APPENDIX A

Element Ratings

Once the post processing is complete, a review of the data (images and video) can be used to rate the elements for the bridge inspection report. This condition assessment can be done by referencing the WisDOT Bridge Inspection Field Manual while utilizing the high quality imagery collected at the bridge site.

Below are a few examples of various elements and the associated rating that could be achieved with the video, photo, and thermographic capabilities of the UAS inspection. The discussion for each of the elements below are meant to give examples of the capabilities as well as identify some of the limitations at this time. The discussion of each of these elements is not meant to be a complete assessment for the inspection and rating of each bridge structure as a whole.

Bearing

Bearing from the URT Bridge, B-40-115 in Milwaukee County.

Consistent with the Bridge Inspection Field Manual, Chapter 3.G – Bearings, this element is 311 – Moveable Bearing. The bearing type is easily identifiable through the photos that were collected during the UAS flight. Zooming in on the above photo from the URT Bridge B-40-115, the condition state of each of the defect categories for these bearings can be identified.

Zoomed in on a bearing from the URT Bridge, B-40-115 in Milwaukee County.

Defect categories to assess during inspection are listed in the Bridge Inspection Field Manual. By analyzing the photo, the bearings would be rated as follows:

Defect	**Condition State**	**Comments**
Corrosion (1000)	CS 2 Fair	Freckled Rust. Corrosion of the steel has initiated.
Connection (1020)	CS 1 Good	Connection is in place and functioning as intended.
Movement (2210)	CS 1 Good	Free to move.
Alignment (2220)	CS 1 Good	Lateral and vertical alignment is as expected for the temperature conditions.
Bulging, Splitting, or Tearing (2230)	CS 1 Good	N/A
Loss of Bearing Area (2240)	CS 1 Good	None

Some of the limitations in the rating and assessment of the bearings include but are not limited to:

- Inability to get 360 degrees around each bearing
- Interior bearings are more difficult to see than the exterior bearings
- Difficulty accessing the top view of interior bearings
- Debris, which is sometimes encountered around the bearings, cannot be brushed off with the UAS
- Could difficult to see if rivets or welds are broken

In the inspection, the bearings are reviewed, rated and assessed per each bearing on the bridge. Through the use of the photo and video images, each bearing is looked at individually. Geotagging is important in keeping track of which bearing is being assessed at which location.

Gusset Plate

Gusset plate on the Steuben bridge, B-12-363 in Crawford County.

Consistent with the Bridge Inspection Field Manual, Chapter 3.A – Steel, this element is 162 – Steel Gusset Plate. The steel gusset plate is easily identifiable through the above photo collected during the UAS flight. Zooming in on the above photo from the Steuben bridge B-12-363, the condition state of each of the defect categories for this gusset plate can be identified.

Zoomed in on a gusset plate from the Steuben bridge, B-12-363 in Crawford County.

Defect	**Condition State**	**Comments**
Corrosion (1000)	CS 2 Fair	Freckled Rust. Corrosion of the steel has initiated.
Cracking (1010)	CS 1 Good	None.
Connection (1020)	CS 1 Good	Connection is in place and functioning as intended.
Distortion (1900)	CS 1 Good **	None. **

** Difficult to assess distortion with 100% confidence without a view in line with the plate. For this type of inspection, it would be useful to obtain views of the gusset plate from a variety of angles.

Some of the limitations in the rating and assessment of the gusset plates include but are not limited to:

- Inability to get 360 degrees around each gusset
- It can be hard to see the inside face of the gusset plates
- It can be difficult to get a view in line with the gusset plates to identify any potential distortion in the element.
- It can be difficult to see if rivets or welds may be broken
- Without an extremely accurate model, there is no ability to measure or quantify the extent of any section loss

In the inspection, the gusset plates are reviewed, rated and assessed per each gusset plate on the bridge. Through the use of the photo and video images each gusset plate is looked at individually. Geotagging is important in keeping track of which gusset plate is being assessed at which location.

Piers

Piers from the Dekorra bridge, B-11-022 in Columbia County.

Consistent with the Bridge Inspection Field Manual, Chapter 3.B – Reinforced Concrete, the elements shown here are 205 – Reinforced Concrete Column, and 234 – Reinforced Concrete Cap. The photo below focuses on item 205 – Reinforced Concrete Column to identify the condition state of each of the defect categories for the element.

Zoomed in on a pier from the Dekorra bridge, B-11-022 in Columbia County.

Defect	**Condition State**	**Comments**
Delaminations/ Spalls/Patch Area (1000)	CS 1 Good	None.
Exposed Rebar (1090)	CS 1 Good	None.
Cracking (RC) (1130)	CS 1 Good *	Width less than 0.012 (<5/64) in. or sealed cracks.

Defect	**Condition State**	**Comments**
Abrasion/Wear (PSC/RC) (1190)	CS 1 Good	No Abrasion.
Chloride Concentration (8905)	N/A	Only to be used on those bridges in a chloride testing program.
Precast Concrete Connections (8906)	CS 1 Good	N/A
Settlement (4000)	CS 1 Good **	None **
Scour (6000)	CS 1 Good ***	None ***

* Difficult to accurately and confidently determine narrow crack widths. Hairline cracks typically do not reduce the element condition rating of reinforced concrete. Wider cracks would typically be visible with high quality UAS equipment.

** Settlement unable to be determined through UAS photos

*** Scour to be determined with underwater inspection. Applicable to element 220 – Reinforced Concrete Pile Cap/Footing

In the inspection, the Reinforced Concrete Columns are reviewed, rated and assessed per each column on the bridge. Through the use of the photo and video images, each column is looked at individually. Good field notes, along with geotagging, is important in keeping track of which column is being assessed at which location for larger structures.

Pier from the Dekorra bridge, B-11-022 in Columbia County.

Consistent with the Bridge Inspection Field Manual, Chapter 3.B – Reinforced Concrete, the elements shown here are 205 – Reinforced Concrete Column, and 234 – Reinforced Concrete Cap. The photo below focuses on item 234 – Reinforced Concrete Cap to identify the condition state of each of the defect categories for the element.

Zoomed in on a pier from the Dekorra bridge, B-11-022 in Columbia County.

Defect	**Condition State**	**Comments**
Delaminations/ Spalls/Patch Area (1000)	CS 1 Good CS 2 Fair	Delaminated - Total 1 foot in length is CS 2.
Exposed Rebar (1090)	CS 1 Good	None.
Cracking (RC) (1130)	CS 1 Good *	Width less than 0.012 (<5/64) in. or sealed cracks. *

Defect	Condition State	Comments
Abrasion/Wear (PSC/RC) (1190)	CS 1 Good	N/A for cap element
Chloride Concentration (8905)	N/A	Only to be used on those bridges in a chloride testing program.
Precast Concrete Connections (8906)	CS 1 Good	N/A
Settlement (4000)	CS 1 Good **	N/A for cap element
Scour (6000)	CS 1 Good ***	N/A for cap element

* Difficult to accurately and confidently determine narrow crack widths. Hairline cracks typically do not reduce the element condition rating of reinforced concrete. Wider cracks would typically be visible with high quality UAS equipment.

** Settlement unable to be determined through UAS photos

*** Scour to be determined with underwater inspection. Applicable to element 220 – Reinforced Concrete Pile Cap/Footing

Some of the limitations in the rating and assessment of elements 205 – Reinforced Concrete Column and 234 – Reinforced Concrete Cap include but are not limited to:

- It is difficult to see and quantify small, narrow cracks.
- Orientation needs to be normal to the pier to get an accurate size for spall / patch areas
- It is difficult to see and quantify limits to delamination areas through photos. Thermographic video can be effective.
- Lighting can make it difficult to assess condition of the element, particularly shadows closer to the underside of the bridge deck.

In the inspection, the Reinforced Concrete Caps are reviewed, rated and assessed per linear foot of cap on the bridge. Through the use of the photo and video images, each Reinforced Concrete Cap is reviewed and a cumulative tabulation of the linear feet of defects for all of the cap elements on the bridge is totaled and recorded. Good field notes, along with geotagging, is

important in keeping track of which column is being assessed at which location for larger structures with multiple pier caps.

Paint System

The photo below is from the URT Bridge B-40-115 in Milwaukee County.

Paint system on the URT bridge, B-40-115 in Milwaukee County.

Consistent with the Bridge Inspection Field Manual, Chapter 3.I – Steel Protective Coatings, element is 8516 – Painted Steel. It can be evaluated using the photos and video images that were collected during the UAS flight. Zooming in on the above photo from the URT Bridge B-40-115, the condition state of painted steel can be identified.

Evaluation of paint system on the URT bridge, B-40-115 in Milwaukee County.

(Element 8516 – Painted Steel is only evaluated for the defect Effectiveness (3440))

LEGEND	
	Painted Steel – Effectiveness (3440) – 5.0 SF evaluated at CS 3, Remainder is CS 1

Defect	**Condition State**	**Comments**
Effectiveness (3440)	CS 1 Good CS 3 Poor	Peeling, bubbling, or cracking to finish and primer coats. Total of 5.0 square feet is CS 3.

Some of the limitations in the rating and assessment of element 8516 – Painted Steel include but are not limited to:

- Orientation needs to be normal to the girder to get an accurate size for areas of peeling, bubbling, or cracking.

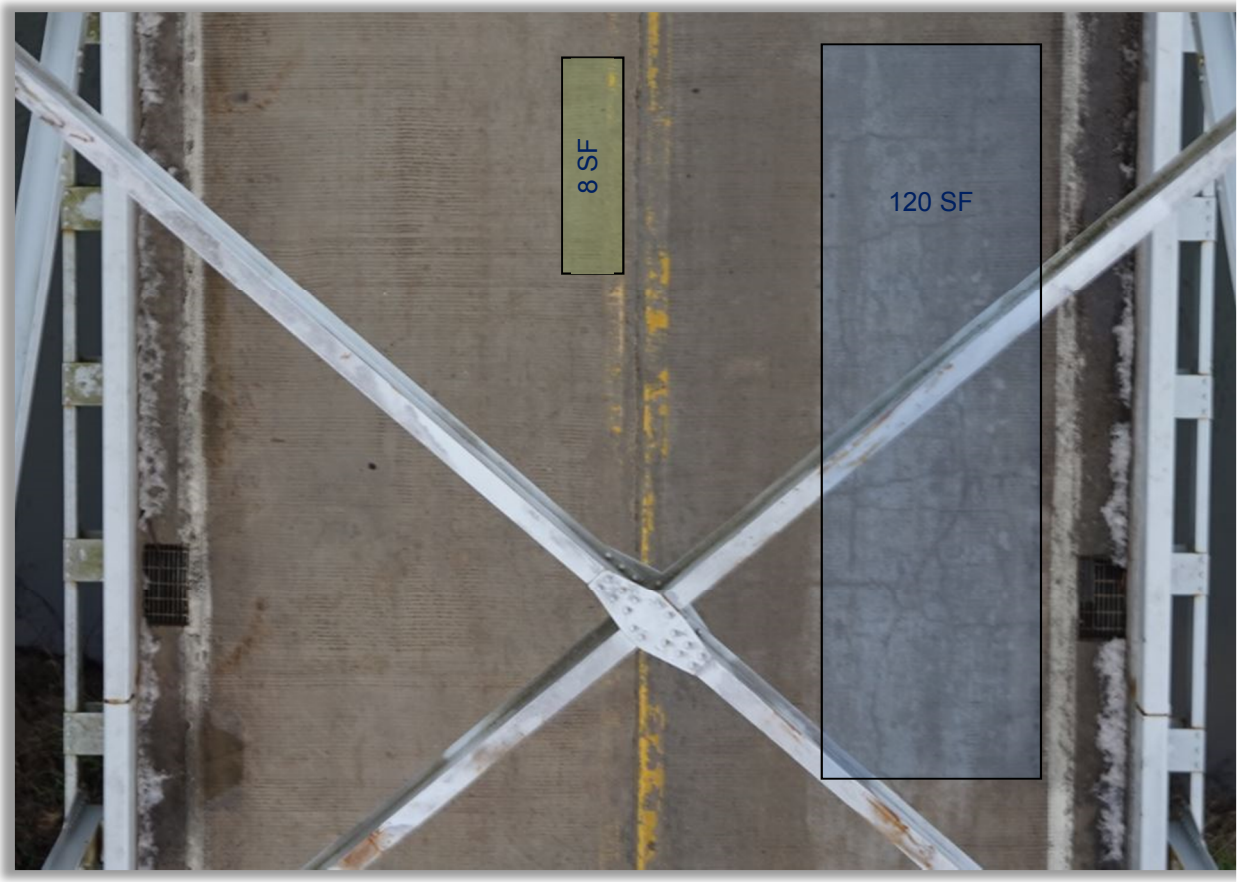
- Debris, which is sometimes encountered on the top of the bottom flange can hide defects and cannot be brushed off with the UAS
- Lighting can make it difficult to assess condition of the element, particularly shadows closer to the underside of the bridge deck overhang.
- It is more difficult to assess the painted steel for the interior girders.

In the inspection, the painted steel is reviewed, rated and assessed by the square foot (SF) for all steel superstructure elements as well as primary steel substructure elements (pier caps, columns, towers, and abutments) on the bridge. Through the use of the photo and video images the Painted Steel is reviewed and a cumulative tabulation of the square feet of defects for all of the elements on the bridge is totaled and recorded. Good field notes, along with geotagging, is important in keeping track of all of the elements assessed particularly for larger structures with multiple elements.

Deck

Wearing surface on the Steuben bridge, B-12-363 in Crawford County.

Consistent with the Bridge Inspection Field Manual, Chapter 3.J –Concrete Wearing Surfaces, the element evaluated here is 8514 – Concrete Overlay.



Wearing surface on the Steuben bridge, B-12-363 in Crawford County.

LEGEND	
	Concrete Overlay – Crack (3220) – 120 SF Evaluated CS 2, Remainder is CS 1
	Concrete Overlay – Abrasion (8911) – 8 SF Evaluated CS 2, Remainder is CS 1

Defect	**Condition State**	**Comments**
Debonding/Spalls/Patch Area/Pothole - Wearing Surface (3210)	CS 1 Good CS 2 Fair Difficult to determine	Undetermined from the photo. Potentially evaluate with thermographic scan.

Defect	**Condition State**	**Comments**
Crack – Wearing Surface (3220)	CS 1 Good CS 2 Fair *	Widths 0.012 – 0.05 in. Evaluated 120 SF CS 2, remainder is CS 1
Abrasion, Wear, Rutting, or Loss of Friction – Wearing Surface (8911)	CS 2 Fair **	Abrasion has exposed coarse aggregate but the aggregate remains secure in the concrete. Rutting undetermined through photo images.

* Difficult to accurately and confidently determine narrow crack widths. Hairline cracks typically do not reduce the element condition rating of reinforced concrete. Wider cracks would typically be visible with high quality UAS equipment.

** Difficult to accurately and confidently assess abrasion, wear, rutting or loss of friction surface from photos of surface.

Some of the limitations in the rating and assessment of element 8514 – Concrete Overlay include but are not limited to:

- It is difficult to see and quantify small narrow cracks and delamination.
- Orientation needs to be normal to the deck to get an accurate size for spall / patch areas. Spall depth cannot be accurately determined from aerial photos.
- It is difficult to see and quantify limits to delamination areas through photos. Thermographic video can be effective under the correct weather conditions.
- Lighting can make it difficult to assess condition of the element, particularly shadows from parapets, railings or overhead members.
- Bridges with live traffic can cover patched or spalled areas and may be missed depending on the timing of the UAS flight.
- A complete assessment of the bridge deck also requires evaluation of the sides and the underside of the deck.
- Snow or grit and debris in the flow line can cover potential defects in the bridge at the time of the UAS flight.

In the inspection, the Concrete overlay is reviewed, rated and assessed per square foot of the deck on the bridge. Through the use of multiple photos, video images, and thermographic imaging, the assessment of the entire Concrete Overlay can be compiled for the bridge.

APPENDIX B

Part 107 Rule Summary

FAA News

Federal Aviation Administration, Washington, DC 20591

June 21, 2016

SUMMARY OF SMALL UNMANNED AIRCRAFT RULE (PART 107)

Operational Limitations	• Unmanned aircraft must weigh less than 55 lbs. (25 kg). • Visual line-of-sight (VLOS) only; the unmanned aircraft must remain within VLOS of the remote pilot in command and the person manipulating the flight controls of the small UAS. Alternatively, the unmanned aircraft must remain within VLOS of the visual observer. • At all times the small unmanned aircraft must remain close enough to the remote pilot in command and the person manipulating the flight controls of the small UAS for those people to be capable of seeing the aircraft with vision unaided by any device other than corrective lenses. • Small unmanned aircraft may not operate over any persons not directly participating in the operation, not under a covered structure, and not inside a covered stationary vehicle. • Daylight-only operations, or civil twilight (30 minutes before official sunrise to 30 minutes after official sunset, local time) with appropriate anti-collision lighting. • Must yield right of way to other aircraft. • May use visual observer (VO) but not required. • First-person view camera cannot satisfy “see-and-avoid” requirement but can be used as long as requirement is satisfied in other ways. • Maximum groundspeed of 100 mph (87 knots). • Maximum altitude of 400 feet above ground level (AGL) or, if higher than 400 feet AGL, remain within 400 feet of a structure. • Minimum weather visibility of 3 miles from control station. • Operations in Class B, C, D and E airspace are allowed with the required ATC permission. • Operations in Class G airspace are allowed without ATC permission. • No person may act as a remote pilot in command or VO for more than one unmanned aircraft operation at one time. • No operations from a moving aircraft. • No operations from a moving vehicle unless the operation is over a sparsely populated area. • No careless or reckless operations. • No carriage of hazardous materials.

	• Requires preflight inspection by the remote pilot in command. • A person may not operate a small unmanned aircraft if he or she knows or has reason to know of any physical or mental condition that would interfere with the safe operation of a small UAS. • Foreign-registered small unmanned aircraft are allowed to operate under part 107 if they satisfy the requirements of part 375. • External load operations are allowed if the object being carried by the unmanned aircraft is securely attached and does not adversely affect the flight characteristics or controllability of the aircraft. • Transportation of property for compensation or hire allowed provided that- o The aircraft, including its attached systems, payload and cargo weigh less than 55 pounds total; o The flight is conducted within visual line of sight and not from a moving vehicle or aircraft; and o The flight occurs wholly within the bounds of a State and does not involve transport between (1) Hawaii and another place in Hawaii through airspace outside Hawaii; (2) the District of Columbia and another place in the District of Columbia; or (3) a territory or possession of the United States and another place in the same territory or possession. • Most of the restrictions discussed above are waivable if the applicant demonstrates that his or her operation can safely be conducted under the terms of a certificate of waiver.
Remote Pilot in Command Certification and Responsibilities	• Establishes a remote pilot in command position. • A person operating a small UAS must either hold a remote pilot airman certificate with a small UAS rating or be under the direct supervision of a person who does hold a remote pilot certificate (remote pilot in command). • To qualify for a remote pilot certificate, a person must: o Demonstrate aeronautical knowledge by either: ▪ Passing an initial aeronautical knowledge test at an FAA-approved knowledge testing center; or ▪ Hold a part 61 pilot certificate other than student pilot, complete a flight review within the previous 24 months, and complete a small UAS online training course provided by the FAA. o Be vetted by the Transportation Security Administration. o Be at least 16 years old. • Part 61 pilot certificate holders may obtain a temporary remote pilot certificate immediately upon submission of their application for a permanent certificate. Other applicants will obtain a temporary remote pilot certificate upon successful completion of TSA security vetting. The FAA anticipates that it will be able to issue a temporary remote pilot certificate within 10 business days after receiving a completed remote pilot certificate application. • Until international standards are developed, foreign-

	certificated UAS pilots will be required to obtain an FAA-issued remote pilot certificate with a small UAS rating. A remote pilot in command must: • Make available to the FAA, upon request, the small UAS for inspection or testing, and any associated documents/records required to be kept under the rule. • Report to the FAA within 10 days of any operation that results in at least serious injury, loss of consciousness, or property damage of at least $500. • Conduct a preflight inspection, to include specific aircraft and control station systems checks, to ensure the small UAS is in a condition for safe operation. • Ensure that the small unmanned aircraft complies with the existing registration requirements specified in § 91.203(a)(2). A remote pilot in command may deviate from the requirements of this rule in response to an in-flight emergency.
Aircraft Requirements	• FAA airworthiness certification is not required. However, the remote pilot in command must conduct a preflight check of the small UAS to ensure that it is in a condition for safe operation.
Model Aircraft	• Part 107 does not apply to model aircraft that satisfy all of the criteria specified in section 336 of Public Law 112-95. • The rule codifies the FAA's enforcement authority in part 101 by prohibiting model aircraft operators from endangering the safety of the NAS.

APPENDIX C

Structures Considered for Pilot UAS Inspection

P-42-34

Near Green Bay. 150 miles from Madison. 140 miles from Milwaukee
single span 90 ft overhead steel truss

BRIDGE CLOSED

B-9-488

Near Chippewa Falls. 210 miles from Madison. 280 miles from Milwaukee (180 miles from P-42-34)
2-span (130-130) overhead steel truss

BRIDGE CLOSED

B-12-363

Near Fennimore. 90 miles from Madison. 170 miles from Milwaukee (170 miles from B-9-488)
Single span 160 ft overhead steel truss

B-40-115

IH 43 N-S Freeway over CMSTPP RR, Milwaukee County, Steel Plate Girder, URT Bridge
Inspect steel members below deck, concrete piers, and bearings.
Possibly collect thermography of the deck and piers

B-11-22/23 IH 39 over Wisconsin River, Columbia County, Steel Girder/Floorbeam/Stringer

Access interior girders where snooper cannot reach, bearings and piers.

B-32-115 STH 16 EB over La Crosse River and CP RR, La Crosse County, Steel Deck Truss

2.9 Miles to Airport

Collect photos of gusset plates, interior truss, bearings, and pack rust identification. Coordinate with FAA (2.9 miles from active airport). Coordinate with Railroad (span over active rail)

B-32-111 STH 16 WB over La Crosse River and CP RR, La Crosse County, Steel Plate Girder

2.9 Miles to Airport

Inspect pin & hanger condition and paint system.

B-47-40 USH 10 over St. Croix River, Pierce County, Steel Plate Girder/Lift Bridge

Observe mechanical operations (collect video of lift mechanism in operation). Coordinate with Bridge Tender

B-15-100 Michigan Street over Sturgeon Bay, Door County, Overhead Steel Truss

2.1 Miles to Airport

Visually determine condition (of elements determined by type of inspection). Perform intermittent inspection during lift span operation.

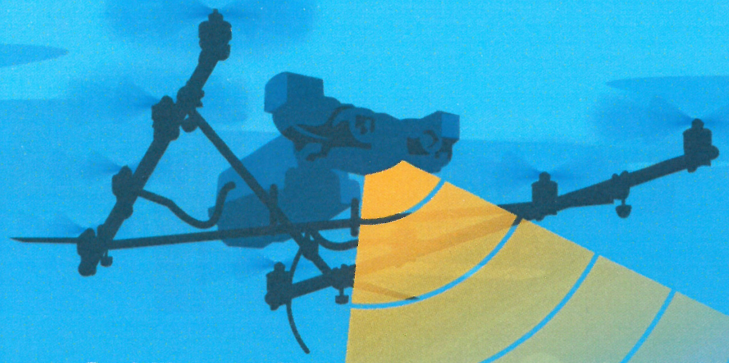
APPENDIX D

Topcon Falcon 8 Specifications

TOPCON

FALCON 8

AERIAL IMAGING SOLUTION



Stability and Endurance

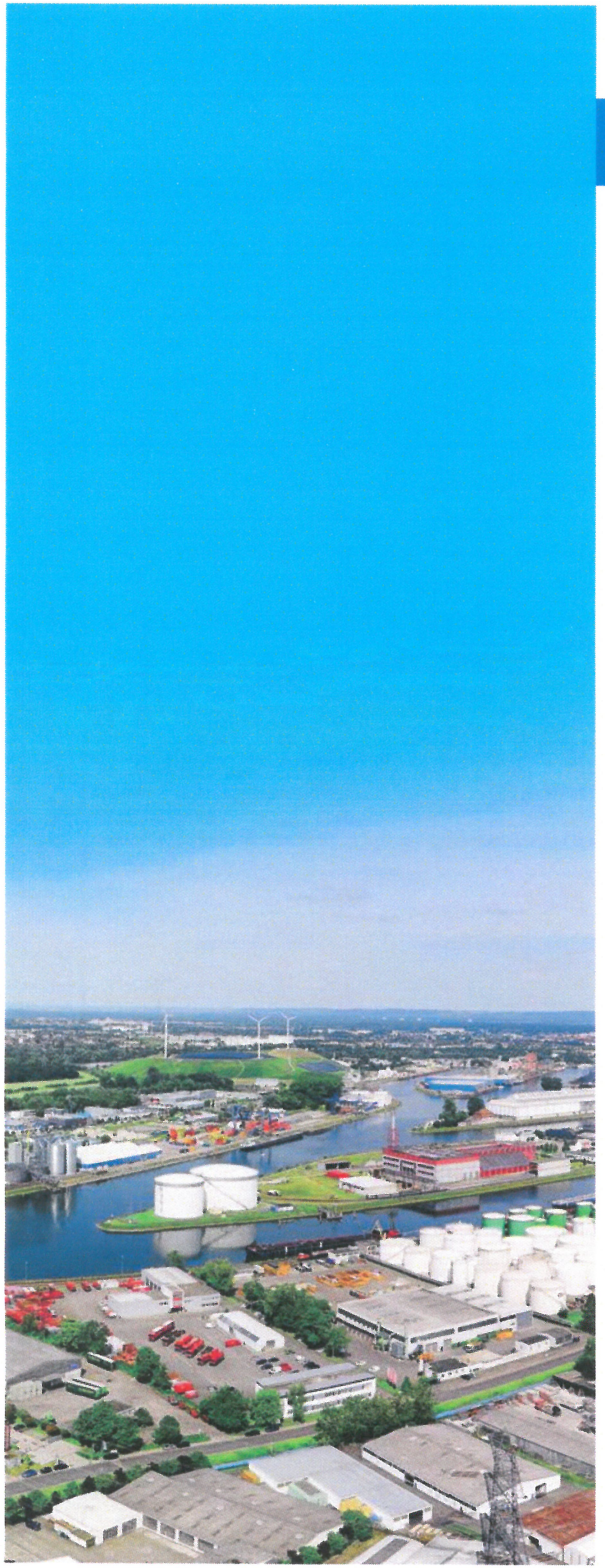
Take off from any location and be able to work even in heavy winds – the Falcon 8 is resistant to magnetic interferences and temperature variations.

Built-in Failsafe

With many levels of built-in redundancies – three autopilots, redundant electronics, a redundant propulsion system, and redundant radio links – the Falcon 8 ensures top performance, precision and safety.

Top Quality Data

Using best-in-class sensors and a camera mount compensating for abrupt maneuvers, the Falcon 8 delivers incredibly detailed survey and inspection data – revealing the finest cracks and heat leaks.



Falcon 8

The Topcon Falcon 8 powered by Ascending Technologies is a rotary-wing UAS designed for inspection and monitoring or survey and mapping applications, depending on which camera payloads are used. Rotary-wing UASs are best applied to smaller scale projects and those for which flexibility for take-off and landing or oblique perspective is required. The Falcon 8 offers the flexibility to get into small spaces and compromising situations often presented in inspection and monitoring applications. Due to its best-in-class sensors, active vibration damping and actively compensating camera mount, the Falcon 8 is well suited for smaller mapping and inspection projects up to 35 hectares that require high resolution imaging.

There are two Falcon 8 models to choose from depending on your application:

- **GeoEXPERT** – Payload includes a high-resolution RGB camera (Sony Alpha 7R) for small survey, modeling and mapping projects.
- **InspectionPRO** – Payload consists of an RGB camera and IR sensor (Panasonic Lumix DMC-TZ71 + FLIR TAU 640) or the video camcorder (Sony HDR-PJ810E) for inspection and monitoring applications.

With the AscTec® Trinity, the UAS propulsion and complete flight control electronics are triple protected.

Falcon 8 GeoEXPERT

- Efficient dam and wall survey
- Monument monitoring
- Geodata capture and analysis
- Vegetation control
- Mining surveys
- Archeology and geology
- 3D terrain modeling
- Inventory analysis
- Building surveys
- Volume surveys
- Construction progress and mapping

Falcon 8 InspectionPRO

- Bridge and inspection survey
- Onshore and offshore inspections
- Windpark inspection
- Visual inspection of structural integrity
- Industrial indoor/outdoor inspection
- Solar park inspection
- Structural condition assessment operations

SURVEY AND MAPPING

The Falcon 8 GeoEXPERT is a great solution for small mapping or survey projects with limited space for take-off and landing – which is often the case for projects in built-up areas or smaller construction sites. High-resolution geo-referenced aerial images can be taken from various heights, uniformly and precisely, within set GPS tolerances and offer a complement to conventional survey methods. The Falcon 8 can map 35 hectares in a single flight providing reliable material to create orthophotos or 3D models in Agisoft PhotoScan, or similar processing software.

The Falcon 8 can be used for:

- Archeology and geology
- 3D terrain modeling
- Inventory analysis
- Construction site mapping
- Volumetric 3D measurements
- Georeferenced 2D and 3D information
- Building survey and modeling

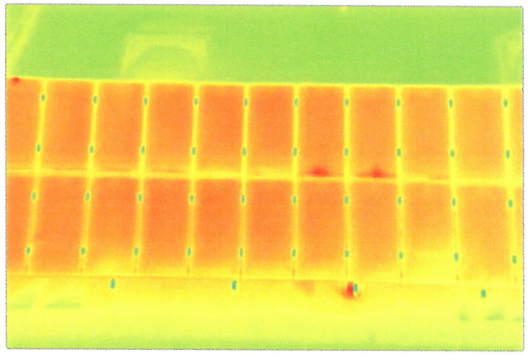
INSPECTION AND MONITORING

Safety is required at many inspection sites where the environment can be dangerous and impacted. Falcon 8 offers the ultimate in safety. Remotely controlling the UAS with the Mobile Ground Station (MGS) keeps the pilot away from the site. Critical situations like strong wind and data link will clearly be indicated on the MGS with visual and acoustic warnings.

The Falcon 8 can fly anywhere and operate in the toughest weather conditions. As a result, important decisions can be made immediately saving time and resources.

The Falcon 8 offers:

- Less risk and expense than conventional methods
- Minimized downtime and safer shutdowns
- More quality and detail with HD imaging, thermal and RGB stills and videos
- Precise structure analysis and quick damage detection
- Low noise and emissions
- Robust functionality in electromagnetic fields
- Wind load balancing up to 15 m/s
- Second operator independent camera control



PAYLOAD OPTIONS

The Falcon 8 is a lightweight octocopter using a patented V-shape design granting the camera an unobstructed view not only to look down, but also up, allowing structures like bridges to be inspected or surveyed from below. The UAS frame is made of specially designed carbon fiber components.

Every camera is modified and integrated mechanically and electronically into the camera mount. The combination of design and material leads to many advantages such as being lightweight, stable, flexible, and easily maintained.

SURVEY AND MAPPING

The survey and mapping model of the Falcon 8, the GeoEXPERT, includes the Sony Alpha 7R payload. It reproduces the finest details with minimal image noise even in poor lighting.

In combination with a 35mm full-frame sensor and a Bionz-X image processor, the Sony Alpha 7R with ZEISS lens (Sonnar T FE 35 mm F/2.8 ZA) currently is the best available on the market.

INSPECTION AND MONITORING

The inspection and monitoring model of the Falcon 8, the InspectionPRO, includes the Panasonic Lumix TZ71 and the FLIR TAU 640 2. With remote controlled 30x optical zoom (24-720 mm), the Panasonic Lumix DMC TZ71 produces high-resolution images from a safe distance. The high-sensitivity CMOS sensor and the excellent display processing unit provide luminous photo quality.

The FLIR TAU 640 2 simultaneous captures images at 640 x 512 pixels, includes second generation Digital Detail Enhancement and makes flight times of over 20 minutes possible.

Even small thermal leaks or defects on solar power plants can be detected from long distances.

VIDEOGRAPHY

Enjoy blur-free, smooth video clips with the Sony Camcorder HDR-PJ810E with full HD quality and 12x optical zoom- and not just under ideal conditions. The Exmor R™ CMOS sensor and its Balanced Optical SteadyShot™ provide excellent results with no need for laying plates, stringing wires or installing mobile cranes.

Automatically fly any path as a hovering Steadicam through preprogrammed settings. Simply define the location and the time and capture the scene in no time.

In video mode, a single pilot steers the flight system with the right control stick while controlling the camera with the left.

MOBILE GROUND STATION

The Mobile Ground Station (MGS) is the main UI of the Falcon 8 UAS. Data links, remote control of the camera, video link, video display and the controls for the Falcon 8 are completely integrated into the MGS. Flight data, camera settings and live images are always at hand on your MGS and at the same time provide absolute freedom of movement.

The mobile ground station includes:

- Remote control
- Status display
- Dual diversity data link for telemetry in real time
- Analog video receiver
- HD video monitor

The optional independent camera control and video goggles allow two person operation for inspection flights.

NAVIGATOR SURVEY SOFTWARE

The Falcon 8 comes with flight planning software as part of the survey package for ease-of-use. As part of the package, users receive:

- **AscTec® Navigator** – Waypoint flight planning software
- **Photo Tagger** – combine logs with images for use in post-processing software

The AscTec® Navigator is easy-to-use flight planning software for carrying out complex surveying projects with the minimum time and effort. With just a few clicks you can plot matrices, define routes and set all relevant system and camera parameters. Missions can be edited at all times and can be exactly reproduced as often as desired.

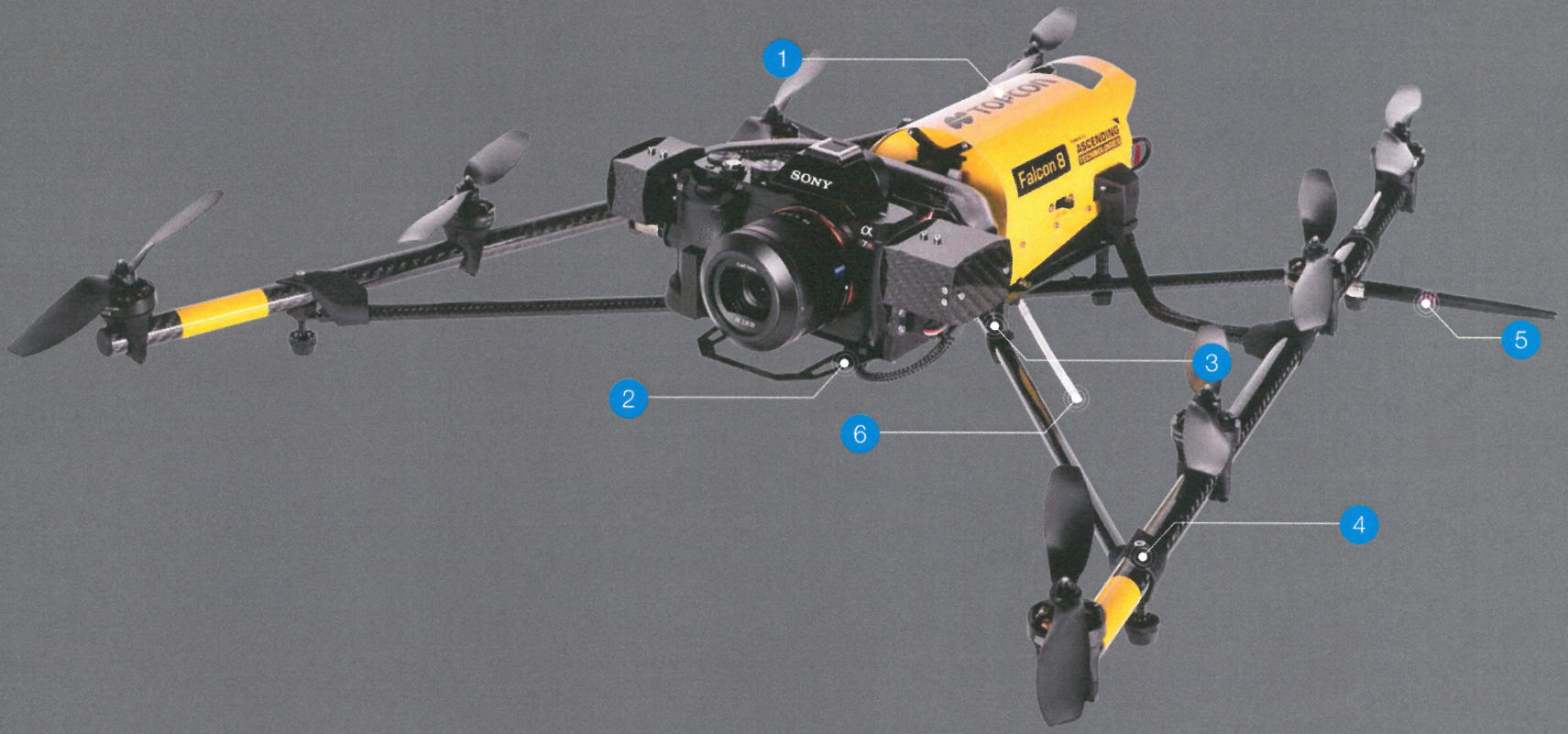
KIT COMPONENTS

Falcon 8 GeoEXPERT for surveying and mapping includes:

- Falcon 8 – high-end octocopter
- Mobile Ground Station
- High-resolution digital camera, Sony Alpha 7R
- Software options: photo package or survey package
- Batteries
- Chargers
- LiPo safety bag
- Transport case
- Backpack

Falcon 8 InspectionPRO for inspection and monitoring includes:

- Falcon 8 – high-end octocopter
- Mobile Ground Station
- Inspection payload TZ71 (RGB+IR camera combination)
- Independent camera control
- Software options: photo package
- Video goggles
- Batteries
- Chargers
- LiPo safety bag
- Transport case
- Backpack



1. Central unit
2. Actively stabilized mount with camera
3. Carbon cross
4. Motor rails
5. Data link antennas
6. Video link antenna

GeoEXPERT WORKFLOW

The Falcon 8 comes fully assembled and ready to fly. Pre-flight setup and planning steps are minimal, which offer a simple, streamlined workflow for new users. The maximum take off weight of the UAS is only 2.3 kg and the system is of high quality – made and tested in Germany.

- High-reliability, safety and performance
- Simple operation with high-tech autopilot
- Automated waypoint navigation
- Program and automate flight paths
- Backpack for off-road missions to remote locations

FLIGHT PLANNING

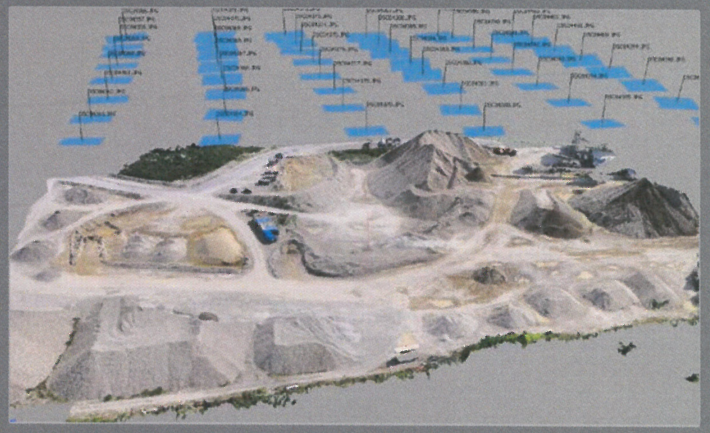
Flight planning is simple, much is contained in the Mobile Ground Station firmware. Simply enter your required parameters to survey your area of interest right at the project site. Flight pattern and attitude are automatically optimized and defined by your settings.

Optionally, plan your flights with AscTec® Navigator desktop software to generate high-quality and easy-to-edit material in just a short period of time.

IMAGE ACQUISITION

- Position yourself to overview the complete area you want to survey.
- Position the Falcon 8 in one of the corners of that area and align its heading with the first line of your flight pattern.
- Select the Quick Survey function via Status Display on the Mobile Ground Station and follow the assistant to set the required configuration.
- Define turning direction (left/right), inline and slide overlap (in %).
- Define the required ground sampling distance (GSD). Click "Start" and your Quick Survey begins.

POST PROCESSING



Transfer your data utilizing a simple USB interface.

Use Photo Tagger to post-process log files and to combine logs with images or utilize Agisoft Photoscan Pro for post-processing survey missions.

InspectionPRO WORKFLOW

High-risk applications demand advanced workmanship and tools. The unique functions and advanced flight characteristics of the Falcon 8 InspectionPRO make it a superb tool for inspection and monitoring projects. Pre-flight setup and planning steps are minimal.

- Combination of thermal and digital camera
- Independent camera control for a second camera operator
- Video goggles for quick live view and initial diagnosis
- Magnetic resistance
- Automated 3D flights can be reproduced

FLIGHT PLANNING

The Falcon 8 gives you full control over your flight planning. Manually fly the Falcon 8 around the object to be inspected, or program your flight path in advance. Save your accomplished flight path and repeat it automatically for exact comparison during a next inspection.

FIELD REVIEW

View real-time data on the monitor of the Mobile Ground Station or using the video goggles. Freely adjust the Falcon 8's alignment and image zoom using the live image.

IMMEDIATE DECISIONS

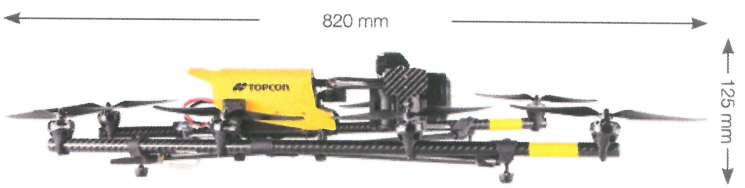
Important decisions can be made immediately or at the end of the flight on the basis of reliable pictures and video footage. Whether it is a hairline fracture or an energy leak – every second counts – the RGB and infrared images provide full insight.

SAFETY AND SPECIFICATIONS

The Topcon Falcon 8 uses the groundbreaking AscTec® Trinity technology, making your Falcon 8 even more efficient and safe in daily operation. AscTec® Trinity is the first fully adaptive control unit (autopilot) with up to 3 levels of redundancy for multi-rotor flight systems. Three IMUs synchronize all sensing data and would identify, signal and compensate in case of trouble.

Further unique safety features include:

- **Redundant propulsion system**: Automatic compensation of defect propellers, motors or motor controllers.
- **Perfectly predictable flight behavior**: Even in weak GPS environment or magnetic fields.
- **Unbelievable position accuracy**: Tiny positional corrections are possible with extreme precision.
- **Minimal impact energy**: Super lightweight system with micro sized 8 inch propellers.



Flight Systems	
Type	V-Form Octocopter
Dimensions	770 x 820 x 125 mm
Engines	8 electric brush-less motors
Rotor Diameter	20 cm (8 inches)
Rotors	Total Rotors: 8 / Weight: 6 g each
Weight	Without payload: 1086 g Max Take-off: 2.3 kg Max Payload: 800 g
Flight Time	12 - 22 minutes
Maximum Flight Range	1 km
Tolerable Wind Speed	Up to 15 m/s
Navigation Sensors	
AscTec® Trinity (IMU, barometer and compass)	
AscTec high-performance GPS (GNSS)	
Maximum Airspeed	
Manual Mode	16 m/s
Height Mode	5 m/s
GPS Mode	4.5 m/s
Maximum Climb / Sink Rate	
Manual Mode	6 - 10 m/s
Height Mode	3 m/s
GPS Mode	3 m/s

Wireless Communication
2x Independent (diversity) control/data links
2.4 GHz FHSS link (10' to 63 mW)
1 Analogue diversity video receiver
5.8 GHz (25 mW)
LiPo Battery Types (mAh)
PP 6250 / 3 Cells 6250 (~ 426 g)
Available Payload Options
Sony Alpha 7R
Panasonic Lumix TZ71 + FLIR TAU 640
Sony Camcorder HDR-PJ810E
Certifications
CE
RoHS

APPENDIX E

DJI Inspire 1 Specifications

Appendix

Specifications

Aircraft	
Model	T600
Weight	2845 g (Battery and Propellers Included, Zenmuse X3 Excluded) 3060 g (Battery, Propellers and Zenmuse X3 Included)
Maximum Weight of Payload	3500 g
Hovering Accuracy (P Mode)	Vertical: 0.5 m Horizontal: 2.5 m
Max Angular Velocity	Pitch: 300°/s Yaw: 150°/s
Max Tilt Angle	35°
Max Ascent Speed	5 m/s
Max Descent Speed	4 m/s
Max Speed	22 m/s (ATTI mode, no wind)
Max Service Ceiling Above Sea Level	4,500 m (Software altitude limit: 120 m above takeoff point)
Max Wind Speed Resistance	10 m/s
Max Flight Time	Approximately 18 minutes
Motor Model	DJI 3510
Propeller Model	DJI 1345T
Indoor Hovering	Enabled by default
Operating Temperature Range	-10° to 40° C
Diagonal Distance	559 to 581 mm
Dimensions	438x451x301 mm
Gimbal	
Model	ZENMUSE X3
Output Power (With Camera)	Static: 9 W; In Motion: 11 W
Operating Current	Station: 750 mA; Motion: 900 mA
Angular Vibration Range	±0.03°
Mounting	Detachable
Controllable Range	Pitch: -90° to +30° Pan: ±320°
Mechanical Range	Pitch: -125° to +45° Pan: ±330°
Max Controllable Speed	Pitch: 120°/s Pan: 180°/s

Camera	
Name	X3
Model	FC350
Total Pixels	12.76M
Effective Pixels	12.4M
Image Max Size	4000x3000
ISO Range	100-3200 (video) 100-1600 (photo)
Electronic Shutter Speed	8 s to 1/8000 s
FOV (Field Of View)	94°
CMOS	Sony EXMOR 1/2.3"
Lens	20mm (35mm format equivalent) f/2.8 focus at ∞) 9 Elements in 9 groups Anti-distortion
Still Photography Modes	Single shoot Burst shooting: 3/5/7 frames Auto Exposure Bracketing (AEB): 3/5 bracketed frames at 0.7EV Bias Time-lapse
Video Recording Modes	UHD (4K): 4096x2160p24/25, 3840x2160p24/25/30 FHD: 1920x1080p24/25/30/48/50/60 HD: 1280x720p24/25/30/48/50/60
Max Bitrate Of Video Storage	60 Mbps
Supported File Formats	FAT32/exFAT Photo: JPEG, DNG Video: MP4/MOV (MPEG-4 AVC/H.264)
Supported SD Card Types	Micro SD Max capacity: 64 GB. Class 10 or UHS-1 rating required.
Operating Temperature Range	0° to 40° C
Remote Controller	
Name	C1
Operating Frequency	922.7MHz~927.7 MHz (Japan Only) 5.725~5.825 GHz;2.400~2.483 GHz
Transmitting Distance	Up to 5.0 km or 3.1 miles (unobstructed, free of interferences and FCC compliant) when it is FCC compliant. Up to 3.5 km or 2.1 miles (unobstructed, free of interferences) when it is CE compliant.
EIRP	10dBm@900m, 13dBm@5.8G, 20dBm@2.4G
Video Output Port	USB, Mini-HDMI

Power Supply	Built-in battery
Charging	DJI charger
Dual User Capability	Host-and-Slave connection
Mobile Device Holder	Tablet or Smart Phone
Output Power	9 W
Operating Temperature Range	-10° to 40° C
Storage Temperature Range	Less than 3 months: -20° to 45° C More than 3 months: 22° to 28° C
Charging Temperature Range	0-40° C
Battery	6000 mAh LiPo 2S
Charger	
Model	A14-100P1A
Voltage	26.3 V
Rated Power	100 W
Battery (Standard)	
Name	Intelligent Flight Battery
Model	TB47
Capacity	4500 mAh
Voltage	22.2 V
Battery Type	LiPo 6S High voltage battery
Energy	99.9 Wh
Net Weight	570 g
Operating Temperature Range	-10° to 40° C
Storage Temperature Range	Less than 3 months: -20° to 45° C More than 3 months: 22° C to 28° C
Charging Temperature Range	0° to 40° C
Max Charging Power	180 W
Battery (Optional)	
Name	Intelligent Flight Battery
Model	TB48
Capacity	5700 mAh
Voltage	22.8 V
Battery Type	LiPo 6S
Energy	129.96 Wh
Net Weight	670 g
Operating Temperature Range	-10 to 40° C

Storage Temperature Range	Less than 3 months: -20 to 45° C More than 3 months: 22° to 28° C
Charging Temperature Range	0° to 40° C
Max Charging Power	180 W
Vision Positioning	
Velocity Range	Below 8 m/s (2 m above ground)
Altitude Range	5-500 cm
Operating Environment	Brightly lit (lux > 15) patterned surfaces
Operating Range	0-300 cm
DJI GO App	
Mobile Device System Requirements	iOS version 7.1 or later; Android version 4.1.2 or later
Supported Mobile Devices	* iPhone 6 Plus, iPhone 6, iPhone 5S, iPad Air 2, iPad Mini 3, iPad Air, iPad Mini 2, iPad 4;* Samsung Note 3, Samsung S5, Sony Z3 EXPERIA;* Note: It is recommended that you use a tablet for the best experience

Intelligent Flight

Intelligent Flight mode includes Course Lock, Home Lock, Point of Interest (POI), Follow Me and Waypoints features to assist users to create professional shoots during the flight. Course Lock and Home Point lock helps to lock the orientation of aircraft so that the user can focus more on other operations. Point of Interest, Follow Me and Waypoints mode enable aircraft to fly automatically according to the pre-set flight maneuvers.

Course Lock	Lock the current nose direction as the aircraft's forward direction. The aircraft will move in the locked directions regardless of its orientation (yaw angle).
Home Lock	Pull the pitch stick backward to move the aircraft toward its recorderd Home Point.
Point of Interest	The aircraft will orbit around the subject automatically to allow the operator can be more focus on framing their shoot on the subject in Point of Interest.
Waypoints	Record a flight path, then the aircraft will fly along the same path repeatedly while you control the camera and orientation. The flight path can be saved and re-apply in the future.

Enable Multiple Flight Mode by launching the DJI GO app > Camera View > > Advanced Settings > Mulitple Flight Mode before using the Intelligent Flight Mode for the first time.

After-Sales Information

Visit the following pages to learn more about After-sales policy and warranty information:

1. After-sales Policy: http://www.dji.com/service
2. Refund Policy: http://www.dji.com/service/refund-return
3. Paid Repair Service: http://www.dji.com/service/repair-service
4. Warranty Service: http://www.dji.com/service/warranty-service