nonparticipating persons; and
    b. The owner/controller of any vessels, vehicles or structures has granted permission for operating closer to those objects and the PIC has made a safety assessment of the risk of operating closer to those objects and determined that it does not present an undue hazard.

    The PIC, VO, operator trainees or essential persons are not considered nonparticipating persons under this exemption.

27. All operations shall be conducted over private or controlled-access property with permission from the property owner/controller or authorized representative. Permission from property owner/controller or authorized representative will be obtained for each flight to be conducted.

28. Any incident, accident, or flight operation that transgresses the lateral or vertical boundaries of the operational area as defined by the applicable COA must be reported to the FAA's UAS Integration Office (AFS-80) within 24 hours. Accidents must be reported to the National Transportation Safety Board (NTSB) per instructions contained on the NTSB Web site: www.ntsb.gov.

If this exemption permits operations for the purpose of closed-set motion picture and television filming and production, the following additional conditions and limitations apply.

29. The operator must have a motion picture and television operations manual (MPTOM) as documented in this grant of exemption.

30. At least 3 days before aerial filming, the operator of the UAS affected by this exemption must submit a written Plan of Activities to the local Flight Standards District Office (FSDO) with jurisdiction over the area of proposed filming. The 3-day notification may be waived with the concurrence of the FSDO. The plan of activities must include at least the following:
    a. Dates and times for all flights;
    b. Name and phone number of the operator for the UAS aerial filming conducted under this grant of exemption;
    c. Name and phone number of the person responsible for the on-scene operation of the UAS;
    d. Make, model, and serial or N-Number of UAS to be used;
    e. Name and certificate number of UAS PICs involved in the aerial filming;
    f. A statement that the operator has obtained permission from property owners and/or local officials to conduct the filming production event; the list of those who gave permission must be made available to the inspector upon request;
    g. Signature of exemption holder or representative; and
    h. A description of the flight activity, including maps or diagrams of any area, city, town, county, and/or state over which filming will be conducted and the altitudes essential to accomplish the operation.

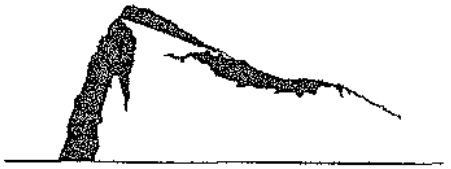
31. Flight operations may be conducted closer than 500 feet from participating persons consenting to be involved and necessary for the filming production, as specified in the exemption holder's MPTOM.

Unless otherwise specified in this grant of exemption, the UAS, the UAS PIC, and the UAS operations must comply with all applicable parts of 14 CFR including, but not limited to, parts 45, 47, 61, and 91.

This exemption terminates on April 30, 2017, unless sooner superseded or rescinded.

Sincerely,

/s/
John S. Duncan
Director, Flight Standards Service



January 12, 2015

United States Department of Transportation
Federal Aviation Administration
800 Independence Ave, SW
Washington, DC 20591

RE: Petition for Exemption from certain Title 14 CFRs in regards to Section 333 of the FAA Modernization & Reform Act of 2012 concerning Unmanned Aerial Systems (UAS)

To whom it may concern:

Good day. Per this letter of request, I seek exemption from several Title 14 CFRs that relate to the commercial use of unmanned aerial systems (UAS). The following will be included in this request: Name & information of Petitioner; Executive Summary of Petitioner summarizing the rules Petitionec seeks exemption from and reasons the exemptions would serve the public good; Specific Title 14 CFRs to which an exemption is sought; the extent & reasons foc the requested exemptions; reasons why safety would not be compromised.

PERSONAL INFORMATION

Name	Richard Bowden Dobbins (**hereafter referred to as "Petitioner"**)
Company	The Dobbins Company
Address	3827 Cliff Crest Dr.
	Smyrna, Georgia 30080
	404-451-1595
	rick@dobbinscompany.com

EXECUTIVE SUMMARY

The Petitioner was born on December 7, 1959 in Atlanta, Ga. and is a US citizen. He is the CEO of Thc Dobbins Company which has been in business sincc 1975. The Dobbins Company is a consulting firm whose primary clients are banks and commercial finance companies located mainly in the southeast USA. The petitioner is a licensed private pilot with an instrumcnt rating. He has previously owned a 1975 Cessna Cardinal RG. Petitioner has never been cited for any FAA violations. Since 2013, Petitioner has owned a DJI Phantom 2 and a Phantom 2 Vision UAS. As a hobbyist, Petitioner has become very proficient with the Phantom models with over 100 hours flown in type. Petitioner is requesting an exemption from the current rules in Section 333 which govern thc uses of UASs for commercial purposes. The Petitioner seeks authorization to perform commercial UAS operations for real estate inspections. This would include residential, commercial and rural properties. Prospective customers and clients would include real

estate agents & brokers, management companies, insurance companies & vendors, banks and private property owners.

The Title 14 CFRs exemptions that this request entails are 61.113(a) & (b); 91.7(a); 91.119; 91.121; 91.151(a); 91.405; 91.407(a); 91.409(a)(1) & (2); 91.417(a) & (b). Reasons for request are cited below.

PUBLIC GOOD

Aerial videography for geographical awareness and for real estate marketing and inspections has been around for a long time through manned fixed wing aircraft and helicopters. But for small business owners, its expense has been cost-prohibitive. Granting this exemption to the Petitioner would allow him to provide this service at a much lower cost. Further, the small UAS being utilized in this application will pose no threat to the public given its small size and lack of combustible fuel when compared to larger manned aircraft. The operation of this U A S will minimize ecological damage and promote economic growth by providing information to businesses & individuals in the metro Atlanta and north Georgia area.

DESCRIPTION OF UAV TO BE DEPLOYED UNDER REQUESTED EXEMPTIONS

Petitioner currently owns a DJI Phantom 2 quad copter and a DJI Phantom 2 Vision quad copter. These are virtually the same model of UAV. The difference is in camera capabilities and slightly different control links. The petitioner intends to use the Phantom 2 as the primary UAV in commercial applications described herein. The Phantom 2 is a quad copter that can take off and land vertically. It weighs approximately 3 lbs. and has a maximum airspeed of approximately 25 knots. This UAS uses lithium polymer batteries which have approximately 20-25 minutes of total charge time. This gives this UAS approximately 12-15 minutes of flight time with sufficient remaining battery charge to land safely. The particular model of Phantom 2 being utilized under this request for exemption has First Person View (FPV) which allows the PIC to visually monitor certain telemetry data on a ground station monitor including altitude (AGL), GPS signal strength, battery charge information, etc. This FPV also gives the PIC video feed from the attached GoPro camera showing what images are being captured. This is a significant safety feature as it shows the attitude of the UAS and its forward direction. However, this FPV feature will never be used as a tool to deviate from VLOS operation by the PIC.

PREFLIGHT

The petitioner will always follow procedures outlined in the UAS operator's manual as to proper preflight inspection of all hardware, software, environment and any other factors needed to ensure a safe flight.

FCC INFORMATION

The UAS be deployed here is a DJI Phantom 2. The control link operates on the 2.4 GHz ISM radio frequency. Its published range is 1000 meters (3280 feet). The receiver sensitivity is -97dBm.

PIC QUALIFICATIONS

The petitioner holds a FAA Private Pilot's License with an instrument rating. Petitioner has over 600 hours PIC time in a variety of Cessna and Piper aircraft with the majority being in the 1975 Cessna 177RG he previously owned. Petitioner has owned the UAS described above since 2013 and has over 100 hours in this type of UAS as a hobbyist. The petitioner envisions being the PIC in all operations that will be performed under the requested rule exemptions and the subsequent COA request. However, if another PIC is used for these operations, petitioner agrees that any PIC of the UAS in the envisioned operations will hold at least a FAA Private pilots certificate, hold at least a 3rd class medical certificate, have no less than 25 hours of PIC time in the UAS being deployed before beginning any type of commercial for hire operations and conform to all safety protocols.

DESCRIPTION OF INTENDED COMMERCIAL OPERATIONS

Petitioner intends to solicit work for aerial real estate inspections from real estate agents & brokers, insurance companies & related vendors, banks and private property owners to provide photography and videography of residential, commercial and rural real estate. This work will always be conducted with the permission of the property owner or their respective agent. Flight operations will be restricted to flights directly over the property that has granted permission. Given the type of work being targeted here, the Petitioner does not foresee any instance where the UAS would be flown over any crowds or assemblages of people in an open air environment. If in fact any job does entail flights over crowds, petitioner will elect not to make said flight. Safety will always be the primary concern regarding any flight at any time.

Petitioner agrees to place a sign during any flight operation that says: CAUTION-UNMANNED AERIAL VEHICLE IN OPERATION. STAY BACK 100 FEET FROM AIRCRAFT.

UAS OPERATING PARAMETERS

The UAS being deployed in these exemption request can fly at a speed of approximately 25 knots. However, given the intended use describe here, this speed will never be necessary. Much slower speeds are preferred to collect the photographic material needed.

Although the UAS being deployed has an approximate control link distance of 3/4 mile, this is much more than VLOS will allow. Petitioner agrees never to fly UAS outside of VLOS.

Petitioner will only fly UAS during the day in VMC conditions. Given the petitioner agrees to never fly higher than 300 feet AGL, distance from clouds should not be a factor if flown in VMC conditions.

Petitioner agrees to use a Visual Observer (VO) during all operations. The VO will be used to help assure VLOS at all times.

The UAS will not operate within 5 nautical miles of an airport reference point as denoted on a current FAA published acronautical chart.

The UAS being deployed with these exemption requests has the capability of using GPS signals to return to its initial point of take off if connection with the radio control link is lost.

The petitioner agrees to yield right of way to all manned aviation activities at all times.

EXEMPTION REQUESTS

The following are a list of Title 14 CFAs which the petitioner seeks exemption. **Please note** that the Petitioner has used Exemption No. 11138 to Douglas Trudeau (Regulatory Docket No. FAA-2014-0481) as a reference. Given that the petitioner and Mr. Trudeau intend to use the exemptions in similar manners and both use similar equipment, it seemed prudent not to burden the reviewer in this matter with exemption requests that have been previously deemed that relieve was not necessary. These rules are Part 21, 45.23(b), 91.9(b)(2), 91.103(b), 91.109 and 91.203(a) & (b). If the reviewer believes that these rules need to be addressed in this request, the petitioner will make a supplemental request including these additional rule exemptions.

RULE 61.113 PRIVATE PILOT PREVELEGES AND LIMITATIONS

The Petitioner currently holds an FAA Private Pilot Certificate with an Instrument Rating (a copy of this certificate is included in supplemental material as part of this request). In addition to the certificate, Petitioner agrees to maintain a 3rd Class Medical Certificate. However, petitioner has an eye sight problem that may cause rejection of the medical unless addressed by rule exemption. Petitioner has what is called a ***unilateral papilledema*** of the right eye. This is an inflammation of the right optic nerve to which there is no cure or corrective lens solution. This causes blurriness in the right eye. The left eye has 20/20 vision and when using both eyes, Petitioner has 20/20 long distance sight. Corrective lens are need for reading. This sight condition has caused Petitioner to cease operating manned aircraft. However, this condition does not affect Petitioner's ability to operate a UAS in any way. The petitioner seeks an exemption from some eyesight requirements for the 3rd Class medical certificate.

As to private pilot limitations concerning operations for hire or compensation, it seems that Exemption No. 11062 to Astraeus has allowed this exemption previously and was noted in the Trudeau Exemption No. 11138.

As to airmanship skills, the Petitioner has been operating his UAS since 2013 and has over 100 hours of flight time. Petitioner currently fly's this UAS several hours a month as a hobby and is very proficient and has the skills to maintain altitude, maintain VLOS, navigate, avoid obstacles, avoid air traffic and respond to loss of control link. Petitioner understands that he must make at least 3 takeoffs and landings within a 90 day period for currency purposes.

RULE 91.7(a) CIVIL AIRCRAFT AIRWORTHINESS

There is no current FAA regulatory standard for determining airworthiness of UAS and there is no certificate currently available for UAS airworthiness. Petitioner seeks an exemption from this rule by ensuring that the UAS is in an airworthy condition based on compliance with the operating documents prior to every flight. Flight manuals and other important documents will be kept in a location readily accessible to the PIC at all times.

RULE 91.119(c) MINIMUM SAFE ALTITUDES

91.119 prescribes safe altitudes for the operation of civil aircraft, but it allows helicopters to be operated at lower altitudes in certain conditions. Petitioner seeks an exemption from this rule as Petitioner will only operate the UAS in a range from ground level up to but not exceeding 300 feet (AGL) and will only operate in safe areas away from the public thus providing a level of safety not available to manned aircraft. The petitioner asserts that given the size, weight, maneuverability and speed of the UAS, an equivalent or higher level of safety will be achieved that from conventional manned helicopters.

Petitioner will avoid actively populated areas. These areas will be interpreted to include areas on a FVR chart depicted in yellow and will be supplemented with information from a Flights Standard District Office (FSDO). Petitioner intends to operate the UAS over real estate for inspection purposes. Petitioner will not operate over any assemblage of people in an open air environment

Per the exemption granted in No. 11138 concerning 91.119(c), Petitioner agrees to act in strict accordance to that exemption. However, Petitioner seeks an exemption from the rule stipulating that a UAS cannot be operated *within 500 feet* of a structure *without permission of the owner*. Given the intended use Petitioner will use these exemptions for, which is for photography and videography of real estate for marketing & inspection purposes, agreement from the ***engaging*** property owner or their agent is an absolute necessity. The UAS will only be flown over properties with this permission. However, given the housing density in the Atlanta, GA area, maintaining a 500 foot distance from other structures even while strictly flying over a permission granting owner's property is impossible in many instances. The Petitioner seeks an exemption to this rule which would allow a 50' stand-off from other structures as long as the UAS is operated completely over and within the property boundary lines of a permission granting property owner. Petitinner agrees to always keep privacy rights of other property owners in mind and will never engage a UAS in any type of surveillance or spying.

RULE 91.121 ALTIMETER SETTINGS

Petitioners' UAS has GPS derived altitude capabilities with a barometrie sensor. The petitiuner believes this rule in not applicable to the UAS operations intended.

RULE 91.151(a) FUEL REQUIREMENTS FOR FLIGHT IN VFR CONDITIONS

Petitioner seeks relief from this rule due to the UAS being deployed is battery operated and the requirements under this rule are not applicable. The UAV in question has First Person Vision capabilities which transmits certain telemetry to a monitor where the PIC can monitor certain aspects of the flight including battery level. A typical battery for a

Phantom 2 UAS will last approximately 20-25 minutes before total exhaustion. Certain battery level warnings are set where the PIC will know when the battery state is at 30% and 15% remaining charge levels. This will normally allow a flight of 12 – 15 minutes with sufficient battery charge to make a safe landing. Petitioner will never begin a flight unless a fully charged battery is used.

RULE 91.405(a) MAINTENANCE REQIOERD, 91.407(a) OPERATION AFTER MAINTENANCE, PREBVENTITIVE MAINTENANCE, REBUILDING OR ALTERATION: 91.409(a)(2) INSPECTIONS; 91.417(a)(b) MAINTENANCE RECORDS

Petitioner seeks relief from these rules due to it being an alternate inspection requirement of 91.409(a)(2). The Petitioner will inspect and ensure UAS is in a condition for safe flight and adhere to all operating documents.

SUPPLEMENTAL INFORMATION

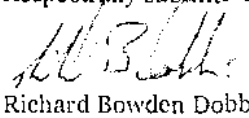
The Petitioner has provided the following information to support these requests for rule exemptions:
1) Copy of petitioners FAA Private Pilot's License, 2) Phantom 2 User Manual v.1.04, 3) NAZA M-V2 Main Controller Quick Start Guide v.1.26 (This is the micro controller that operates the UAS), 3) iOSD Mini User Manual (This provides telemetry data during flight).

CLOSING

The Petitioner believes that exemption from the above listed Title 14 CFRs is warranted given Petitioner's background as a Private Pilot, the nature of the type of UAS flights that will be undertaken, the size & weight of the UAS being deployed, the safety precautions to the general public and the NAS the Petitioner intends to adhere to, the positive environmental impact the flight operatinns would have compared to manned fuel consuming missions and the economic benefit the Petitioner's business would have in this new area of aviation.

Thank you for your review of this matter. Please feel free to contact me at any time with any questions regarding this matter.

Respectfully submitted,



Richard Bowden Dobbins

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
CERTIFICATE OF WAIVER OR AUTHORIZATION

ISSUED TO
The Dobbins Company

3827 Cliff Crest Drive
Smyrna, GA 30080

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

OPERATIONS AUTHORIZED
Operation of the DJI Phantom 2 and DJI Phantom 2 Vision Unmanned Aircraft Systems at or below 200 feet Above Ground Level (AGL) for the purpose of aerial data collection.

LIST OF WAIVED REGULATIONS BY SECTION AND TITLE
N/A

STANDARD PROVISIONS

1. A copy of the application made for this certificate shall be attached and become a part hereof.
2. This certificate shall be presented for inspection upon the request of any authorized representative of the Federal Aviation Administration, or of any State or municipal official charged with the duty of enforcing local laws or regulations.
3. The holder of this certificate shall be responsible for the strict observance of the terms and provisions contained herein.
4. This certificate is nontransferable.

Note-This certificate constitutes a waiver of those Federal rules or regulations specifically referred to above. It does not constitute a waiver of any State law or local ordinance.

SPECIAL PROVISIONS

Special Provisions are set forth and attached.

This certificate FAA-2015-0060-333E is effective from April 17, 2015 to April 30, 2017 and is subject to cancellation at any time upon notice by the Administrator or his/her authorized representative.

BY DIRECTION OF THE ADMINISTRATOR

/S/

FAA Headquarters, AJV-115	Jacqueline R. Jackson
(Region)	(Signature)
April 10, 2015	Manager, UAS Tactical Operations Section
(Date)	(Title)

FAA Form 7711-1 (7-74)

STANDARD PROVISIONS

A. **General.**

1. The approval of this COA is effective only with an approved FAA Grant of Exemption.

2. A copy of the COA including the special limitations must be immediately available to all operational personnel at each operating location whenever UAS operations are being conducted.

3. This authorization may be canceled at any time by the Administrator, the person authorized to grant the authorization, or the representative designated to monitor a specific operation. As a general rule, this authorization may be canceled when it is no longer required, there is an abuse of its provisions, or when unforeseen safety factors develop. Failure to comply with the authorization is cause for cancellation. The operator will receive written notice of cancellation.

B. **Safety of Flight.**

1. The operator or pilot in command (PIC) is responsible for halting or canceling activity in the COA area if, at any time, the safety of persons or property on the ground or in the air is in jeopardy, or if there is a failure to comply with the terms or conditions of this authorization.

See-and-Avoid

Unmanned aircraft have no on-board pilot to perform see-and-avoid responsibilities; therefore, when operating outside of active restricted and warning areas approved for aviation activities, provisions must be made to ensure an equivalent level of safety exists for unmanned operations consistent with 14 CFR Part 91 §91.111, §91.113 and §91.115.

a. The pilot in command (PIC) is responsible:

- To remain clear and give way to all manned aviation operations and activities at all times,
- For the safety of persons or property on the surface with respect to the UAS, and
- For compliance with CFR Parts 91.111, 91.113 and 91.115

b. UAS pilots will ensure there is a safe operating distance between aviation activities and unmanned aircraft (UA) at all times.

c. Visual observers must be used at all times and maintain instantaneous communication with the PIC.

d. The PIC is responsible to ensure visual observer(s) are:

- Able to see the UA and the surrounding airspace throughout the entire flight, and
- Able to provide the PIC with the UA's flight path, and proximity to all aviation activities and other hazards (e.g., terrain, weather, structures) sufficiently for the PIC to exercise effective control of the UA to prevent the UA from creating a collision hazard.

e. Visual observer(s) must be able to communicate clearly to the pilot any instructions required to remain clear of conflicting traffic.

2. Pilots are reminded to follow all federal regulations e.g. remain clear of all Temporary Flight Restrictions, as well as following the exemption granted for their operation.

3. The operator or delegated representative must not operate in Prohibited Areas, Special Flight Rule Areas or, the Washington National Capital Region Flight Restricted Zone. Such areas are depicted on charts available at http://www.faa.gov/air_traffic/flight_info/aeronav/. Additionally, aircraft operators should beware of and avoid other areas identified in Notices to Airmen (NOTAMS) which restricts operations in proximity to Power Plants, Electric Substations, Dams, Wind Farms, Oil Refineries, Industrial Complexes, National Parks, The Disney Resorts, Stadiums, Emergency Services, the Washington DC Metro Flight Restricted Zone, Military or other Federal Facilities.

4. All aircraft operated in accordance with this Certificate of Waiver/Authorization must be identified by serial number, registered in accordance with 14 CFR part 47, and have identification (N-Number) markings in accordance with 14 CFR part 45, Subpart C. Markings must be) as large as practicable.

C. **Reporting Requirements**

1. Documentation of all operations associated with UAS activities is required regardless of the airspace in which the UAS operates. NOTE: Negative (zero flights) reports are required.

2. The operator must submit the following information through mailto:9-AJV-115-UASOrganization@faa.gov on a monthly basis:
   a. Name of Operator, Exemption number and Aircraft registration number
   b. UAS type and model
   c. All operating locations, to include location city/name and latitude/longitude
   d. Number of flights (per location, per aircraft)
   e. Total aircraft operational hours
   f. Takeoff or Landing damage

g. Equipment malfunctions. Reportable malfunctions include, but are not limited to the following:

(1) On-board flight control system

(2) Navigation system

(3) Powerplant failure in flight

(4) Fuel system failure

(5) Electrical system failure

(6) Control station failure

3. The number and duration of lost link events (control, performance and health monitoring, or communications) per UA per flight.

D. **Notice to Airmen (NOTAM).**

A distant (D) NOTAM must be issued when unmanned aircraft operations are being conducted. This requirement may be accomplished:

a. Through the operator's local base operations or NOTAM issuing authority, or

b. By contacting the NOTAM Flight Service Station at 1-877-4-US-NTMS (1-877-487-6867) not more than 72 hours in advance, but not less than 24 hours prior to the operation, unless otherwise authorized as a special provision. The issuing agency will require the:

(1) Name and address of the pilot filing the NOTAM request

(2) Location, altitude, or operating area

(3) Time and nature of the activity.

AIR TRAFFIC CONTROL SPECIAL PROVISIONS

A. **Coordination Requirements.**

1. Operator filing and the issuance of required distance (D) NOTAM, will serve as advance ATC facility notification of UAS operations in an area.

2. Operator must cancel NOTAMs when UAS operations are completed or will not be conducted.

3. Coordination and deconfliction between Military Training Routes (MTRs) is the operator's responsibility. When identifying an operational area the operator must evaluate whether an MTR will be affected. In the event the UAS operational area overlaps (5 miles either side of centerline) an MTR, the operator will contact the scheduling agency 24 hours in advance to coordinate and deconflict. Approval from the scheduling agency is not required. Scheduling agencies are listed in the Area Planning AP/1B Military Planning Routes North and South America, if unable to gain

access to AP/1B contact the FAA at email address mailto:9-AJV-115-UASOrganization@faa.gov with the IR/VR routes affected and the FAA will provide the scheduling agency information. If prior coordination and deconfliction does not take place 24 hours in advance, the operator must remain clear of all MTRs.

B. **Communication Requirements.**

1. When operating in the vicinity of an airport without an operating control tower, announce your operations in accordance with the FAA Aeronautical Information Manual (AIM) 4-1-9 Traffic Advisory Practices at Airports without Operating Control Towers.

C. **Flight Planning Requirements.**

This COA will allow small UAS (55 pounds or less) operations during daytime VFR conditions under the following conditions and limitations:

(1) At or below 200 feet AGL; and

(2) Beyond the following distances from the airport reference point (ARP) of a public use airport, heliport, gliderport, or seaport listed in the Airport/Facility Directory, Alaska Supplement, or Pacific Chart Supplement of the U.S. Government Flight Information Publications.

a) 5 nautical miles (NM) from an airport having an operational control tower; or

b) 3 NM from an airport having a published instrument flight procedure, but not having an operational control tower; or

c) 2 NM from an airport not having a published instrument flight procedure or an operational control tower; or

d) 2 NM from a heliport

D. **Emergency/Contingency Procedures.**

1. Lost Link/Lost Communications Procedures:

- If the UAS loses communications or loses its GPS signal, the UA must return to a pre-determined location within the private or controlled-access property and land.

- The PIC must abort the flight in the event of unpredicted obstacles or emergencies.

2. Any incident, accident, or flight operation that transgresses the lateral or vertical boundaries defined in this COA must be reported to the FAA via email at

mailto:9-AJV-115-UASOrganization@faa.gov within 24 hours. Accidents must be reported to the National Transportation Safety Board (NTSB) per instructions contained on the NTSB Web site: **www.ntsb.gov**

AUTHORIZATION

This Certificate of Waiver or Authorization does not, in itself, waive any Title 14 Code of Federal Regulations, nor any state law or local ordinance. Should the proposed operation conflict with any state law or local ordinance, or require permission of local authorities or property owners, it is the responsibility of the operator to resolve the matter. This COA does not authorize flight within Special Use airspace without approval from the scheduling agency. The operator is hereby authorized to operate the small Unmanned Aircraft System in the National Airspace System.

Extended User Manual - eXom

Revision 1 / April 2015

senseFly
a Parrot company

GENERAL INFORMATION

READ THIS USER MANUAL CAREFULLY BEFORE USING A SENSEFLY LTD PRODUCT.

senseFly Ltd products are intended for professional use only.

Applicable Regulations

senseFly Ltd products are subject to Civil Aviation regulations. Regulations may vary depending on the country where you intend to operate your product.

ANY USE OF SENSEFLY LTD PRODUCTS IN BREACH OF THE LAW OF THE COUNTRY WHERE YOU OPERATE THE PRODUCT IS UNDER YOUR SOLE RESPONSIBILITY.

INFORM YOURSELF BEFORE USING THE PRODUCT. SOME COUNTRIES MAY HAVE LAWS THAT LIMIT THE USE OF UNMANNED AIRCRAFT TO 'LINE-OF-SIGHT' OPERATIONS AND/OR PROHIBIT THE USE OF UNMANNED AIRCRAFT AT ALL OR IN SPECIFIC AREAS.

Privacy

Recording and circulating an image of an individual may constitute an infringement of their image and privacy for which you can be liable. Ask for authorization before taking pictures of an individual, particularly if you want to keep your recordings and/or circulate images on the Web or any other medium. Do not circulate degrading images or ones that could undermine the reputation or dignity of an individual. Check that your use of the cameras on board senseFly Ltd products comply with the legal provision on privacy in the country where you operate your product.

Limited Warranty

SenseFly Ltd warrants that the product will be free from defects in material and workmanship for a period of twelve (12) months from the date of delivery. SenseFly Ltd further warrants that the product will perform substantially in accordance with its specification. During the warranty period senseFly Ltd's sole liability shall be at senseFly Ltd's sole option, either to repair or to replace the defective product with another product or a product with similar specifications, at no charge, or to reimburse the purchase price of the product, or if repair or replacement is not possible, issue a credit note; provided however, that the defect has been confirmed by senseFly Ltd and that the defective product is returned to senseFly Ltd in accordance with the support and repair form together with all required flight logfiles.

Warranty does not apply, without limitation, in case: a) the products are not stored and used according to their specifications, b) the products are damaged due to carelessness, negligence, or wrong use by the user, and c) for defects due to normal wear and tear including, but not limited to, deterioration to the airframe after first flight, normal degradation, misuse, moisture or liquids, proximity or exposure to heat, accidents, excessive strain, abuse, neglect, misapplication, repairs or modifications made by third party other than senseFly Ltd, damage due to manual operation, damage due to take-off or landing location with obstacles, damage due to low altitude flight, damage due to loss of data radio connection, damage due to strong wind, rain or humidity, or other causes for which senseFly Ltd has no control.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND OF ANY DTHER OBLIGATION ON THE PART DF SENSEFLY LTD.

Limitation of liability

TO THE EXTENT PERMITTED BY APPLICABLE LAW, IN NO EVENT WILL SENSEFLY LTD BE LIABLE FOR ANY LDSS OF REVENUE, LOSS OF PROFIT, LOSS OF DATA, OR INOIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF SENSEFLY LTO HAS BEEN NOTIFIED OF THE POSSIBILITY OF SUCH OAMAGES, ANO WHETHER THIS LIABILITY ARISES FROM A CLAIM BASED ON CONTRACT, WARRANTY, TDRT OR OTHERWISE, WITH THE EXCEPTION OF GROSS NEGLIGENCE AND DEATH.

YOU SHALL AT ALL TIMES DPERATE THE PRODUCT IN AREAS OR UNDER CIRCUMSTANCES SO AS TO GUARANTY SECURITY AND SAFETY OF PEOPLE, PROPERTY AND ANIMALS.

Disposal of this product at the end of its life

At the end of this product's life, please do not dispose of this product in your general household waste. Instead, in order to prevent possible harm to the environment or human health from uncontrolled waste disposal, please dispose of this product separately in accordance with your local laws and regulation. For more information on the separate collection systems for waste electrical and electronic equipment that are available for consumers, near your home, free of charge, please contact your local municipal authority.

You can also contact senseFly Ltd or the reseller from which you purchased your drone who may provide recycling services or be part of a recycling scheme.

Copyrights

senseFly Ltd reserves the right to make changes to specifications and product descriptions contained in this document at any time without notice. Please consult www.sensefly.com for the latest release.

Address

senseFly Ltd
Route de Genève 38
1033 Cheseaux-Lausanne
Switzerland

Website: http://www.sensefly.com

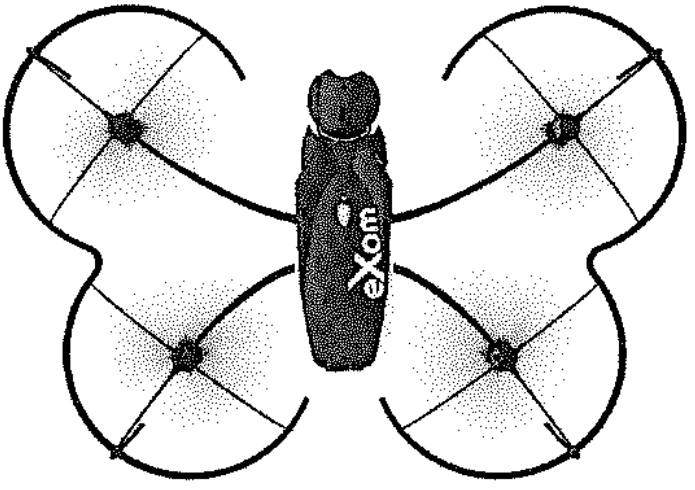
Technical support

If you have questions about any of your senseFly products, please visit my.senseFly* where you'll find:

- Our Knowledge Base.
- A form for contacting support.

* my.sensefly.com

Congratulations on your purchase of the *eXom*, a complex and powerful yet intuitive inspection and mapping system. We take great care to develop and design the best possible hardware and software tools for quick, high-quality and easy-to-use inspection and aerial mapping.



The *eXom* is a technologically advanced drone (UAV, RPAS or UAS) platform capable of manual, stabilised, pre-planned and interactive flight and is equipped with multitude of professional-grade sensors.

Note: This manual refers to *eMotion X* and version 3.4 of *Postflight Terra 3D* software. The *eXom* requires *eMotion X*. If you installed eMotion before purchasing your drone, check the version and upgrade if necessary. You can consult the Release Notes* for changes included in more recent versions of the software.

Package contents

The standard *eXom* package contains the following items:

- 1x carrying case with foam protection
- 1x *eXom*
- 2 sets of 4 spare propellers
- 4 x Lithium-Polymer battery packs
- 2 x Lithium-Polymer battery charger (including cables)
- 4 x spare legs
- 8 x spare leg caps
- 1x 2.4/5.8 GHz USB ground modem for data link (including USB cable)
- 1x 2.4 GHz remote control (RC) (including 3 AA batteries)
- 1x USB cable for interfacing with camera and on-board autopilot
- 1x *eXom* User Manual

Depending on your order, your package may also include other items. Please verify upon delivery that your package is complete. In case of a missing item, please contact your *eXom* reseller immediately.

Hardware features

The *eXom* has the following components:

- **Central body:** The core of the *eXom*, housing its autopilot, image processing logic and communications.
- **Arms:** Carbon fibre composite arms provide a lightweight and sturdy structure.
- **Power button/status LED & strobe:** Power button has an LED built into it that indicates the current state of the *eXom* when on the ground and flashes brightly in the air.
- **Top cover:** Light yet durable cover to protect the drone's electronics.
- **Sensor modules:** Composed of high-speed ultrasonic sensors and navcam, the 5 sensor modules (head, left, right, rear and bottom) are used for navigation, landing and situational awareness.
    - **Navcam:** High-speed optical sensor that constantly analyses the *eXom*'s surroundings for navigation and collision avoidance.
    - **Ultrasonic transmitter:** Emits ultrasound which is then picked up by the ultrasonic receiver.
    - **Ultrasonic receiver:** Detects the ultrasound emitted by the transmitter, allowing the *eXom* to measure its distance from a surface.
- **TripleView head:** Stabilised head equipped with:
    - **Main camera:** Capable of capturing high-resolution video and still imagery.
    - **Thermal camera:** Capable of capturing high-resolution thermal video and still imagery.
    - **Flash:** Able to provide high-intensity flashes of light.
    - **Headlamp:** Provides lighting for video and navigation.
    - **Head sensor module:** Contains an ultrasonic transmitter, ultrasonic receiver and navcam for navigation, landing and situational awareness.

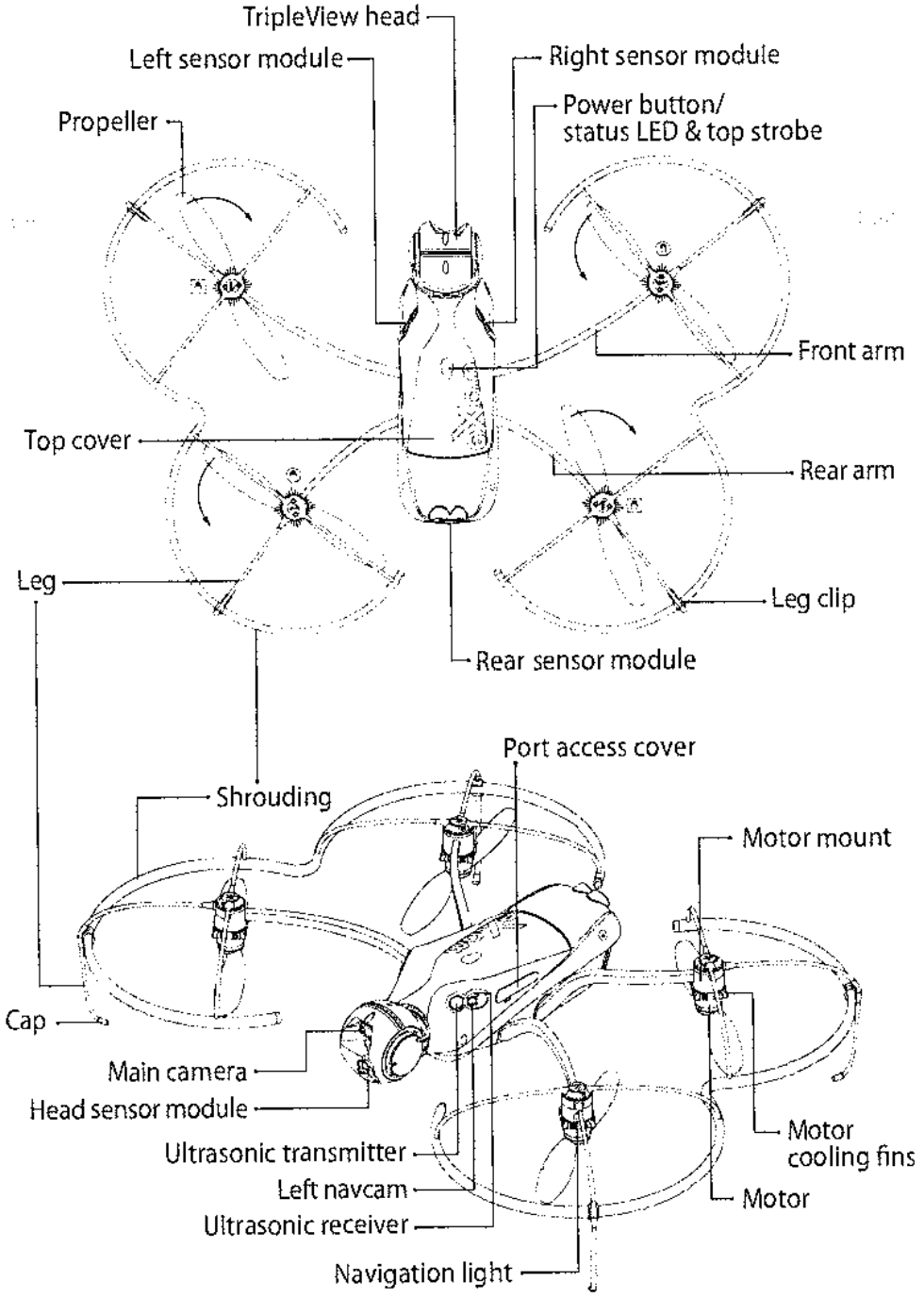
- **Propeller:** Used to generate thrust. The *eXom*'s propellers are detachable so that they can be easily replaced.
- **Motor:** Powers the propellers.
- **Motor mount:** Houses the motor and connections and supports the legs and shrouding.
- **Motor cooling fins:** Provide air cooling for the motors.
- **Shrouding:** Made of durable carbon fibre composite, it protects the propellers and surfaces with which the drone might come into contact.
- **Navigation lights:** Indicate the drone's position and orientation. The light on the left-hand (port) side shines red and the one on the right-hand (starboard) side shines green.
- **Leg:** Supports the *eXom* on the ground.
- **Cap:** Provides protection for the surface the drone lands on.
- **Battery:** The *eXom* is powered by a LiPo (Lithium Polymer) battery stored within the battery compartment.
- **Battery compartment:** Holds the removable battery.
- **Battery release tabs:** Squeeze the tabs to remove the battery.
- **Battery level indicator:** Press the button and a series of LEDs indicate the battery level.
- **Bottom strobe:** Positioned on the bottom of the drone, it indicates the drone's location when viewed from below.
- **Port access cover:** Protects the *eXom*'s ports:
    - **SD card slot:** Holds the SD card on which video and images are stored.
    - **Autopilot port:** Used for upgrading your drone's firmware.
    - **Maintenance port:** Only for use by senseFly support.

- **Maintenance button:** Only for use by senseFly support.
- **Maintenance switch:** Only for use by senseFly support.

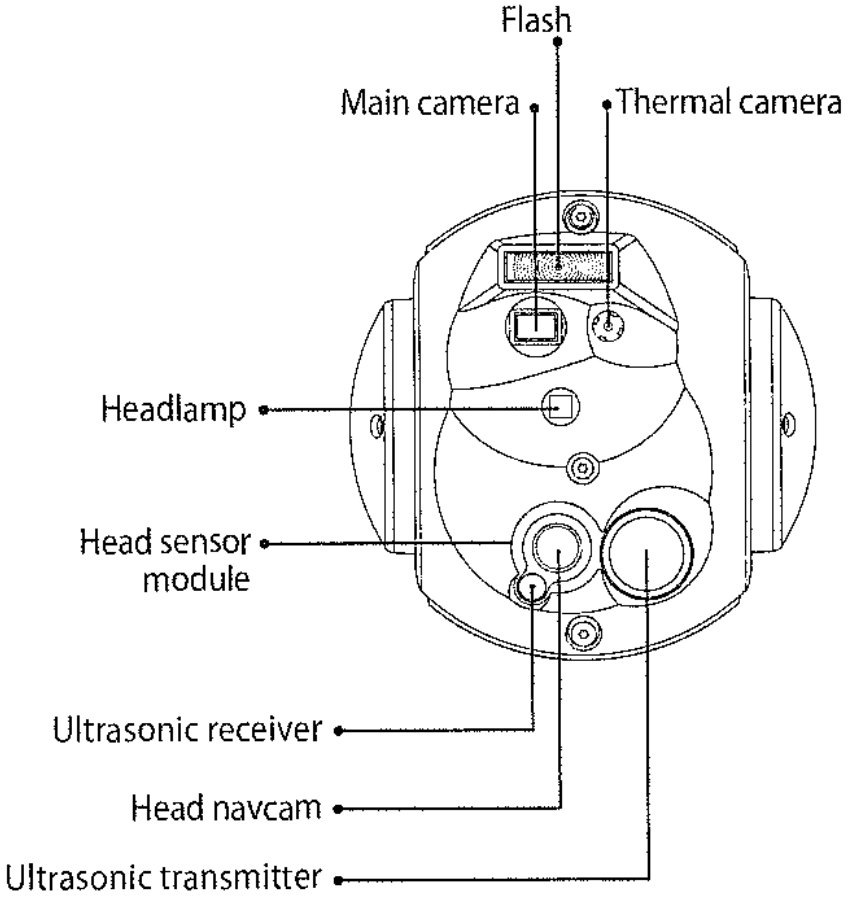
Caution: The propellers spin at high speeds and can be potentially dangerous if they come into contact with exposed skin. Be sure to always keep your hands clear of the propellers when the battery is installed in your *eXom*.

Caution: Proper care of your battery is essential. Please read section 'Proper battery care' on page 90 before using your drone for the first time.

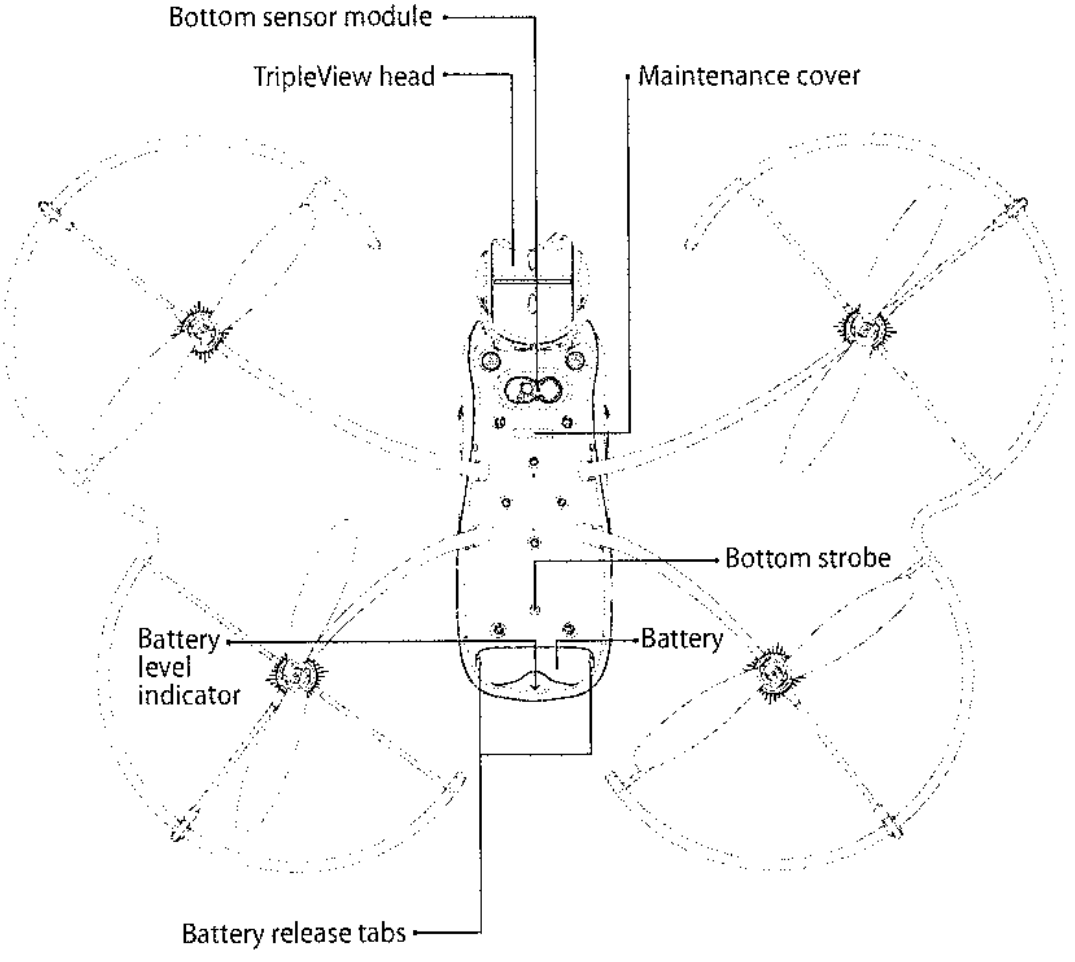
Top


TripleView head
Left sensor module
Right sensor module
Propeller
Power button/
status LED & top strobe
Front arm
Top cover
Rear arm
Leg
Leg clip
Rear sensor module
Port access cover
Shrouding
Motor mount
Cap
Main camera
Head sensor module
Motor
cooling fins
Ultrasonic transmitter
Left navcam
Motor
Ultrasonic receiver
Navigation light

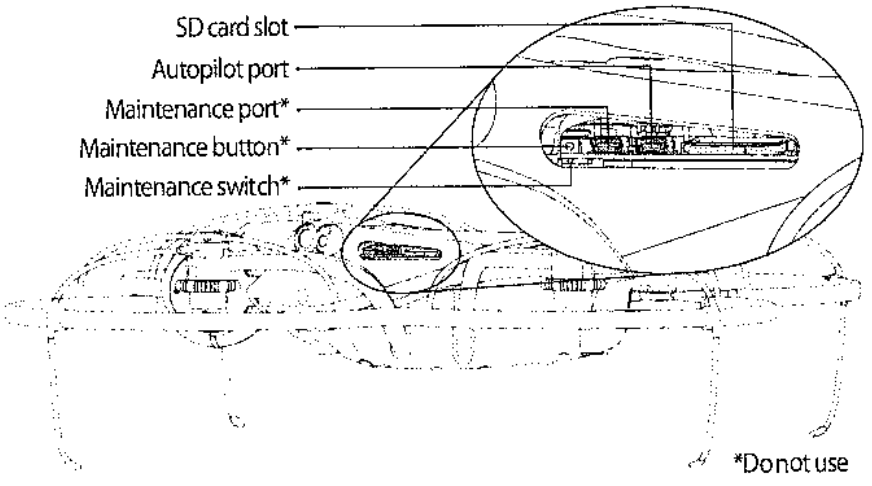
TripleView Head



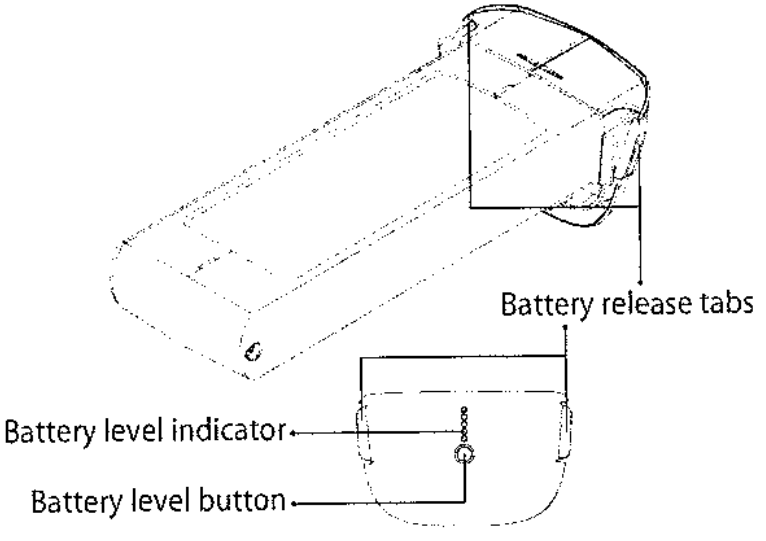
Bottom


Bottom sensor module
TripleView head
Maintenance cover
Bottom strobe
Battery level indicator
Battery
Battery release tabs

Ports



Battery



Part I

Getting Started

The first part of this document introduces you to the *eXom* and contains the basic information you will need to plan and execute a flight.

A typical mission can be divided into three main phases:

1. **Planning:** Every project begins with careful planning, whether it is a quick flight over a small area or a multi-stage flight in complex terrain. Section 'Planning a flight' on the next page describes how to use the Mission Planning feature to quickly generate a flight plan.

2. **Pre-flight preparation:** In section 'Executing a flight' on page 33 you will learn how to prepare your drone for flight.

3. **Executing a flight:** Once planning and preparation is complete, it is time for the drone to perform its flight. Though the *eXom* can follow a flight plan without intervention from take-off to landing, you can also modify its flight plan at any point during flight.

4. **Processing image data:** The last step in a project is viewing images and video, or converting the images taken by your *eXom* into usable products such as precise geo-referenced orthomosaics or 3D terrain models. section 'Processing image data' on page 62 leads you through the process of obtaining the video and images the drone has recorded, checking if the image quality suits your needs while still in the field and producing advanced 2D and 3D maps.

1 Planning a flight

Goal of this section: This section introduces the *eMotion X* software used to interface with the *eXom*. It describes the steps required to fly your drone and plan a simple mapping flight.

1.1 Installing *eMotion X*, *Postflight Terra 3D*, and the ground modem drivers

You can download the latest version of *eMotion X* and *Postflight Terra 3D* at:

http://my.sensefly.com

We recommend that you download and install *Google Earth™* to take full advantage of the features of *eMotion X*. You can find more information at the following address:

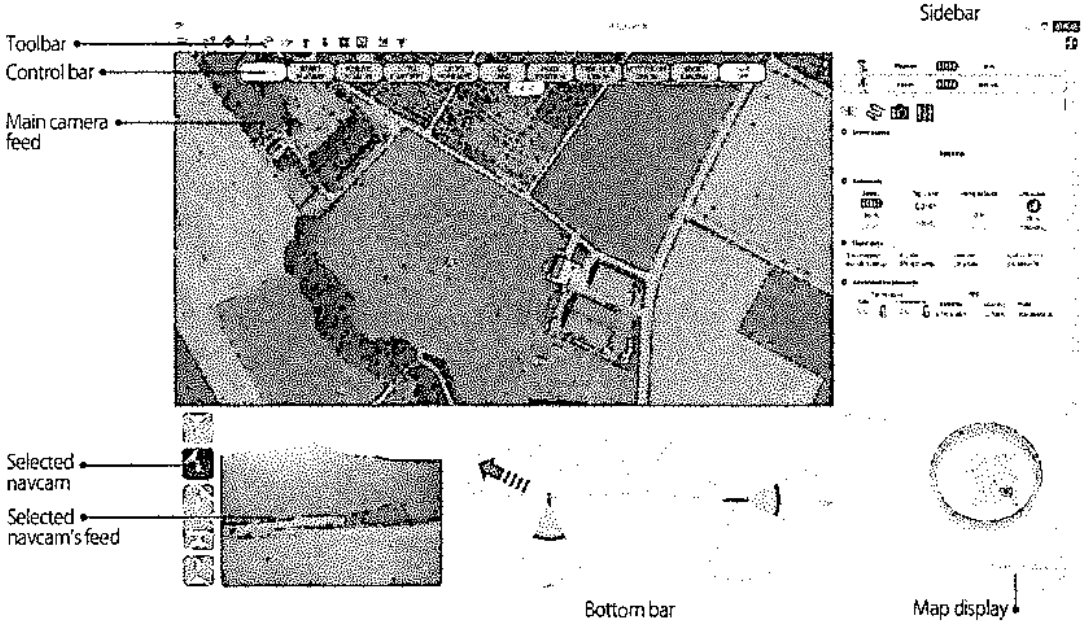
www.google.com/earth/

To install *eMotion X* on Windows, simply execute the provided installers for *eMotion X* and *Postflight Terra 3D* and follow the on-screen instructions. The *eMotion X* and *Postflight Terra 3D* software will be available in the 'Start' menu. Drivers for the USB ground station ground modem will automatically be installed along with *eMotion X*.

In case a problem arises after connecting the ground modem to the computer for the first time you can find the drivers in one of the following directories (depending on your version of Windows):

```
C:\Program Files\senseFly\eMotion X\usb_driver\
C:\Program Files (x86)\senseFly\eMotion X\usb_driver\
```

1.2 The *eMotion X* interface



The main screen of *eMotion X* is split into several sections:

- **Main Area:** The Main Area of *eMotion X* can display a map with the drone's current position, or the feed from the main or thermal cameras.
- **Control Bar:** The Control Bar is used to issue various commands to the *eXom* while it is in flight, such as starting the mission phase or holding position. It is also used to display and acknowledge warnings that may occur either before or during a flight.
- **Toolbar:** The Toolbar contains buttons to switch between 2D and 3D, control the layers, sources or map information and other display options related to the Map Area. *eMotion X* can use many sources of mapping information.
- **Sidebar:** The Sidebar is split into several tabs, each with a particular function:

- **Sensor bar:** The sensor bar displays the feed from the selected navcam. When viewing the main or thermal camera feed in the main area, you can also find the map in the sensor bar.

1.3 About flight plans

If you want your *eXom* to fly part of its mission autonomously, you must create a flight plan, which is a path defined by a set of waypoints, or points in 3D space, and a set of actions that can be performed at or in between waypoints, such as taking images, capturing images, carrying out a manoeuvre, proceeding to the next waypoint or landing.

A flight plan is shown in the Map Area using:

- In 2D view, circles to represent waypoints.
- In 3D view, vertical lines to represent the altitude of the drone with inverted cones to represent the waypoint itself.

1.4 Creating a new flight plan

eXom flights plans are made up of a series of blocks. Each block is made up of a mission polygon and a series of waypoints.

Note: Each block can be assigned to a different drone.

To create a flight plan:

1. Click the Mission Planning tab in the *eMotion X* sidebar.
2. Click to create a new block. A new mission polygon, including the required waypoints, is automatically calculated and displayed.
3. Adjust the ground resolution and other mapping and mission parameters in the Mission Planning tab to suit your terrain and quality requirements.

4. Click and drag the corners of the polygon to adjust its size and shape.
5. Click and drag the home and mission waypoints to adjust their position.
6. Click waypoints and edit their properties in the sidebar.
7. Check the resulting flight characteristics in the tab. Once you are satisfied, upload the mission plan to the drone by clicking the 'Upload' button.

Click the button in the Toolbar to to toggle 3D mode on and off.

Review the flight plan to ensure that there is sufficient clearance between the flight plan and the ground.

Caution: Neither *eMotion X* nor the automatic mission planning tool are aware of obstacles in the area. In addition, if you do not use elevation data, the mission planning tool assumes that the mission area is flat and at the same altitude than the take-off location. It is also not aware of any legal restrictions (such as minimum or maximum altitude) that may apply in your region. The resulting flight plan should be carefully reviewed in order to avoid any collision with uneven terrain or tall objects such as buildings, and to comply with local regulations.

The final step after you have prepared a flight plan is to save it to a file that you can load into the *eXom* when you are in the field. Select the Setup Phase tab from the Sidebar, click on 'Save flight plan to file...', choose a filename and location and click 'Save'.

1.5 About the working area

The cylindrical volume of space in which the drone is allowed to fly is known as the working area. Attempting to leave this area (fly out of the circle or over the height limit defined) will cause the drone to raise a warning and carry out a security action. The working area is represented by:

- In 2D view, a large semi-transparent grey circle.

- In 3D view, a large semi-transparent grey cylinder.

See section 'Waypoints and their properties' on page 65 for more information on waypoints and the various symbols presented in the Map Area.

A complete *eXom* flight plan is divided into two separate phases: the setup phase and the mission phase. The mission phase includes waypoints and actions related to mapping and capturing images. The setup phase includes waypoints and actions related to take-off and landing. The setup phase is usually planned in the field, and is explained in detail in section 'About mission planning' on page 43.

1.6 The mission phase of a flight

To create a mapping flight for the systematic coverage of an area use the automatic mission planning feature of *eMotion X*. By simply positioning a rectangle around the area you would like to cover, *eMotion X* will generate a mission plan optimised for the ground resolution that you desire.

Note: For more complex terrain and missions, *eMotion X* has the ability to set polygonal mission areas of any size and shape, and to automatically adjust waypoint altitudes based on elevation data.

Follow these steps to automatically setup waypoints for a mapping mission:

1. Select the Mission Planning tab from the Sidebar. A grey zone will appear in the Map Area to designate the mission area to cover. Information such as size and position is overlaid on the area. A mission plan, including the required waypoints, is automatically calculated and displayed to preview the mission plan that will be created.

2. Adjust the location, size, and shape of the mission area. The area can be relocated by dragging the gray zone. The four square handles on the edges of the area can be used to resize it and the round handles on the corners of the area can be used to rotate it. As you adjust the area the mission plan preview is continuously updated.

3. Adjust the mapping and mission parameters in the Mission Planning tab to suit your terrain and quality requirements.

4. Check the resulting flight characteristics in the tab. Once you are satisfied, assign the mission plan to the drone by clicking the Assign button.

5. Click the button in the Toolbar to to toggle 3D mode on and off. Review the flight plan to ensure that there is sufficient clearance between the flight plan and the ground.

Caution: *eMotion X* as well as the automatic mission planning tool are not aware of any obstacles that may exist in the area. In addition, when not using elevation data, the mission planning tool assumes that the mission area is flat and at the same altitude than the take-off location. It is also not aware of any legal restriction (such as minimum or maximum altitude) that may exist in your region. The resulting flight plan should be carefully reviewed in order to avoid any collision with uneven terrain or tall objects such as buildings, and to comply with local regulations.

1.6.1 Getting ready for a mission

Before leaving for the field to perform a flight, be sure to fully charge all your *eXom* batteries. When delivered, the *eXom* battery may not be fully charged.

To charge *eXom*'s battery pack, connect it to the battery charger provided.

The charger provided independently balances the voltage of each of the cells contained in the battery pack to ensures optimal performance and battery life.

If you plan on performing a flight away from an Internet connection it is useful to pre-load map tiles by selecting 'Download maps...' from the File menu. More details on how to take advantage of the various map sources available in *eMotion X* can be found in section 'Toolbar' on page 71.

1.6.2 How to pick the *eXom* up

Caution: Switch the *eXom* off before picking it up. Never attempt to pick the *eXom* up while the propellers are turning.

The *eXom* has been designed to be picked up one-handed at the narrowest point on the central body.

2 Executing a flight

Goal of this section: This section describes how to prepare your *eXom* for flight, take off, monitor and control from the air, and initiate an autonomous landing.

Note: We recommend that you perform your first flight in a large obstacle-free area and limit the length of the mission in order to familiarise yourself with the *eXom* in flight.

2.0.3 Preparing the *eXom* for flight

The *eXom*'s advanced yet simple design means it can go from the box to being ready for flight in minutes. We recommend that you perform the following steps before every flight to ensure that the platform is best prepared for flight.

2.0.4 Pre-flight checklist

- Weather checked.
- Propellers attached.
- Charged *eXom* battery installed.
- Fresh AA batteries in the remote control.
- General inspection complete.
- Drone powered on.
- Drone connected to *eMotion X* through the ground modem*.

* If you only intend to fly manually, although a connection to *eMotion X* is not necessary, it is highly recommended for flight monitoring and drone location tracking.

- Main camera and thermal camera are ready to capture images and video.
- Images are successfully streaming from all navcams.
- Ultrasonic sensors are all working correctly.
- Takeoff zone is free of obstacles.
- An appropriate working area has been set.

2.0.5 Weather check

Before each flight, you should be aware of the weather conditions. The *eXom* is a small drone that cannot fly in heavy rain or strong wind conditions. In case of doubt, make sure to check a weather bulletin including wind estimations in the flight area. Note that wind is often stronger at higher altitudes and that the wind perceived at the surface is not always a good reference to estimate the wind at flight altitude. Cloud velocity or tall tree movements can help you to estimate the wind speed once you are out in the field.

Weather forecasts may use various units to measure wind speed. As a reference,

Caution: Do not fly *eXom* missions if the wind speed exceeds 8 m/s (29 km/h, 18 mph, 16 kts).

Caution: The *eXom* is not designed to fly in temperatures above 40° C. Avoid exposing the drone to high temperature for prolonged periods of time. In particular, leaving the drone exposed to the sun or in a car should be avoided.

2.0.6 Flying conditions

Avoid flying the *eXom* in the following conditions:

- In high winds.

- When there is precipitation, for example, rain, snow or hail.
- In very dusty conditions.
- If sand is being blown into the air.
- In very low light conditions.

2.0.7 Landing conditions

Do not attempt to land the *eXom* on the following:

- Area with less than 1 m clearance on all sides of the *eXom*.
- Surface that does not allow all 4 feet to contact the ground.
- Muddy, wet, dusty or sandy area.
- Into water or deep snow.
- A steeply inclined surface.

2.0.8 How to install the *eXom*'s battery

Place the *eXom* on the ground or on a level surface in the vicinity of the take-off location. Slide the battery firmly into the battery compartment, making sure that it clicks into place.

Caution: Take care to keep clear of the propellers, in case they unexpectedly start spinning.

Note: Only insert the battery when you are ready for start-up. Oo not leave the battery connected for extended periods of time when the drone is on the ground, as this may discharge the batteries and cause irreparable damage to them.

2.0.9 How to power on the *eXom*

Press the power button. The *eXom* will perform an automatic self-check of its sensors and acquire satellite signals. Do not move the drone during these tests. It is important that the drone is not inclined more than 10 degrees in order to start up properly. Pre-flight checks may last from a few seconds to several minutes in the case of poor satellite signal reception.

Note: Satellite positioning signals are not required for manual flight using the remote control. If the satellite check fails, you can still fly manually, but with only limited assistance from the drone.

Caution: Do not attempt to use *eMotion X* to fly *eXom* in areas where satellite positioning signals (GPS/GLONASS) are unavailable, for example, indoors.

Note: If there was any problem during the pre-flight checks performed by the drone this will be indicated by a Pre-flight error in *eMotion X*.

2.0.10 How to connect to *eMotion X*

Start by connecting the USB ground modem to your computer. Then launch *eMotion X*, which will display the Connection window. Select the *eXom* connection profile, choose the corresponding FTDI port and click 'OK'.

Note: Every *eXom* is paired with the ground modem it is delivered with, and will only work with that particular modem. The name of the FTDI port corresponding to the ground modem is labelled as '*eXom*-SERIAL', where SERIAL is the serial number of the drone it is paired with.

Once your drone has set its position using satellite signals, an icon of the drone

will appear at its location on the map. If the drone's location is not on the map you can click the button from the Toolbar to centre the map on the drone.

2.0.11 How to change the remote control's batteries

1. The battery cover is on the back of the remote control. Slide the battery cover off.
2. Remove any used batteries.
3. Replace them with fresh batteries, following the polarity (+/-) indication on the inside of the battery compartment.
4. Replace the battery cover.

Caution: Always change all the batteries at once. Do not mix fresh and used batteries.

2.1 General inspection

A general inspection should be performed before every flight. It is also good practice to perform a full airframe check regularly to keep your *eXom* in good shape. See section 'Full inspection' on page 87 for more details.

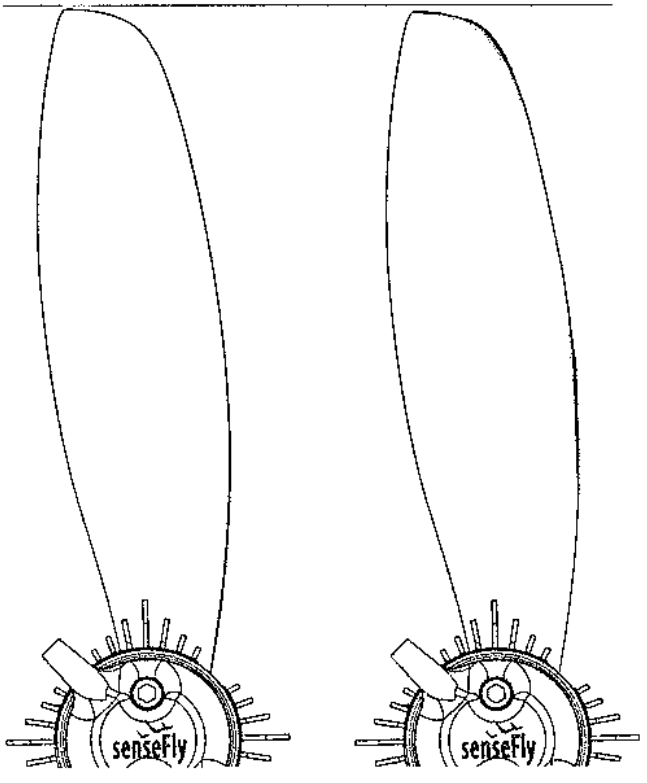
2.1.1 Visually inspect the drone

The sensors and lenses must be clean and unobstructed for them to work correctly.

- Remove the battery from the drone.
- Pick the drone up from above, holding the central body at its narrowest point.

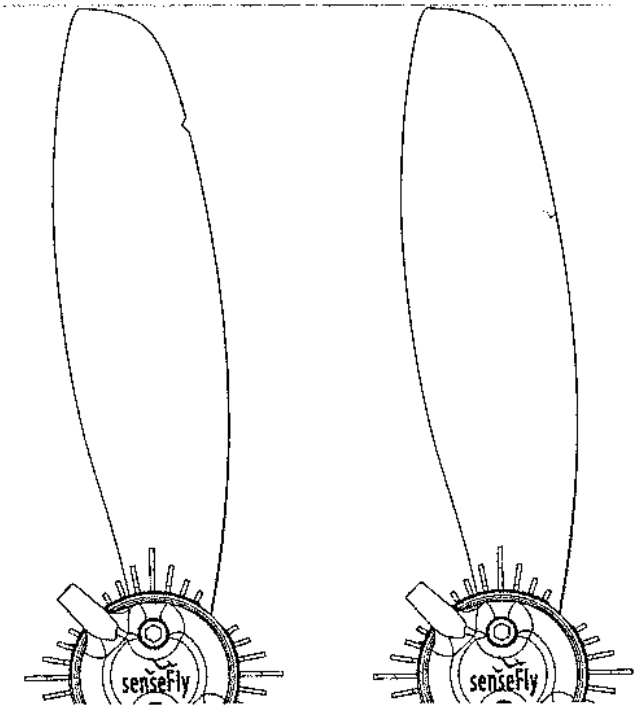
- Visually inspect each of the 5 vision sensors.
- Visually inspect the 5 ultrasonic transmitters and receivers.
- Visually inspect the main camera.
- Visually inspect the thermal camera.
- Check that all propellers are properly locked on.
- Check that the legs are in good condition and properly attached with their caps in place.
- Check that the shrouding is in good condition and properly attached at the leg clips.
- Check that the top cover is attached and in good condition.
- Ensure that nothing is at risk of touching the spinning propellers.
- Check that the *eXom*'s main body is in good condition.
- Check that the *eXom*'s head is undamaged and turns freely on both axes.
- Check that all LEDs and strobes are clean and free of obstacles.
- Replace the battery, ensuring it clicks into the battery compartment.

2.1.2 Visually inspect the propellers



New propeller:
OK to fly

Worn propeller:
replace



Damaged propeller: Replace

Cracked propeller: Replace

- Replace propellers that are considerably worn down.
- Replace propellers that have many deep indentations on their leading edge.
- Replace cracked propellers.

2.1.3 Check sensor and camera operation

- Insert the drone's battery.
- Holding the drone's central body from above at it's narrowest point, place it on the ground and power it on.
- Launch *eMotion X* and connect to your drone.

- In *eMotion X*, switch to interactive mode.
- **Check the vision sensors.**
  Click to activate each vision sensor and view the resulting video feed.
- **Check the bottom sensor module's ultrasonic sensor.**
  View the bottom sensor module's distance reading in *eMotion X*. It should show that the ground is close to the sensor.
- **Check the front, left, right and rear sensor module's ultrasonic sensors.**
  Walk in a circle around your drone, about 2 m away from it, while viewing the sensor module readings in *eMotion X* (for example, with your computer and ground modem in your hands).

  The sensor display in *eMotion X* should show that there is an object approximately 2 m away from each sensor in turn.
- **Check the main camera.**
  View the main camera's video feed.
- **Check the thermal camera.**
  View the thermal camera's video feed.

2.1.4 Pre-flight remote control check

If you plan to use the remote control during a flight we recommend that you check it before flight.

1. Place the drone in a safe and suitable take-off location.
2. Insert the battery and power on the drone.
3. Launch *eMotion X* and connect to the drone.
4. If you are not comfortable piloting the drone will only basic assistance, switch Extended Assistance on in the Flight Parameters tab.

5. Switch the remote control on.

6. Slide the take off/land slider up. The drone will take off. Allow it to spin around once to calibrate its compass.

7. Use the remote control to carry out some small, simple manoeuvres (yaw, tilt, climb, descend).

8. Slide the take off/land slider down. The drone will land.

9. Turn the remote control off.

Caution: If you detect a problem with the remote control, land the drone immediately. If you cannot land with the remote control, click LAND NOW in *eMotion X*. Do not attempt to fly with a malfunctioning remote control.

Caution: Always keep the area around the propeller clear of obstacles and body parts to prevent injury.

2.1.5 How to set the working area

- Launch *eMotion X* and connect to your drone.
- In *eMotion X*, click and drag the working area so that its centre is at the position you want.
- Click the Parameters tab.
- Set the working area radius.
- Set the working area ceiling.

2.1.6 How to remove the battery

1. Grip the battery release tabs and squeeze them together.
2. Pull the battery out.

Caution: Never try to remove the battery while the propellers are turning.

2.2 About mission planning

Use *eMotion X* to build the mission blocks, waypoints and optionally, the actions that you want your *eXom*'s to carry out during the mission.

eXom missions consist of one or many mission blocks. Each block can have a different setup phase, a different purpose and you can assign each block to a different drone. A mission might include, for example, several blocks for inspecting several surfaces and objects, and a horizontal mapping block to gather mapping data of the surrounding area.

2.2.1 The setup phase of a flight plan

The setup phase of a mission block includes the following locations:

- **Take-off location:** The point from which the drone takes off, automatically set to the location calculated from satellite positioning signals (GPS/GLONASS) by the drone when it is powered on. This location defines the altitude of 0 m/ATO (ATO stands for above take-off); the altitudes of all other waypoints, when defined in m/ATO, are referenced to the altitude of this location.
- **Start waypoint:** The first point that the drone flies towards when the mission is launched.

- **Home waypoint:** The safe point for the drone to return and hover in case of emergency. The drone will land directly below this waypoint at the end of an autonomous flight.
- **Mission waypoints:** The series of waypoints that define the mission.

Immediately after take-off the drone will climb to an altitude of 1 m.

- **If the first mission block is a mapping block**
  The drone pauses briefly then flies to the start waypoint and follows the flight plan you have set up.
- **If the first mission block is not a mapping block**
  The drone hovers, awaiting your command.

Caution: The drone's ability to maintain its position in a hover depends on the conditions. There must be good lighting conditions and good satellite positioning signal reception.

Caution: If you are using only the basic level of manual assistance, you must be prepared to take immediate control of the drone as soon as it reaches 1 m above the ground. It will not stabilise itself.

2.2.2 About mission blocks

Mission blocks have the following properties:

- **Description**
  The name you have given to the block.
- **Area**
  The surface area of the block.
- **Resolution**
  The ground resolution that you want the images captured to have.

- **Overlap**
  The percentage you want one image to overlap the next.

- **Use elevation data**
  Check this checkbox to have *eMotion X* automatically set mission height according to elevation data.

- **Reverse flight direction**
  Check this checkbox if you want your drone to fly the mission in the opposite direction to the one chosen automatically by *eMotion X*.

- **Perpendicular lines**
  Check this checkbox if you want to double the number of images and increase overlap by flying a second set of flight lines perpendicular to the first.

2.2.3 How to create a mission block

In the Mission Planning tab, click ✚ Add mission block and choose the type of block:

- **Horizontal Mapping**
  Define a mission polygon and *eMotion X* will automatically set out the waypoints and flight lines.

2.2.4 How to edit a mission block

1. Click ❯ to expand the mission block you want to edit.
2. Click ✎ Edit.
3. Edit the mission block fields.

2.2.5 How to assign a mission block to a drone

1. Click .
2. Choose the drone that want to carry out that mission block.

2.2.6 How to remove a mission block

1. Click to expand the mission block you want to edit.
2. Click .
3. Choose Remove.

2.2.7 Choosing a take-off location

It is important to carefully select the place you take off from, the Start waypoint and the Home waypoint to ensure your drone remains at a safe distance from obstacles.

Select a take-off location clear of obstacles (buildings, rocks, power lines, hills, trees, etc.) within a distance of at least 10 m in the all directions.

2.2.8 Landing and the home waypoint

The Home waypoint is used both as the location under which the drone will land in Fully Autonomous mode and as a safety position in case of an in-flight warning.

Caution: The ground sensor can only provide usable feedback in daylight conditions above flat terrain that contains enough visual texture. If these conditions are not met the drone cannot ensure a safe landing.

The precision of the landing will depend on the satellite positioning accuracy, lighting conditions, the ground's visual texture and the wind. Define a security

perimeter around the landing point. Place the Home waypoint in a location that has no obstacles within a radius of 10 m to give the drone enough space to land. Ensure that the entire landing area is flat to allow the ground sensor to function properly.

By default, the Home waypoint is set to an altitude of 75 m/ATO. In case a Go to Home Waypoint procedure is triggered during flight[1] the drone will, by default, determine the highest altitude between its current altitude and the Home waypoint's altitude, and climb towards that highest altitude (if required). Once it reaches this highest altitude it will then fly towards the Home waypoint.

Due to this behaviour, the altitude of the Home waypoint should be selected with care; it should be at least 20 m higher than the surrounding obstacles to avoid the risk of a crash, but should not be set too high to reduce the effect of potentially high winds and altitude and to prevent the drone from getting lost. Alternatively, you can change the altitude transition behaviour within the Setup Phase tab. See section 'Waypoints and their properties' on page 65 for more information on altitude transition behaviours and how to modify them.

2.2.9 Take-off and start mission

Once you've planned your mission and the *eXom* status LED is solid green your drone is ready to take off.

- Click TAKE OFF on the Control Bar.
- Allow the drone to take off and calibrate its compass (it spins around once).
- Click START MISSION.

Caution: Keep clear of the drone during take-off.

Caution: Never attempt a hand-held take-off.

[1] either automatically due to an In-flight warning or manually using *eMotion X*

After take-off, the drone switches into waypoint navigation mode and flies to the Start waypoint, then proceeds with the mission.

2.2.10 Landing after a mission

After finishing its mission the drone will return to the Home waypoint and automatically initiate a landing sequence. Once on the ground, the propellers will stop.

The vision sensors must have sufficient light and texture to accurately detect the drone's height above the ground. Ensure that the sensors are clear of dirt or other obstructions. Ensure that there is a high-contrast surface in the landing zone. Do not attempt to land on low-texture surfaces such as snow or clean sand.

Disconnect the battery from the drone before picking it up. We recommend you immediately import the images and flight data after each flight (see section 'Importing images and flight data' on page 62) before putting the *eXom* back in its case for storage.

2.2.11 Emergency landing

Return to home and land

If you need to abort the mission and land, for example, in case of an emergency, click GO LAND on the control bar.

The drone will immediately fly in a straight line to the Home waypoint, then descend vertically, land and power off its motors.

Caution: In most circumstances, we recommend setting the Home waypoint to be the highest waypoint in the mission. This reduces the risk of collision as the drone returns to the Home waypoint.

Land immediately at current location

If you need the drone to land immediately without first returning to the Home waypoint, do one of the following:

- Rapidly click the LAND NOW button on the Control Bar three times (triple-click).
- Switch on the remote control and pilot the drone to the ground.

Caution: If you decide to switch on the remote control, make sure you have the level of assistance you are expecting - basic or extended.

Caution: The drone will immediately descend at a moderately fast rate of descent. There is a high risk of collision with any objects or people that are directly under the drone.

3 Manual control of the *eXom*

Goal of this section: This section describes how to use the remote control to manually control the drone, with basic or extended manual assistance.

Caution: Manual operation of the *eXom* requires a moderate level of piloting skills. We recommend several practice flights, especially with only basic assistance, before you first inspection mission.

3.1 About the remote control

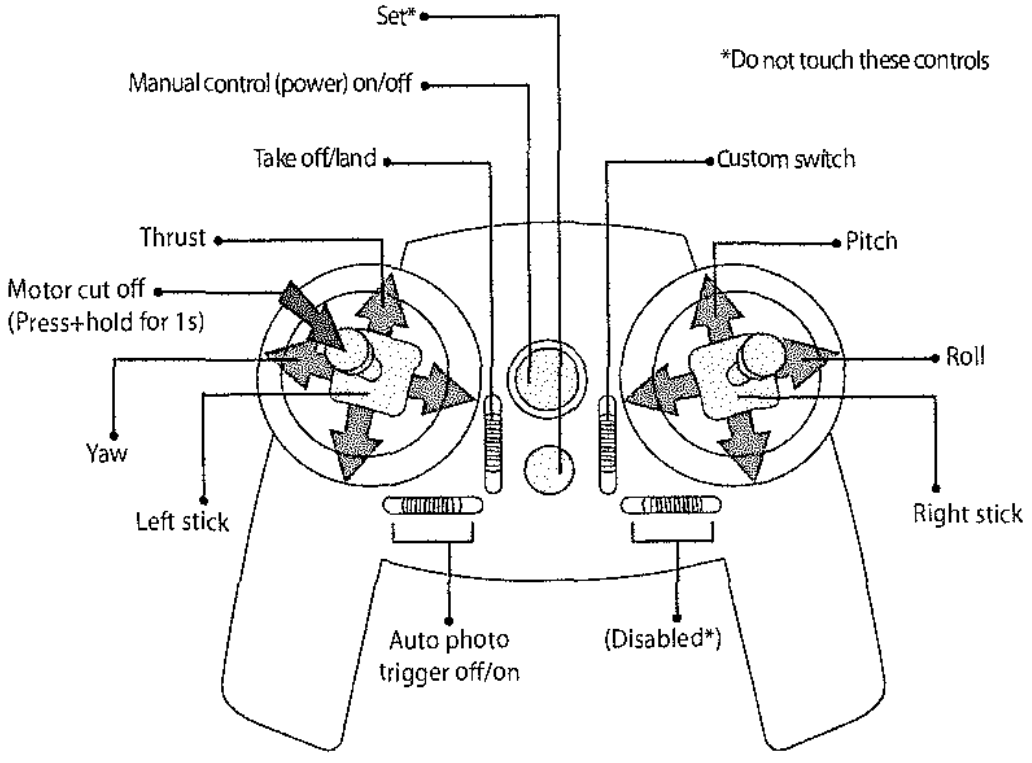
By using the remote control, it is possible to override the drone's autopilot and fly manually. With extended manual assistance, the sticks of the remote control are used to send commands to the drone, which acts on those commands while maintaining stable flight. Without only basic manual assistance, the sticks of the remote control directly set the motors' thrust.

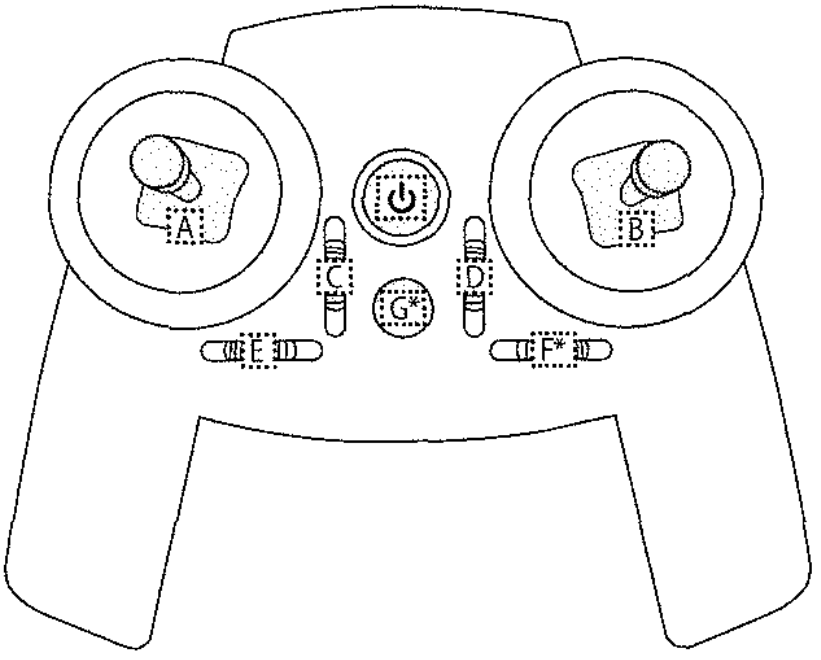
Caution: Do not turn the remote control on without it being held in the hands of a pilot who is ready to take immediate manual control of the drone. Turn the remote control off before putting it down.

Caution: The remote control emits an audible low-battery warning. If you hear this warning, take action immediately; land your drone and change the batteries.

Manual control of the *eXom* can be achieved at any time if the drone is within range of the remote[2].

[2] see section 'Drone specifications' on page 107 for the range of the remote control


Set*
*Do not touch these controls
Manual control (power) on/off
Take off/land
Custom switch
Thrust
Pitch
Motor cut off
(Press+hold for 1s)
Roll
Yaw
Left stick
Right stick
Auto photo
trigger off/on
(Disabled*)



3.2 About flight assistance

There are 2 levels of flight assistance:

- Basic assisted manual control
- Extended assisted manual control

With extended manual flight assistance, the sticks on the remote control set the desired speed, pitch, turn rate and climb or sink rate. These commands are then transferred to control signals for the propellers by the autopilot based on feedback from its sensors. This control scheme simplifies control of the *eXom*.

Manual flight without assistance allows you to have direct control over the *eXom*'s propellers, overriding control from the on-board autopilots. The left stick controls the thrust and yaw. The right stick controls pitch and roll. The drone only assists with maintaining a flat pitch/roll.

Caution: Although assistance is provided, the pilot must still be aware of obstacles in the area, the drone's proximity to the ground, the inversion of control commands when the drone is flying towards the pilot and the distance between the drone and the pilot.

3.3 How to change assistance level

Choose Manual control mode from the Parameters tab in the sidebar.

3.4 Using the remote control

The following table describes the drone's response to your inputs on the remote control.

- Push forward on a stick means push the stick away from you (or up in the above diagram).
- Pull back on a stick means pull the stick towards you (or down in the above diagram).
- Release a stick means let go and let the stick spring back into its neutral position.
- To press on a stick means push down on the top of the stick, along the stick's axis. You will feel a click.
- Turn (yaw) direction is given as if you were on board the drone (from the drone's frame of reference).

Table 1: Remote Control Functions

Item	User's action	Drone's response	
		Extended assistance	**Basic assistance**
A: Left stick	Push forward	Climb	Increase thrust
	Pull back	Descend	Decrease thrust
	Push left	Rotate left	Yaw to left (port)
	Push right	Rotate right	Yaw to right (starboard)
	Release	Maintain altitude	Neutral thrust
	Press+hold (1 s)	Motor cut off	
B: Right stick	Push forward	Fly forward	Pitch forward
	Pull back	Fly backwards	Pitch backward
	Push left	Fly left	Roll to left (port)
	Pull back	Fly right	Roll to right (starboard)
	Release	Maintain level flight	Flat pitch/roll

	Press	No response	No response
A+B: Both sticks	Release	Hover	Neutral thrust
C: Take off/ land	Push forward	On the ground: take off While landing: abort landing	
	Pull back	Land While taking off: abort take-off	
D: Custom	Push forward	User defined	
	Pull back	User defined	
E: Auto photo sequence	Push left	Off	
	Push right	On	
F: Disabled	Do not use		
G: Set	Do not press		

Caution: Flying with the remote control, especially with only basic manual assistance requires some piloting experience.

3.5 Take-off with manual flight

1. Prepare the drone for flight as described in section 'Preparing the *eXom* for flight' on page 33 while keeping the remote control turned off.
2. Take the remote control in your hands and switch it on. Leave the sticks alone, in their neutral position.
3. Place the *eXom* in its take-off location and power it on using the power button. The status LED will indicate the progress of the drone's autopilot's start-up sequence.
4. Push the take off slider (C) on the remote control up. The drone will climb to 1 m.
5. Leave the sticks alone while the drone spins around once to calibrate its internal compass.

With extended assistance:

The drone will hover awaiting commands from the remote control.

With only basic assistance:

You have full manual control of the drone. You must immediately adjust the drone's position using the remote control.

Note: Although it is possible, do not use the remote control to take control of the drone before compass calibration is complete. Flying an uncalibrated drone can result in it rotating (yawing) unexpectedly.

3.5.1 Manual landing

Caution: We recommend you perform a standard landing procedure using *eMotion X* whenever possible.

Pilot your drone down to the ground. Approach the ground at low vertical speed. Once on the ground, press and hold the left stick for 1 s to stop the motors.

3.5.2 Motor cut off

Pressing the left stick down until it clicks and holding for 1 s will cause the *eXom*'s motors to stop.

Caution: Only stop the motors when the drone is on the ground. Always stop the motors before picking the drone up.

Caution: If the drone is in the air, only use this feature in an absolute emergency. The drone will immediately drop out of the sky and risks damaging or injuring anything or anyone beneath it. Even at low altitude, using this feature will cause irreparable damage to the drone.

3.5.3 How to take manual control of the *eXom* in-flight

Caution: Make sure that the level of manual assistance you want is activated in *eMotion X*'s Parameters tab.

If your drone is already in the air, switch the remote control (RC) on. You will immediately have remote control of the drone.

3.5.4 How to climb using the remote control

Push the left stick up and the drone will climb.

3.5.5 How to hover using the remote control

Release both sticks, allowing then to spring back to their central position. The drone will maintain a hover.

Caution: If you have selected only basic manual assistance, you must maintain the drone's position and altitude manually using the remote control.

Caution: If your drone is at altitude in a zone that has little or no satellite positioning signal coverage, extended manual assistance will not be able to automatically maintain a hover. You must use the right and left sticks to maintain a hover manually.

3.5.6 How to yaw using the remote control

Push the left stick to the right to turn the drone on its axis to the right (clockwise when viewed from above).

Push the left stick to the left to turn the drone on its axis to the left (anticlockwise when viewed from above).

3.5.7 How to fly forward using the remote control

Release the left stick, allowing it to spring back to its central position. Push the right stick up and the drone will tilt and fly forward.

Caution: By releasing the left stick with extended manual assistance, you are instructing the drone to maintain its altitude. With only basic assistance, you must use the left stick to provide enough additional thrust to maintain altitude.

3.5.8 How to tilt and fly to the left or right using the remote control

Release the left stick, allowing it to spring back to its central position. Push the right stick to the left or right and the drone will tilt and fly in that direction.

Caution: By releasing the left stick with extended manual assistance, you are instructing the drone to maintain its altitude. With only basic assistance, you must use the left stick to provide enough additional thrust to maintain altitude.

3.5.9 How to stop the propellers using the remote control

Press the left stick down and hold for 1 s.

Caution: Only stop the propellers once the drone has landed or in an emergency. Stopping the propellers while the drone is in flight will cause it to fall out of the sky.

3.5.10 Returning control to *eMotion X*

To return control to *eMotion X*, press the power on/off button to switch the remote control off.

3.6 In-flight monitoring and control

You can monitor and control your drone while in-flight through *eMotion X* using the map, video streams, ultrasonic sensor readouts and the Flight Monitoring tab in the Sidebar.

The Map Area displays the current position of your drone, updated live as the drone executes its flight.

Note: All waypoints, image locations and flight paths displayed in *eMotion X* are a reflection of the data contained within the drone autopilot. If at any point the connection between *eMotion X* and the drone is lost, the drone will by default continue its planned flight, including the imaging mission and the selected automatic landing, fully autonomously. If you would like the drone to return to the Home waypoint instead of continuing its mission when it detects a loss of connection you may set the appropriate parameter in *eMotion X*.

During the Mission phase of an autonomous flight the *eXom* will automatically take pictures at pre-defined moments based on the parameters that were defined during mission planning.

At the top of the Map Area is the Control Bar, which can be used at any time to send commands to your drone as well as to acknowledge warning and failure messages if they occur. During a fully autonomous flight the *eXom* will control its flight autonomously from take-off to landing and you do not need to use any of the control buttons. They can however be useful in unexpected situations to temporarily hold position by pressing the HOLD button or to send the drone to the Home or Start waypoints with the 'GO TO HOME WPT' or 'GO TO START WPT' buttons, respectively. Detailed descriptions of the buttons and their effects on the drone are described in section 'Control Bar' on page 73.

3.7 Powering your *eXom* off

Wait for the propellers to stop spinning, then press the power button on the top of the *eXom*.

Caution: Never attempt to power the drone off using its built-in power button while the propellers are spinning.

3.8 About in-flight errors

The drone can encounter two types of error messages while flying: In-flight warnings and Critical failures. In-flight warnings typically indicate a dangerous situation such as a low battery or strong winds and typically result in a Security action such as a return to the Home waypoint. Critical failures occur only when the drone's ability to fly is severely compromised, such as a loss of satellite positioning signals or an empty battery. When a critical failure arises, the drone will immediately perform an emergency landing.

Caution: We recommend that you familiarise yourself with the possible in-flight errors to have a better understanding of what happens if they occur in the field. A full list of possible In-flight warnings and Critical failures and the drone's reaction to them is described in section 'In-flight warnings' on page 93 and section 'Critical failures' on page 96.

Note: It is important to keep track of the location of the drone during a Critical failure until the moment it reaches the ground. Its position's coordinates can aid in finding it afterwards. Instructions on how to find a lost drone can be found in section 'Losing and locating your *eXom* in the field' on page 101.

4 Processing image data

4.1 Importing images and flight data

The next step to creating mapping products, after completing a flight, is to import the raw images and log files to a computer.

eMotion X features a Flight Data Manager to help you transfer and consolidate all the data related to a mapping mission. Open the Flight Data Manager by clicking on the Flight Data Manager icon when you load *eMotion X*. Alternatively, click on the button in the Toolbar and select 'Flight Data Manager...'

Follow these steps to import data from the drone:

- **Step 1 - Select a flight:** If the flight was monitored from the computer you are using to import images then the flight is saved within the local database. Select the date that the flight took place. A list of flights (including number of images taken) from that date will appear in the combo box, select the one you wish to import.
- **Step 2 - Create a directory:** Choose a directory name that uniquely identifies your flight (e.g. the date, the name of the area, etc.).
- **Step 3 - Prepare data for import:** Remove the SD card from the drone and insert it into your computer's SD card slot. A new storage drive will appear on your computer.

  Select 'Import from SD-card reader'. Alternatively, transfer the images from the camera by lifting it out of its compartment just enough to connect a USB cable to it and turn the camera on. Copy all the images into a temporary folder on your computer. Select 'Import from a specific folder' and choose the temporary folder.
- **Step 4 - Import flight logs:** Confirm that the Drone and eMotion Flight Logs found by the Flight Data Manager are correct. You may select logs manually if they are not correctly detected.

- **Step 5 - Import images:** Confirm that the images corresponding to your flight were found and matched to the Drone Flight Log correctly.
- **Step 6 - Select outputs:** Choose the output actions to execute and files to create. Geo-tagging images is necessary to create geoinfo, KML and *Postflight Terra 3D* files.
- **Step 7** Eject the SD-card drive before removing the SD-card. You can now open the KML file in *Google Earth™* or the project in *Postflight Terra 3D* for further processing.

4.2 In-field image quality check

Postflight Terra 3D software[3], available as a free download with the *eXom* package, can be used to rapidly create a Quality Report directly in the field. The Quality Report that is automatically generated as well as the orthomosaic provide immediate feedback on the quality of the images gathered during your mission.

You can open a project for processing in *Postflight Terra 3D* directly from the Flight Data Manager after importing your data by clicking the 'Open project in Terra' button. You will now see the main *Postflight Terra 3D* window. The position of your images will appear as red dots in the Map Area of *Postflight Terra 3D.*

After importing flight data and images you can create a *Postflight Terra 3D* project by following these steps:

1. Launch *Postflight Terra 3D* and start the New project wizard by selecting 'New project' from the 'Project' menu.
2. Select the same folder in which you saved the images and Drone Flight Log as the location for the project (the 'Create in' field). Choose a name for your project, preferably the same as the name of the folder and select the 'New project' button. Click 'Next'.
3. Add the images taken during your last *eXom* mission. Click 'Next'.

[3] powered by Pix4D; see section 'Installing *eMotion X*, *Postflight Terra 3D*, and the ground modem drivers' on page 26 for installation instructions

4. Load the geolocation data from the Drone Flight Log file (with extension .bbx) by clicking on 'From file...' and selecting the file. Click 'Next', then click 'Finish' in the next screen. You will now see the main *Postflight Terra 3D* window. The position of your images will appear as red dots in the Map Area of *Postflight Terra 3D*.

To create a Quality Report while in the field bring up the local processing panel by selecting 'Local processing' from the 'Process' menu or by clicking the icon in the Toolbar. Select only the 'Initial project processing' checkbox and the 'Rapid' button. If you wish to create a low-resolution orthomosaic while generating the report, check the 'Orthomosaic and DSM generation' checkbox. Click 'Start' to begin rapid processing.

Postflight Terra 3D will now process the data and produce a report that includes the overall completeness and georeference quality of the images taken during your last mission. You may use this information to decide whether further imaging flights are required while you are still in the field. The quality report will be displayed in a new window (click the icon in the Toolbar if it does not appear).

Part II
Advanced functionalities

4.3 Waypoints and their properties

The *eXom* uses a flight plan consisting of a list of waypoints to navigate. A waypoint essentially consists of a circle about a given position and information that defines how the drone should behave when reaching them. The entire list of waypoints is stored in the drone autopilot and can be remotely edited using *eMotion X*.

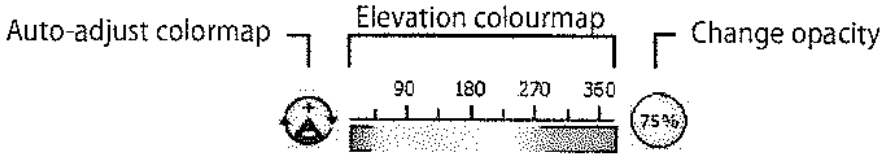
In *eMotion X* every waypoint is defined by the following parameters:

4.4 3D mission planning using elevation data

In Fully Autonomous mode, *eMotion X* has the ability to take into account elevation data to set the altitude of mission waypoints and the resulting flight lines of a mapping mission. This not only improves the resulting ground resolution but also increases mission safety (particularly in uneven terrain) by keeping a more even height between the drone and the ground.

You can display elevation data by clicking on the button in the Toolbar. *eMotion X*'s default Improved SRTM elevation data will be downloaded as tiles from senseFly's servers and overlaid above the map as a colourmap[4]. You can adjust the scale and opacity of the colourmap by using the associated buttons in the bottom-right corner of the Map Area.

[4] *eMotion X* must be connected to the internet. Once downloaded, elevation tiles are cached and can then be used off-line.



Caution: *eMotion X*'s default Improved SRTM elevation data uses a 3 arc-second (approx. 90 m resolution) digital elevation model derived from the SRTM (Shuttle Radar Topography Mission) dataset version 2.1 combined with other data sources (ASTER GDEM, SRTM30, cartographic data, etc.). This data covers nearly all emerged land except the territories below 56° S latitude and the territory of the Russian Federation above 60° N latitude. This data may contain inaccuracies of several meters, and does not contain data on obstacles such as buildings or trees. We highly recommend that you check your flight plan thoroughly, in 2D and 3D, to ensure sufficient clearance between the flight plan and the ground. SenseFly Ltd provides no guarantee regarding the accuracy of the elevation data and it is the operator's sole responsibility to ensure a safe flight trajectory and altitude.

Activate the 3D mission planning feature by selecting the 'Use elevation data' parameter in the mapping mission block. Elevation data is used to adjust every mission waypoint altitude as follows:

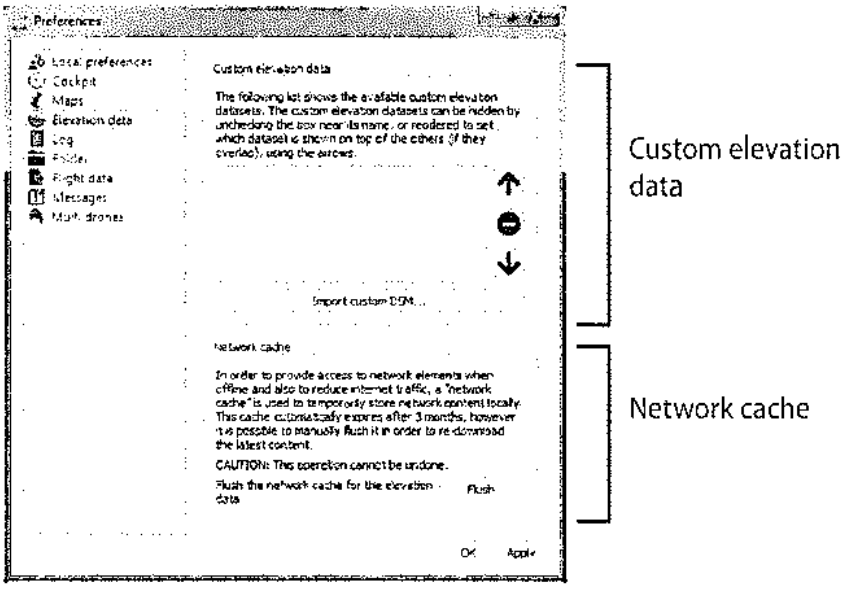
1. The flight planner uses elevation data to find the maximal terrain elevation under the current waypoint, the previous waypoint and the flight line that connects the two.
2. This maximum value is increased by the target altitude value, and the result is set as the altitude of the current waypoint.

One way to increase the resolution and accuracy of the elevation data is to fly a first mission at high altitude and then create a dataset using *Postflight Terra 3D*. You can then automatically import the data into *eMotion X* by selecting 'Send DSM to eMotion' from the 'Process' menu within *Postflight Terra 3D*. The dataset can

then be enabled using the menu in the Toolbar. *eMotion X* will use this custom dataset (wherever it is available) to set waypoint altitudes instead of its default Improved SRTM elevation data.

Note: It is recommended to visually compare imported elevation datasets with the default Improved SRTM elevation layer of *eMotion X* in order to detect possible mismatches. This comparison should be done with a colourmap opacity value of 100%.

More advanced controls of imported datasets are available in the 'Elevation data' panel of the Preferences pane of the menu. From this panel you can add, remove, activate/deactivate or reorder overlays. *eMotion X* uses the top-most elevation data layer to calculate altitude for each waypoint and flight line, with *eMotion X*'s default Improved SRTM elevation dataset always considered the bottom layer.



4.5 Flight visualization in *Google Earth™*

eMotion X includes an interface with *Google Earth™* to help with flight plan verification and visualization, particularly in uneven terrain. Clicking on the button in the Toolbar will open *Google Earth™* and zoom to the current position of the drone. The current position of drone, its planned trajectory, the working area circle and all waypoints currently uploaded to the drone (including Take-Off, Start and Home) are displayed within *Google Earth™*. Any changes to waypoints or flight parameters within *eMotion X* are updated accordingly within *Google Earth™*.

The interface with *Google Earth™* is particularly useful to check the drone's trajectory with respect to obstacles in the area[5]. The flight plan is projected onto the ground in a darker colour, giving you an idea of the distance between the flight path and the ground. If you connect to a simulated drone you can simulate the entire flight and follow the drone within *Google Earth™*.

Note: To use this feature *Google Earth™* has to be installed on the ground station PC, as described in section 'Installing *eMotion X*, *Postflight Terra 3D*, and the ground modem drivers' on page 26. We recommend to use the latest version of the *Google Earth™* software.

Caution: A flight trajectory visualized in *Google Earth™* represents the planned trajectory. The real flight trajectory can be different from the planned due to flight conditions such as strong wind.

Caution: The terrain data within *Google Earth™*, including hills and buildings, may contain significant errors. When planning flights over uneven terrain be sure to keep sufficient distance between the flight plan and the terrain.

[5] While checking flight plans in *Google Earth™* is a good safety practice, senseFly Ltd provides no guarantee regarding the accuracy and completeness of the *Google Earth™* terrain model.

- Once it reaches the Home waypoint (if it has been instructed to return there) the drone will either:
  - begin its landing procedure
  - hover at the Home waypoint until it receives a command.
- After completing a landing procedure and detecting that it has successfully landed, the drone switches its motors off and enters idle mode.
- Turning on the remote control will cause the drone to fly under manual control. Turning off the remote control will return control of the drone to *eMotion X* and its autopilot.
- Clicking the 'HOLD POSITION' button in the Control Bar at any time will cause the drone to hover until it receives a new command from the Control Bar. Alternatively, right-clicking in the Map Area and selecting 'Hold here' will direct the drone towards that position and hover there. This will also happen automatically after certain In-flight warning or Critical failure conditions[7].
- Clicking the 'LAND NOW' button in the Control Bar three times in quick succession will cause the drone to immediately initiate a landing procedure at its current location.

[7] see section 'Troubleshooting' on page 92 for a full list of In-flight warning and Critical failure conditions and the subsequent reactions of the drone

5 *eMotion X* in-depth guide

Goal of this section: *eMotion X* is a powerful tool designed specifically to work with your senseFly drone.

This section includes a comprehensive guide to all the functionalities in *eMotion X* to help you plan and monitor your next mapping flight.

The main *eMotion X* interface is composed of a main panel, a Toolbar and a Sidebar[8].

The main panel can be switched between Map mode and video mode:

- Click to switch to map mode.
- Click to switch to video mode.

In map mode, the main area displays the current location of the *eXom*, a Status Panel with important information on the drone's current status, and a Control Bar used to send commands to the drone (section 'Control Bar' on page 73).

In video mode, the main area displays the *eXom*'s video streams.

The Toolbar above the main panel includes the File menu, controls for selecting the source of map data, display options and other controls (section 'Toolbar').

The Sidebar is separated into tabs that are used during different phases of planning and monitoring a flight. The Sidebar tabs can be hidden at any time by clicking on the left-hand edge of the Sidebar. Each tab is described in detail in the following chapter.

5.1 Toolbar

You can access the File menu by clicking on the button in the Toolbar. From this menu you can connect to or disconnect from a drone, access the Flight Data

[8] for an overview of the *eMotion X* interface see section 'The *eMotion X* interface' on page 27

Manager, change *eMotion X* preferences or import custom maps.

Clicking the icon will launch *Google Earth™* and display the current flight trajectories of drones connected to *eMotion X*, as described in detail in section 'Flight visualization in *Google Earth™*' on page 68.

You can select the background map source from the drop-down list in the Toolbar, and adjust its zoom level using the and buttons. *eMotion X* can use many sources of commercially available and custom mapping information. Tiles from map sources with the icon are downloaded by *eMotion X* from the Internet as required and locally cached on the hard drive. Due to regulatory restrictions, map sources with the icon cannot be saved locally and are not recommended for use in the field.

If you anticipate the use of *eMotion X* in conditions where connecting to the internet is impossible, you can pre-load the map data by selecting 'Download maps...' from the File menu. Follow the instructions in the dialog box to select the zone of interest, map tile source and start downloading.

eMotion X can also import and display custom layers which may include KML files, custom map tiles and elevation data. To import a KML file, select 'Import KML...' from the File menu and select your KML file. The resulting layer will now be available in the Toolbar by clicking on the icon, and can be clicked to display or hide it. *eMotion X* can display lines, polygons, paths and points saved in KML format.

Note: KML files, including associated icons or images included within them, are not copied to the *eMotion X* directory and will no longer appear in *eMotion X* if the original KML files are deleted.

Custom map tiles can also be added as a layer in *eMotion X*. These tile sets must be TMS-compatible sets of files. Select 'Import custom map...' from the File menu and select the folder that contains the tile set. The tile set will then appear in the list of layers in the Toolbar, accessible by clicking the button.

Note: If you use *Postflight Terra 3D* (see section 'Processing image data' on page 62), you can generate TMS-compatible, *eMotion X*-compatible tile sets for each project. In this way, you can create your own map background using the *eXom*. Generate the tile set by selecting 'Generate Google Maps tiles and KML' from the 'Process' menu within *Postflight Terra 3D*.

Whenever the *eXom* takes a picture, *eMotion X* records the location and orientation of the drone and computes the approximate span of the photo on the ground (or 'footprint').

The Toolbar also contains buttons for centering the Map Area on the current position of the drone (button), on a searchable location or coordinate (button) or to continually follow the position of the drone while it is in flight (button).

Finally you can view *eMotion X* in full-screen mode by clicking the button.

5.2 Control Bar

The Control Bar includes buttons for sending commands to the drone and for acknowledging warnings while it is in flight. Certain buttons can only be used during specific flight modes.

The Command buttons allows the operator to directly control the drone while it is in flight. The various buttons are described in table 2 on the next page.

Table 2: Control Bar Buttons

Button	Available	Action
WARNING[9]	Active warning	For yellow In-flight warnings, button text changes to 'ACK WARNING' and clicking will acknowledge the current warning. For red Critical failures, button text changes to 'CRITICAL FAILURE' and cannot be clicked.
START MISSION	No active Security action	Fly towards the first active waypoint in the waypoint list and start the mission from the beginning.
RESUME MISSION	Not in Perform Mission mode	Return to the last position reached during the mission and continue the flight plan.
GO TO START WPT	No active Security action	Fly towards the Start waypoint, hover and wait for next command.
GO TO HOME WPT	Anytime	Fly towards the Home waypoint, hover and wait for next command.
GO LAND	Anytime	Fly towards the Home waypoint and initiate landing procedure.

[9] see section 'Troubleshooting' on page 92 for a full description of In-flight warnings and Critical failures that may occur

HOLD POSITION	No active Security action	Create a waypoint at the current location and altitude, hover at this point and wait for next command.
LAND NOW Click 3x	Anytime	Initiate a landing at the current location. **Must be clicked 3 times in quick succession to be engaged.**
MOTORS OFF Click 3x	Anytime	Immediately stop all 4 motors. **Must be clicked 3 times in quick succession to be engaged.**
ABORT LANDING	During Landing (if no active Critical failure)	Abort current landing procedure, return to the altitude of the Home waypoint, hover at the Home waypoint and wait for next command.

Part III

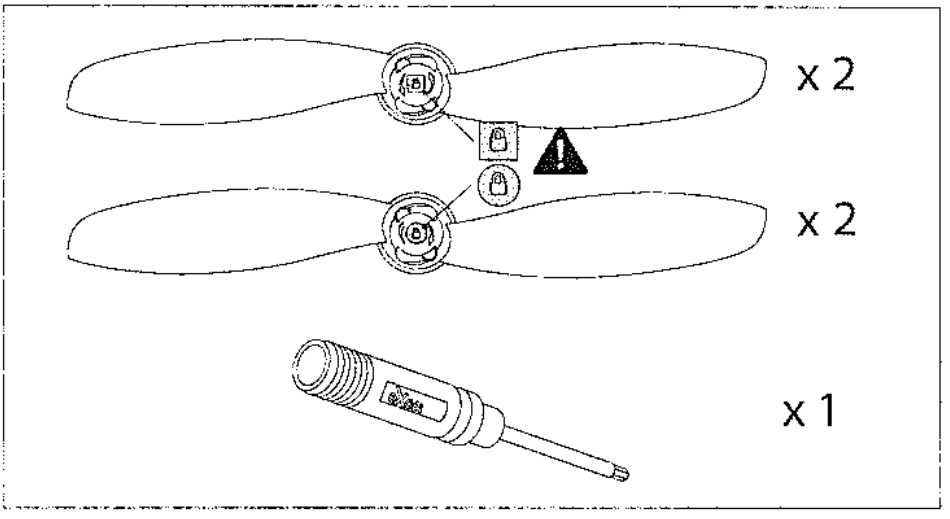
Maintenance and Repair

6 Maintenance and repair of the *eXom*

6.1 Attaching and detaching propellers

Damaged propellers are unsafe, cause vibrations and must be replaced.

Note: You do not need to replace all 4 propellers at once. You can replace one propeller at a time.



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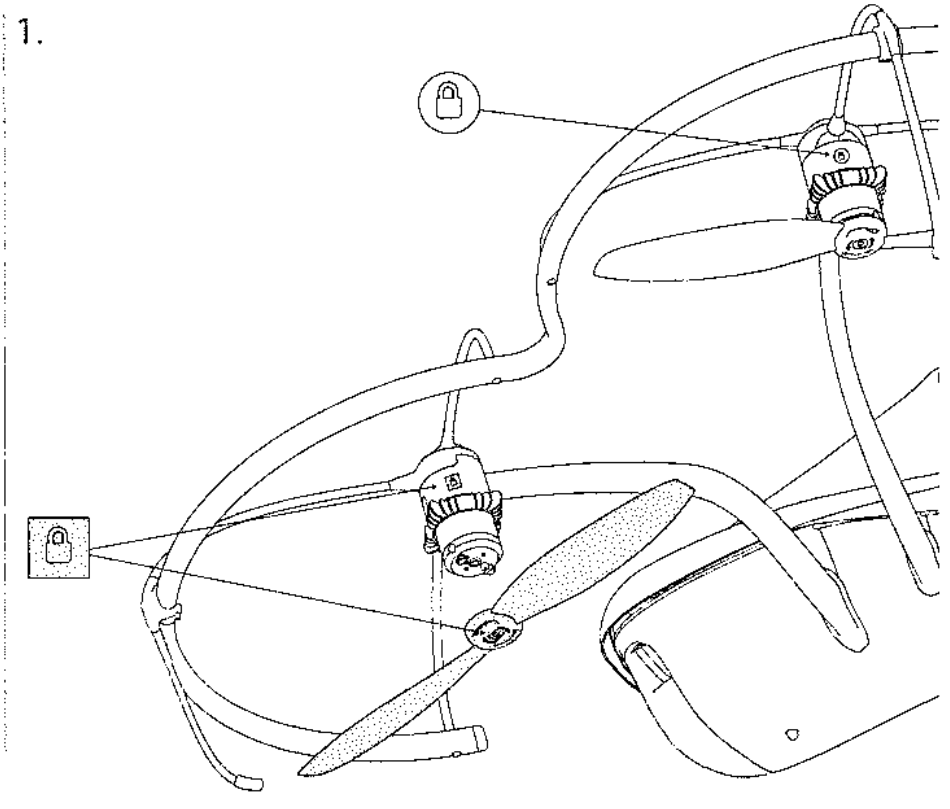
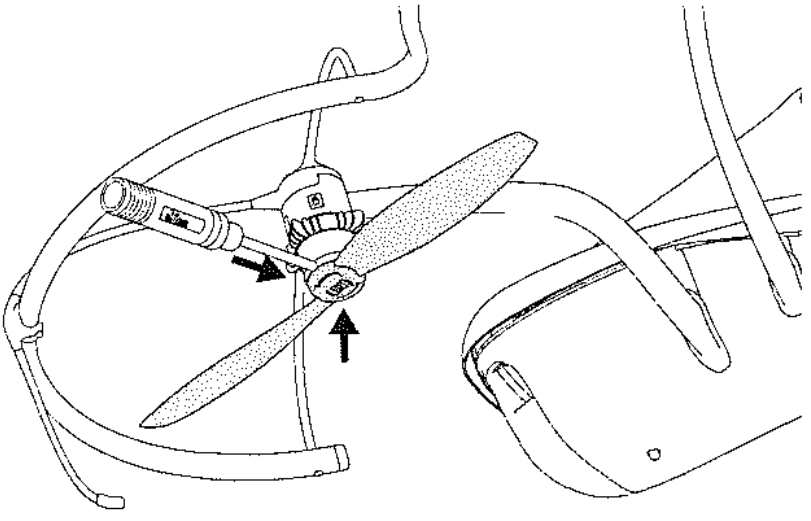
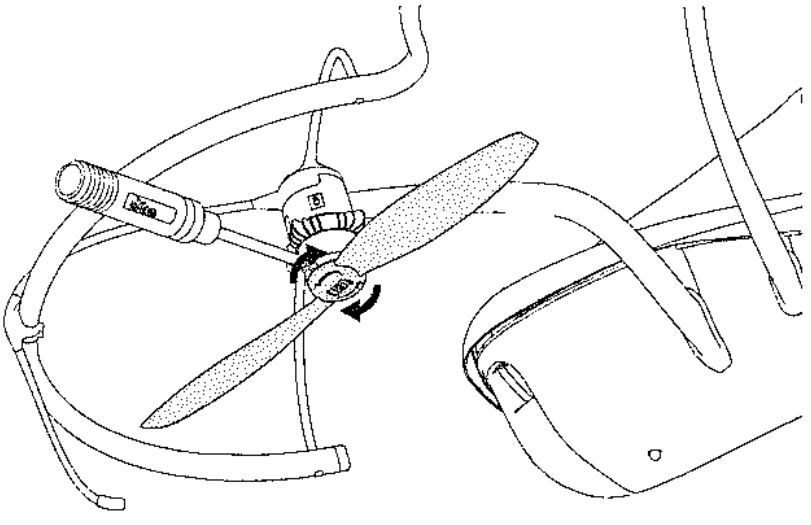


2.



3.



6.1.1 How to detach a propeller

1. Take the screwdriver provided and insert it into one of the sockets on the motor.

2. While holding the screwdriver to prevent the motor from turning, turn to unlock the propeller and remove.

Caution: Do not attempt to unscrew the screw. Only use the screwdriver to hold the motor still while installing the propeller.

Caution: Never fly your *eXom* with a propeller missing or incorrectly locked on.

6.1.2 How to attach the propellers

Note: The *eXom*'s propellers come in pairs that rotate in opposite directions and have opposite pitch. You must install the correct propeller on the correct motor. A blade with a circular lock symbol on it must be installed on the propeller that is labelled with the same circular lock symbol.

1. Take the screwdriver provided and insert it into one of the sockets on the motor.

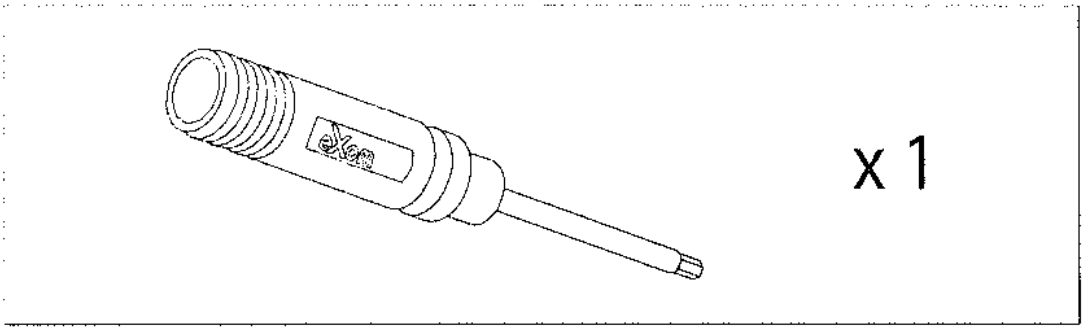
2. Position the correct propeller on the correct motor. Make sure that the labels match (circular or square lock symbol).

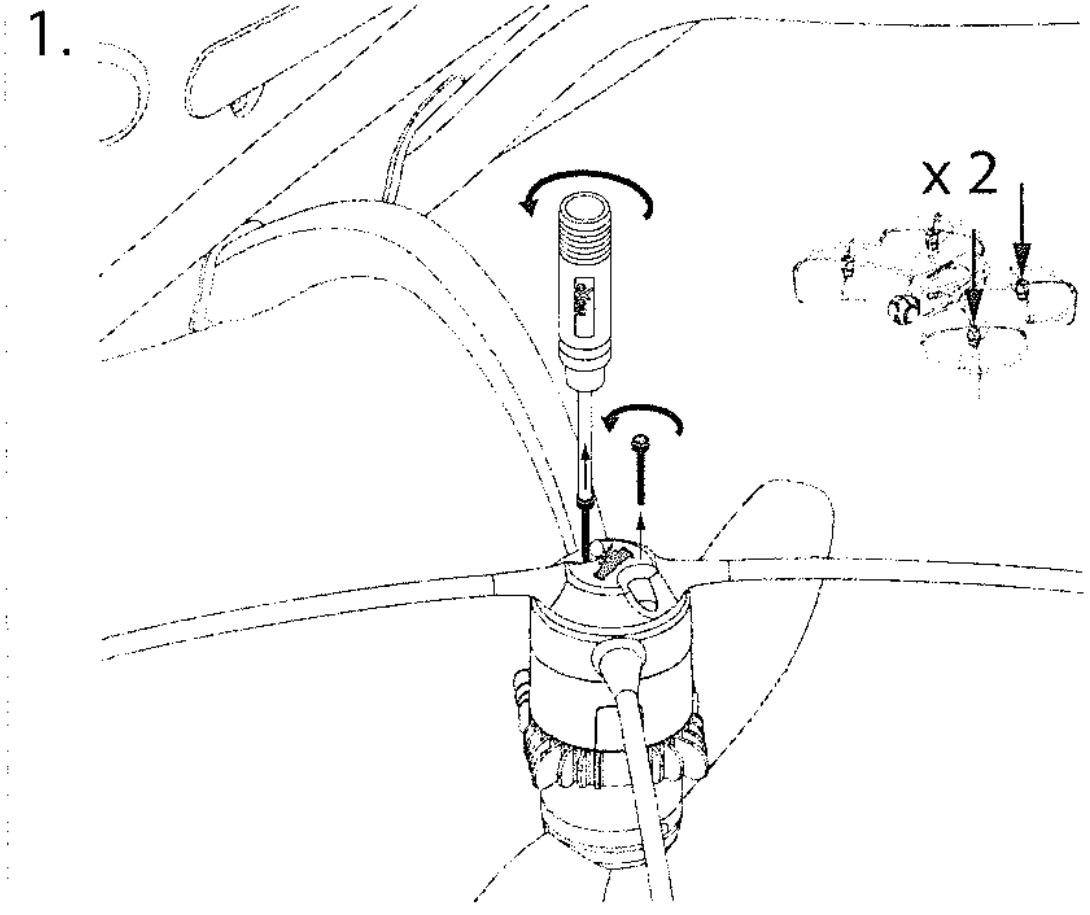
3. While holding the screwdriver to prevent the propeller from turning, push and turn to lock the propeller onto the motor. The propeller should be aligned with the shrouding and the lock arrows should be lined up.

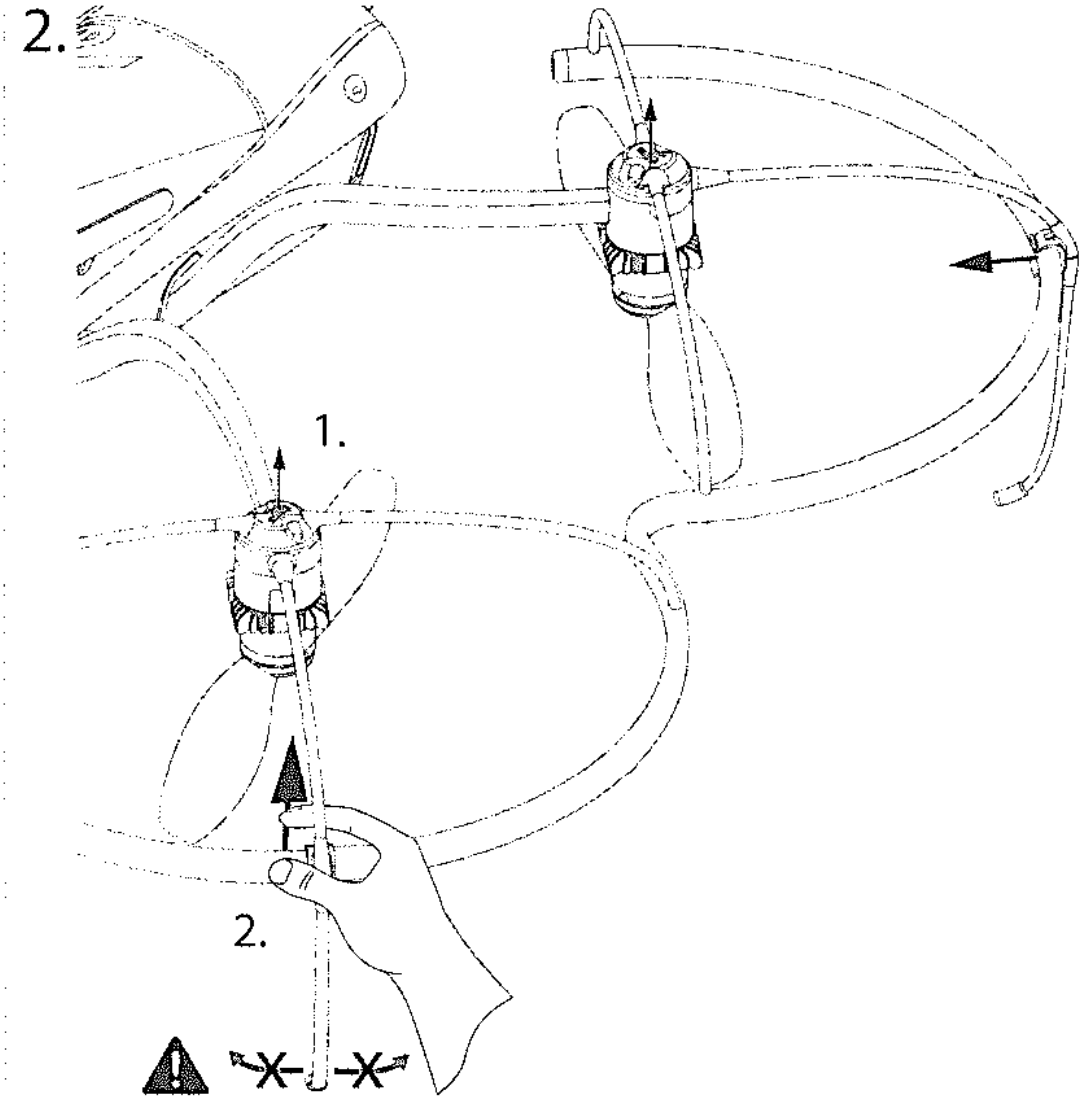
Caution: Do not attempt to unscrew the screw. Only use the screwdriver to hold the motor still while installing the propeller.

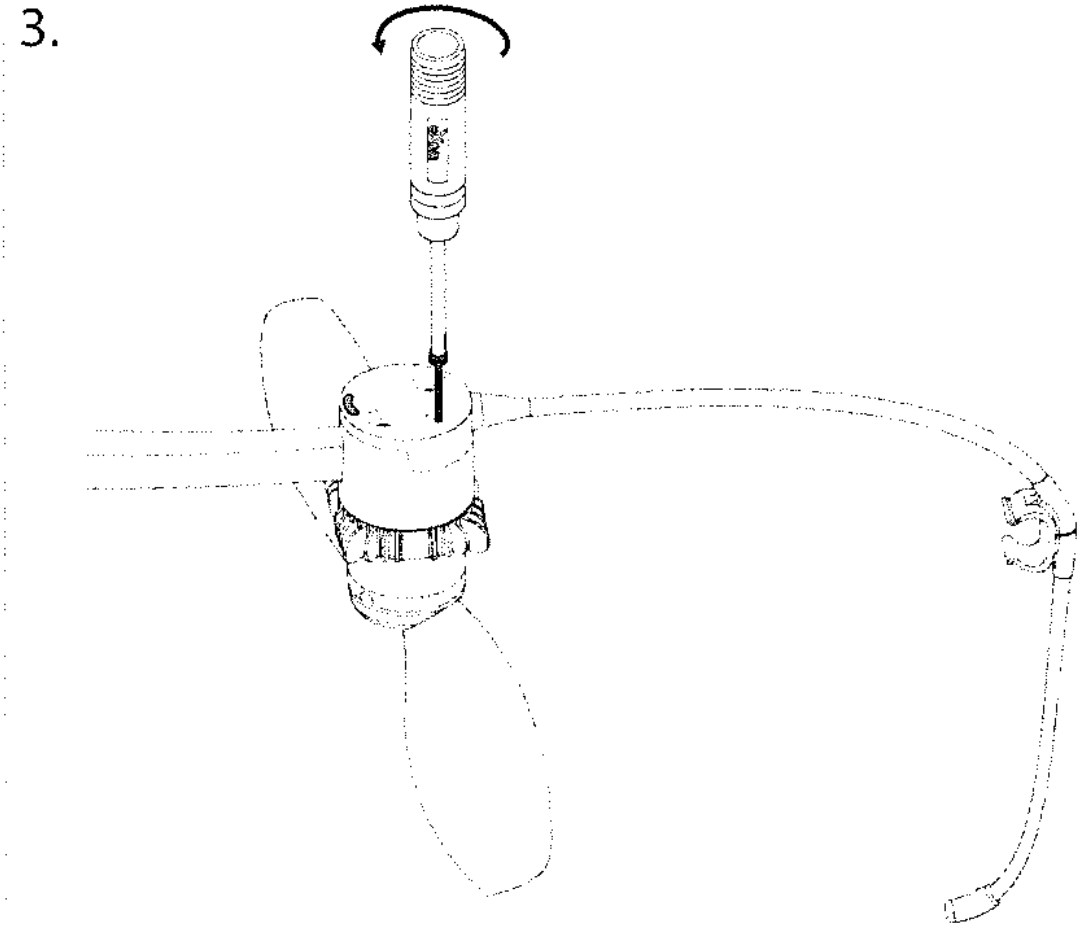
Caution: Never fly your *eXom* will a propeller missing or incorrectly locked on.

6.2 Changing a leg






2.
1.
2.



First, completely remove the shrouding on the side the leg is on...

1. Take the screwdriver supplied with your *eXom* and unscrew the 2 shrouding screws at the top of the leg you want to change.

2. Unscrew the 2 shrouding screws on the top of the other leg (on the same side of the *eXom* as the leg you want to change).

3. Lift the shrouding mounting points a little so that they are free to move.

4. While holding the leg in place, push the shrouding out of each of its clips.

A good way to do this is to hook the fingers of one hand over the leg then push the shrouding out of its clip with your thumb.

Caution: Do not twist the legs.

5. Put the shrouding to one side.

Next, remove the leg...

6. Unscrew the screw that's holding the leg you want to change in place and lift the leg off.

Caution: Never try and unscrew the motor mounting screw that's under the leg.

Note: If undamaged, you can pull off and reuse the cap.

Fit the new leg...

7. Take the new leg and fit it into place. Screw the leg screw back in firmly.

Finally, replace the shrouding...

8. Take the shrouding, pass it under the legs, then clip it back into the clips.

   A good way to do this is to hook the fingers of one hand over the leg then push the shrouding into its clip with your thumb.

9. Slot the top shrouding mounts back into place and firmly screw all 4 screws back in.

Caution: Never attempt to fly without the shrouding or legs.

6.3 Changing a ground modem antenna

1. Grip the serrated part at the base of the antenna and carefully unscrew the old antenna.
2. Ensure that the antenna threads are clean and undamaged.
3. Screw the new antenna firmly on using finger force only. Take care not to cross the threads.

You can obtain replacement antennas from senseFly or your reseller.

6.4 Cleaning the *eXom*

Use a damp cloth to wipe off dirt from the *eXom*'s sensor modules, housing, motors, propellers and shrouding.

Caution: Never bring the *eXom* into direct contact with water; this may damage its electronics.

6.5 Storing the *eXom*

Always clean the *eXom* before returning it to its case for storage.

Whenever possible, store the *eXom* in the case it was supplied in.

6.6 Full inspection

The *eXom* is fully acceptance tested, adjusted and flown before being shipped. When you receive it, it is ready to fly.

Beyond the general airframe inspection that is performed before every flight, senseFly recommends that the operator regularly performs a full airframe and sensor inspection[10].

Caution: The autopilot, sensors and actuators within the central body of the *eXom* are specially calibrated and should only be modified by your *eXom* reseller. Opening the central body of the *eXom* will void the warranty.

6.6.1 Check your motors

The *eXom* uses brushless DC motors to turn its propellers and generate thrust. All 4 motors must be clean and spin smoothly without friction to function correctly.

To check the motors, follow these steps:

1. Remove the battery from the *eXom*.
2. Visually inspect the motors.
3. Turn each propeller with your finger. Ensure that there is no sand or other obstruction preventing the motor from turning smoothly. If the motor does not turn smoothly, blow some air through the motor to dislodge any obstruction.

6.6.2 Check inertial sensors

The inertial sensors are used by the autopilot to compute the attitude (i.e. its orientation in space) of the drone. The attitude is displayed by the artificial horizon in the Flight Monitoring tab of *eMotion X*. To check the inertial sensors, follow these steps:

1. Switch the *eXom* and connect to *eMotion X*.

[10] See section 'Maintenance schedule' on page 102

2. Put the drone on a flat surface (typically an office floor) and check that the artificial horizon is level.

3. Take the drone with your hand and put it in different orientation. Make sure that the artificial horizon displays the corresponding orientation.

The artificial horizon should follow smoothly the motion of the *eXom* and it should not drift when the drone is not moving. In case of doubt, take a short video and follow the instructions in section 'Reporting a problem with your *eXom*' on page 102 for advice.

6.6.3 Check barometric pressure sensor

The barometric pressure sensor is used to measure the altitude from the take-off location. To check it, follow these steps:

1. Switch the *eXom* and connect to *eMotion X*.

2. Move the drone from your feet to above your head (about 2 m altitude variation).

3. Check the altitude on the vertical bar to the right of the artificial horizon or in the Status Panel next to the drone icon on the map).

The displayed altitude should follow the drone motion, i.e. if the drone is raised by 2 m, the altitude reading should increase by about 2 m.

6.7 Repairing the *eXom* airframe

The *eXom*'s advanced materials and construction mean that it has very few user-serviceable parts.

Only carry out the basic repairs described in this user manual. Do not try and disassemble the drone beyond the part replacement procedures described in this manual. Do not try and remove the top cover.

If your drone is damaged, contact senseFly or your *eXom* reseller.

Caution: Never fly a damaged *eXom*.

6.8 Proper battery care

Proper care of your *eXom*'s battery is important to prevent damage to your drone and to maximize flight time. Batteries perform better at medium or high air temperature and it is normal to observe shorter flight times in cold weather.

The charger delivered with your drone automatically checks for healthy voltages of all cells and only attempts charging if they are within limits. If the cells are out of balance, the charger will take care of balancing them.

Caution: The batteries delivered with your drone are designed to be charged with the charger delivered with your *eXom*. senseFly Ltd cannot be held responsible for any consequences resulting from using a different charger. In particular, using a charger improperly configured or designed for other types of batteries may lead the battery pack to be permanently damaged or to catch fire.

LiPo batteries do not exhibit any memory effect. We recommend that you always fully charge them after use even when they are only partially discharged.

When not using the battery store it with 50

Charge level is shown by the battery indicator on the battery.

Dispose of the battery safely and appropriately.

Caution: After flight, the battery will be warm. Allow it to cool down before charging.

Caution: Always fly missions with a fully-charged battery.

Caution: If the battery swells or if any of the cells are punctured the battery is damaged and should be discarded. Do not charge a damaged battery - it may catch fire.

7 Troubleshooting

Goal of this section: This section describes the various error messages that may be displayed during start-up or while the *eXom* is in flight and provides some tips on solving the simplest problems.
In the case of a more serious problem, this section describes how to prepare the required data on the problem and report it to your *eXom* reseller.

The *eXom* can generate several types of error messages. Some of these messages are minor and simply need to be acknowledged through *eMotion X*, whereas others require more specific action from the user. As long as the drone is connected to *eMotion X*, error messages will appear in the software.

7.1 About the autopilots

The *eXom*'s autopilot is divided into 2 functional units - the low-level autopilot and the high-level autopilot. The low-level autopilot deals with direct control of the propellers and interpreting commands from the remote control. The high-level autopilot deals mainly with autonomous flight.

7.2 In-flight warnings

While it is in flight the *eXom* can generate two types of errors: warnings and failures. In-flight warnings occur when there is an event that requires an automatic response from the drone, or the user's attention and action, but does not compromise the drone's ability to continue flying.

If an in-flight warning is raised while flying an autonomous mission, the drone will immediately abort the mission and head back to the Home waypoint (apart from loss of satellite positioning signals). The drone will fly in a straight line in the direction of the Home waypoint, climbing or descending to the waypoint's altitude. Always place your home waypoint so that, in case of in-flight warning, there are no obstacles between the drone and the Home waypoint to prevent a collision.

Once it reaches the Home waypoint the drone will wait for a command until its battery is empty, and then initiate a landing when a 'Failure: empty battery' Critical failure is triggered (as described in section 'Critical failures' on page 96).

If flying manually, warnings must be acknowledged by clicking on the 'ACK WARNING' button on *eMotion X*'s Control Bar, after which, to avoid loss of your drone, collision or a crash, you must carry out the action recommended below. The full list of possible In-flight warnings and required User actions can be found in table 3 on the following page.

Table 3: In-flight warnings

***eMotion X* text**	**Description** **User action**
High-level barometer failure	The high-level autopilot's barometer has failed. **User Action:** Land as soon as possible.
Low-level IMU failure	One of *eXom*'s inertial measurement units has failed. **User action:** Land as soon as possible.
Battery gauge failure	The drone is unable to measure the remaining battery charge. There is a risk that the battery will run out during flight. **User Action:** Land as soon as possible. Recharge the drone battery before the next flight.
Low battery	The remaining battery level is too low to continue the flight plan. **User Action:** Land as soon as possible. Recharge the drone battery before the next flight.
Battery hot	The drone's battery is overheating. There is a risk that it will fail or catch fire. **User Action:** Land as soon as possible. Remove the battery from the drone and place it in a fireproof bag or container to cool down. Do not charge or use the battery again.

Autopilot overheating	The drone's autopilot is overheating. There is a risk that it will fail. **User Action:** Land as soon as possible. Allow the drone to cool before the next flight.
Outside working area	The drone has left the working area. This may occur if waypoints are set close to or outside of the working area or due to strong wind. There is a risk of collision, loss or prosecution. **User Action:** Bring the drone back into the working area.
Above working ceiling	The drone has climbed above the working area ceiling. This may occur if waypoint altitudes are set close to or outside the working area or due to strong wind. There is a risk of collision, loss or prosecution. **User Action:** Bring the drone back below the working ceiling.
Telemetry link failure	The *eXom* has not received any data from *eMotion X* for more than 30 s. This can be due to a large distance between drone and ground modem, a problem with the ground modem, antenna positioning or interference. Video feedback will be lost and piloting will become difficult. **User Action:** Try to improve radio signal quality by following the instructions in section 'Improving radio signal communication' on page 100. If this is impossible, land as soon as possible.

Strong wind	There is too much wind to maintain stable flight. There is a risk the drone crashes, collides or exits the working area. If it cannot reach the Home waypoint, it lands immediately. **User Action:** Land as soon as possible.
Poor GPS coverage	Your *eXom* is unable to reliably calculate its position. Unless flying manually, there is a risk of loss or collision. Manual flight is, however, unaffected. **Response:** Unless flying manually, the drone raises an alert, returns to the Home waypoint and immediately engages its landing sequence. **Prevention:** Only fly autonomously outside, in areas with good satellite positioning signal coverage.

7.3 Critical failures

A critical failure is an error that occurs in flight that prevents the continuation of normal flight. This is the most serious type of error that can occur with the *eXom*. When a critical failure occurs flight is aborted and the drone initiates an Emergency action which immediately directs it to the ground.

Table 4 on the following page describes the critical failures that may occur and what action is taken by the drone. In some cases it may be possible to manually control the drone using the remote control[11]. If a critical failure occurs that results in an Emergency landing we recommend that you keep track of the drone's last known position in the air and in *eMotion X* if possible and follow the instructions in section 'Losing and locating your *eXom* in the field' on page 101.

[11] see section 'Manual control of the *eXom*' on page 80

Table 4: Critical failures

***eMotion X* text**	**Description** **Effect on drone/drone's response** **Prevention** **User action**
High-level autopilot failure	The *eXom*'s high-level autopilot has failed. **Response:** The drone raises an alert and immediately engages its landing sequence. **Prevention:** Only fly within the *eXom*'s recommended operating conditions. **User action:** If automatic landing will be safe, allow your drone to land. If not, land your drone manually.
High-level IMU failure	One of *eXom*'s inertial measurement units has failed. **Response:** The drone raises an alert and immediately engages its landing sequence. **User action:** If automatic landing will be safe, allow your drone to land. If not, land your drone manually.
High-level magnetometer failure	One of your *eXom*'s internal compasses has failed. **Response:** The drone raises an alert and immediately engages its landing sequence. **User action:** If automatic landing will be safe, allow your drone to land. If not, land your drone manually.

Low-level barometer failure	One of your *eXom*'s barometer units has failed. **Response:** An alert is raised and, unless under manual control, the drone flies in a straight line to the home waypoint. If under manual control, the drone carries out an immediate emergency landing. **User action:** If automatic landing will be safe, allow your drone to land. If not, land your drone immediately.
Low-level magnetometer failure	One of your *eXom*'s internal compasses has failed. **Response:** An alert is raised and, unless under manual control, the drone flies in a straight line to the home waypoint. If under manual control, the drone carries out an immediate emergency landing. **User action:** If automatic landing will be safe, allow your drone to land. If not, land your drone immediately.
Battery overheat	Your *eXom*'s batteries have overheated. There is a risk of battery failure or fire. **Response:** The drone immediately lands. **Prevention:** Inspect your batteries before each flight. Store them according to senseFly's recommendations. Do not operate the drone outside the recommended temperature range.
Battery critical level	Your *eXom*'s batteries can no longer provide enough energy to keep the drone airborne. **Effect:** The drone immediately lands. **Prevention:** Do not allow your drone's batteries to run out.

Lost RC signal in manual mode	Your *eXom* lost contact with the remote control during manual flight. **Response (Autonomous flight):** The drone flies in a straight line to the home waypoint. **Response (Manual flight):** The drone immediately lands. **Prevention:** Do not allow your drone to fly beyond the range of the remote control or allow an obstacle such as a building or terrain to block the RC signal.
GPS failure	Your *eXom*'s GPS has malfunctioned. The drone is unable to reliably calculate its position. Unless flying manually, there is a risk of loss or collision. Manual flight is, however, unaffected. **Response:** Unless flying manually, the drone raises an alert and immediately engages its landing sequence. **Prevention:** Only fly autonomously outside, where there is good satellite positioning signal coverage.
Far outside working area	While flying autonomously, your *eXom* has been pushed well outside the working area. **Response:** Unless flying manually, the drone raises an alert and immediately engages its landing sequence. **Prevention:** Only fly your drone in suitable weather conditions.

Abnormal sink rate and attitude	Your *eXom* is descending at an unexpected rate or the drone pitch or roll angle is higher than 90° **Response:** The *eXom* immediately stops its motors. **Prevention:** In manual modes, do not make the drone descend into its own downwash. **User action:** Prepare in whatever way possible for a falling drone.
Motor controller failure	The processor controlling your *eXom*'s propellers has failed. **Effect:** The propellers stop. **User action:** Prepare in whatever way possible for a falling drone.
Battery failure	The battery is not providing enough power for flight. **Effect:** The propellers stop. **User action:** Prepare in whatever way possible for a falling drone.

7.4 Improving radio signal communication

You may occasionally lose the data connection between *eMotion X* and your *eXom* while in the field. Whether there is a loss in uplink or downlink communication, the drone will continue flying along its Flight Plan and should re-establish the connection as it flies closer to the base station or changes direction.

Data connection range can be effected by many external factors such as antenna height, terrain and obstacles or radio interference. We recommend the following tips to improve the range of your connection in the field:

1. Place the USB ground modem as high as possible (for example, on top of a car, ladder or nearby building). A height of at least 2 m is recommended.

2. Ensure that the USB ground modem's antennas are properly screwed on and are pointing straight up.

The strength of the connection between the drone and *eMotion X* is indicated in the Flight Monitoring tab.

7.5 Losing and locating your *eXom* in the field

In case you lose your drone in the field for whatever reason, whether from a loss of communications, a Critical failure or an accidental collision, use the following steps to try to recover it:

1. Do not disconnect the connection in *eMotion X*! If it is out of communication range, the drone should reconnect automatically as it comes back into range.

2. Note the last known location of the drone in *eMotion X* by printing the screen or writing down the location displayed.

3. Move towards this last known direction with the computer running *eMotion X* in the hope of regaining a connection. Be sure to take the remote control with you as well.

4. If you have reached the last known location of your drone and have not yet found it, turn on the remote control.

5. Try moving both the control sticks around. If the drone is within range it may start making noise with its propellers.

6. Try moving downwind from the last known location in case the drone was pushed by the wind while still in the air.

7.6 Reporting a problem with your *eXom*

If there is a problem with your *eXom*, whether it is a software malfunction, damaged airframe or any other problem, we recommend the following actions:

1. If there is an error message displayed in *eMotion X*, begin by checking section 'Troubleshooting' on page 92 to see if there is a solution to the particular message.
2. Check our Knowledge Base, part of my.senseFly[12], to see if there is a solution to your problem.
3. If you have still not found a solution, contact your *eXom* reseller. Please include the following information with your inquiry:
    - The serial number of your drone.
    - A short description of the problem.
    - The Drone Flight Log file of the flight that had a problem.
    - The eMotion Flight Log file of the flight that had a problem. You can find this file in the `eMotion/logs/` directory which is created in `My Documents` on Windows.
    - Photos or video of the *eXom* airframe, if required.

Note: In order to provide support, senseFly may request the flight log files for inspection.

7.7 Maintenance schedule

You must carry out a general airframe inspection[13] before every flight. You must also perform a full airframe and sensor inspection[14] at least once a month, or every

[12] http://my.sensefly.com
[13] See section 'Preparing the *eXom* for flight' on page 33
[14] See section 'Full inspection' on page 87

20 flight hours, whichever comes first. In addition, perform this full inspection when bringing your drone out of long-term storage (more than 1 month) after any repair, part replacement, heavy landing or other unexpected incident.

Maintenance and inspection log

Date	A/C model	S/N	Hours	General/Full	Maintenance activity	Inspected by

Part IV
Specifications

1 Software requirements

eMotion X has the following minimum software requirements:

Operating system	Microsoft Windows 7 / 8
Hardware	1.6 GHz processor
	4 GB RAM (8GB recommended)
	10 GB free storage space
Screen	recommended resolution: 1920×1080
	visible outdoors

Postflight Terra 3D has the following minimum software requirements:

Operating system	Microsoft Windows 7 / 8
	64-bit only
Hardware	1.6 GHz processor (2 GHz Intel i5/i7/Xeon recommended)
	4 GB RAM (16 GB recommended for large projects)
	10 GB free storage space (1 TB recommended for large projects)
Screen	min. resolution: 1024×768

2 Drone specifications

Nominal take-off weight (approx.)	1.7 kg (3.7 lb)
Weight without battery	1.1 kg (2.4 lb)
Maximum take-off weight	1.9 kg (4.2 lb)
Dimensions	799 x 561 x 172 mm (31.5 x 22.1 x 6.8 in)
Max. airspeed (manual flight)	12 m/s (43 km/h, 27 mph)
Max. airspeed (autonomous flight)	8 m/s (29 km/h, 18 mph)
Maximum climb speed	7 m/s (23 ft/s)
Maximum pitch/roll angle	60°
Possible manoeuvres	Climb, descend, hover, pitch, roll, yaw
Nominal endurance (flight time)[15]	22 min
Material	Carbon structure & composite parts
Battery	3-cell 8500 mAh
Battery weight	0.57 kg (1.3 lb)
Optimum charge time	1.5 hours
Main camera - stills	38 Mp
Main camera FOV	63°
Main camera - video	HD (1280 x 720 pixels)
	Stills and video geo-referenced
Thermal camera images	80 x 60 pixels
Thermal camera FOV	50°
Thermal camera temp. resolution	0.1° C (0.2° F)

[15] can vary greatly depending on external factors such as wind, altitude change and temperature.

Navcam resolution	640 x 480 pixels
Navcam FOV	120°
Ultrasonic sensor range	6 m (20 ft)
Ultrasonic sensor FOV	50°
Propulsion	4 x electric brushless motors
Max. wind (manual flight)	10 m/s (36 km/h, 22 mph, 19 kts)
Max. wind (autonomous flight)	8 m/s (29 km/h, 18 mph, 16 kts)
Operating temperature	-10 to 40° C

Communication devices

Ground modem

Range [16]	Up to 2 km (1.2 miles)
Frequency	2.4 GHz & 5 GHz ISM bands
Streams	MiMo 2x2 with Spatial Diversity
Transmision Mode	DFDM[17] or DSSS[18]
Radiated Power	Up to 630 mW[19]
Antennas	Dual Omnidirectional
Security	WPA Encryption

[16] can vary greatly depending on external factors such as cruise altitude, presence of obstacles and radio-frequency interference.
[17] Orthogonal Frequency Division Modulation
[18] Direct Sequence Spread Spectrum
[19] automatically configured based on frequency and legal limits of the country

Remote control

Frequency	2.4 GHz
Range	Up to 0.8 km (0.5 miles)

Carry case dimensions	92 x 64 x 22 cm (36 x 25 x 9 in)