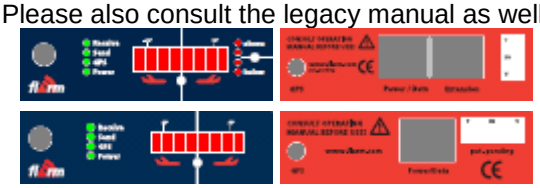
OPERATING MANUAL
FLARM COLLISION AVOIDANCE SYSTEM

Version 242 (December 18, 2016)

This manual only covers hardware version 3 resp.
units with serial numbers F6•••• / F7•••• / F8•••• / F9••••

For legacy units with serial numbers F4•••• / F5••••
Please also consult the legacy manual as well.



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1. Welcome to the FLARM user community

Thank you for purchasing FLARM, a modern low-cost collision-warning unit for sailplanes and light aircraft. The main task for FLARM is to support the pilot, while he scans the airspace ahead with his own eyes. FLARM is simple to use and does not distract the pilot from the main business in hand.

Sport flying is an activity that is associated with considerable risks for crew, passengers, third parties and other objects. **In order to make full and safe use of FLARM, it is absolutely essential to be fully aware of the risks, operating conditions, restrictions and limitations associated with the use of FLARM, ensure a proper installation and do regular firmware updates. This includes familiarity with and observance of this Operating Manual and the Installation Manual.** Additional configuration information can be found in the 'Data Port Specifications' document, e.g. how to suppress additional data at the serial port what might be required in international championships.

We welcome user feedback and reports, suggestions for improvements, and pictures that will help us make further improvements to FLARM. Feedback reports should give a detailed description of the situation, quoting the hardware and firmware versions used, plus the flight data records in IGC format with short time recording intervals.

The latest version of this handbook and other related documents can be found at the Website www.flarm.com. This Website also has answers to Frequently Asked Questions.

This Website also carries announcements when new firmware versions or functions become available. If you enter your name on the mailing list, you will automatically receive notification of changes as and when they happen: www.flarm.com.

From the March 2015 update, every FLARM device needs to be updated with the latest firmware version at least once per year (rolling 365 days). Each update can be applied anytime during a one-year period. This makes it easier to align FLARM firmware updates with the yearly aircraft maintenance process. It is also in line with the maintenance care that a safety system requires.

As the update cycle now becomes individual, no generic information will be sent out on individual firmware version expirations.

If the firmware update is not applied once per year, the device will no longer be operational and stop to operate!

Use the free PC installation software (FlarmTool) available at www.flarm.com. You need a PC with Windows 98 / ME / 2000 / XP / 7 with a serial port or a suited USB-serial converter plus a data-power cable like the one used for most IGC flight recorders. This cable connects the PC to FLARM and supplies FLARM with power. Ensure you have configured the correct PC COM-port, only use the Power/Data-port on FLARM (not the Extension-port) and know the printed device serial number. After completion of the firmware update, use the same PC software to load the most recent obstacle file to FLARM; this file is available on www.flarm.com as well. Then use the PC software to configure the flight recording functionality accordingly. In case of questions, contact your FLARM dealer.

2. How it works

FLARM receives position and movement information from an internal 16 channel GPS receiver with an external antenna. A pressure sensor further enhances the accuracy of position measurements. The predicted flight path is calculated by FLARM and the information - including a unique identifier - transmitted by radio as low-power digital burst signals at one-second intervals. Provided they are within receiving range, the signals are almost at the same time received by further aircraft also equipped with FLARM. The incoming signal is compared with the flight path predicted by calculation for the second aircraft. At the same time, FLARM compares the predicted flight path with known data on obstacles, including electric power lines, radio masts and cable cars.

If FLARM determines the risk of dangerous proximity to one or more aircraft or obstacles, the unit gives the pilot warning of the greatest danger at that moment. The warning is given by a whistle sound (beep) and bright light emitting diodes (LED). The display also gives indication of the threat level, plus the horizontal and vertical bearing to the threat. During circling flight different methods of calculation are employed to those used during straight flight.

The GPS and collision information received from other aircraft can also be made available for third party equipment (e.g. external display, speech synthesizer, PDA) via a serial data output. Such equipment is available from a number of manufacturers.

The operating range is very dependent upon the antenna installation in the aircraft. The typical range is 3 -5 km, which can be valuable for fast sailplanes with a speed of up to 250 kt, providing the pilots in both aircraft with a warning enabling visual identification and reaction to the potential hazard. The effective range can easily be verified with an online tool[1]. Warnings are given in order of the time remaining before a potential collision, not the geometrical distance. The first warning level for another aircraft or an obstacle is delivered at less than 19 - 25 seconds before the possible collision; the second warning level is delivered at less than 14 - 18 seconds before; the third level at less than 6 - 8 seconds before.

The warnings continue as long as FLARM calculates a threat of collision. The warning level may decline or be cancelled, depending upon the prediction. The warnings are selective; they are only issued if the calculation reveals a high probability of collision in the near future. The alarm sensitivity can be configured with the PC.

In addition, FLARM operates as an IGC-file compatible flight recorder including the G-record. Flight logs can be read out either via the SD-card or via the data port and a suitable cable. The SD card does not need to be carried on during the flight. FLARM is optionally also available as diamond-level IGC-*approved* Flight Recorder, optionally with Engine Noise Level sensor (ENL).

With the standard Feb 2011 obstacle database, there is memory for more than 50 hrs of flight recording at a 2s interval (the recommended setting). Use the free PC-software to download flights to your PC and to properly configure your device for flight recording. Flight recording automatically starts when the aircraft is moving and ends when the unit is switched off. Switching off the device during the flight for a longer period results in separate flight record files. Allow at least 1 minute (if the interval is 2s, the recommended setting) after landing before you switch off the device else you lose the last part of the flight. Allow more time after landing if the interval is higher. When the memory is full, the oldest data is overwritten. Always download your flight data before you update the obstacle database or the firmware.

FLARM applies for the radio communication between the units a proprietary and copyright-protected protocol in regionally different frequency bands. The radio communication is separately secured against unauthorized access. The design is protected by several patents. The radio communication protocol is not public, but FLARM Technology Ltd. offers a license contract where it is accessible in the form of a compatible core design ready for integration into 3rd party systems. These systems are officially declared as FLARM-compatible. Any non-licensed use, dissemination, copying, implementation, reverse engineering or decompilation of the FLARM radio communication protocol, the FLARM hardware and firmware or parts of it is forbidden by law and will be prosecuted. FLARM is an internationally registered trademark and can not be used without license. Technical specifications subject to change at any time without notice.

3. General Advice on Operation

This Manual must be carried on board the aircraft. When permanently installed in an aircraft, the 'AFM Supplement' must also be carried in the aircraft.

In flight the pilot must have direct sight of and immediate access to a switch or circuit breaker that disconnects FLARM from the aircraft electrical power supply, without affecting other essential aircraft systems. This might be necessary if the pilot suspects that FLARM may be interfering with another on-board system, the suspected presence of smoke, the smell of smoke, or flying in a country where the use of FLARM is not permitted.

FLARM must not be operated at night or with night vision systems.

FLARM will not operate without adequate GPS signal strength. Correct antenna installation has a great effect on the transmission/receiving range; an incomplete or improper installation can make correct operations impossible without the system being able to detect this.

FLARM is not able to measure its own RF-receiver sensitivity. When the pilot detects that other aircraft are received only when very close or not at all and when the RF-antenna's positioning is clearly not the cause of it, the device must be checked by the manufacturer.

[1] http://flarm.com/support/tools-software/

Installation and operation must be on the basis of non-interference with and no hazard to the existing suite of other certified equipment necessary for safe flying operation, or installed to comply with official requirements. Installation and operation must comply with official regulations and requirements. It is recommended that the FLARM, GPS and radio antennas are all installed as far away as practicable - but at least 25 cm from - susceptible aircraft systems such as GPS antennae and the magnetic compass.

The unit must be protected from solid particles or liquids, should not be exposed in use to temperatures below –10°C or above +60 °C, or stored at temperatures –20°C or above +70 °C, because this may cause irreparable damage. On the ground, the unit should be protected from exposure to long periods of direct sunlight, because it is likely to be overheated. Also avoid static discharges to the radio antenna.

Details on correct installation are found in the Installation Manual. Ensure that you have **configured the correct aircraft type** with the PC-software. Ensure that tug planes are configured as such!

4. Operating Modes

FLARM operates in two modes, *Nearest* and *Collision*. The change from one mode to the other is effected by a two-second push on a button followed by a brief visual confirmation from the unit. After the change has been signalled, the current mode selected is not displayed. When switched on, the unit is in *Nearest* mode.

The warnings given are identical in both modes, and generally relate to an immediate threat to which the pilot should make an immediate and appropriate reaction. The assumption has been made that following a warning it will take up to 12.5 seconds from the time that the other aircraft is seen, until a change in flight path has removed the threat[2].

When operating in the *Nearest* mode, the unit also reports the presence of other aircraft operating in the vicinity, even though calculations indicate that they do not represent a threat. The information displayed is limited to a configurable radius (default is three kilometres) and a vertical separation of 500 m. When no aircraft was displayed so far but one is received now, this is signalled with a click-sound. Only one single aircraft is indicated in green. The optical signal is static (no flashing); the threat intensity is not indicated and there is no sound warning. As soon as FLARM detects the risk of a collision it automatically switches to *Collision* mode, followed by automatic reversion to *Nearest*. The choice of mode is presented, such that immediately after pressing the key, the display presents a diverging pattern  .

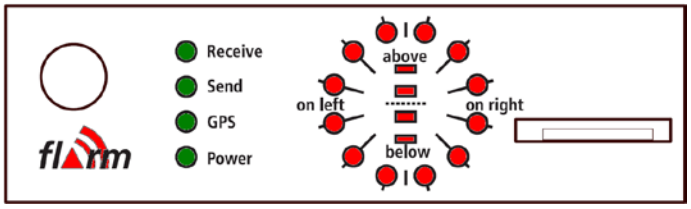
When operating in the *Warning* mode a red LED lights up only if the calculation predicts a threat. Warnings are always shown by flashing LEDs, the threat level being shown by the number of LEDs illuminated, by the frequency of flashes, and the simultaneous sound signal (beep). Selection of this mode is indicated by a upwards converging pattern  immediately after pressing the selector key.

In both modes the pilot can **suppress the display and the acoustic warning**: after a double push FLARM will suppress all visual and acoustic signals relating to traffic, obstacles or other threats. The act of selecting suppression is followed by a descending tone. A further double-push reinstates the *Collision* mode at once and is followed by a rising tone. While warnings are suppressed, FLARM nevertheless continues to transmit signals for reception by other aircraft.

[2] These times were published in 1983 FAA Advisory Circular 90-48-C and were based on military data. They relate to fast jet pilots with no on-board warning systems for other traffic and hazards. The assumption was made that only one aircraft takes avoiding action. Of the 12.5 seconds, five seconds were to recognise the threat of collision and four seconds were required to decide upon avoiding action. No information is available as to whether these times are applicable to light aircraft, sailplanes or helicopters, when using a warning system.

5. Front Panel

The front panel has a push-button, four green Status-LED, twelve bicolour LED for horizontal and four bicolour LED for vertical position indication. Depending on the threat caused by other aircraft or obstacles the LED show up red or green. Also included is a microSD-reader. microSD cards are not included, but widely available in electronic and mobile phone shops.

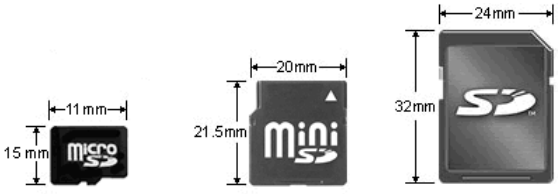


Push-button | 4 green LED (Status) | 12 LED (horizontal) 4 LED (vertical) all bicolor | microSD reader

6. Use the microSD card

microSD cards are smaller than *SD* cards or *miniSD* cards, but mechanical adapters exist to insert a microSD card in a SD or miniSD cards; these adapters are often provided with the cards.

Firmware version 5 and higher handles micro SD cards of SDSC- and SDHC format with FAT16 and FAT32 file system. Maximum size is 32GB (SDHC format).



microSD (used in FLARM) | miniSD (not used) | SD (not used)

Insertion and removal

Carefully **insert** the card upside-down (metal contacts on top), push with the finger until the card locks with a click sound. To **remove**, push the card with the finger into FLARM until it releases with a click sound, then carefully pull it out. No force should be required to insert or remove the card.

Updating the firmware

Download flight records before updating the firmware, otherwise data might be lost. Firmware files for microSD card updates have the extension **.fw** and are available on www.flarm.com. Copy the file to the top level directory, don't use sub-directories. Don't modify filenames. Delete files with the same extension. To start an update, insert the card into FLARM and interrupt power for at least 5 seconds. The update then takes about 50 seconds. The card may remain in the device after updating and during operation.

Updating the obstacle database

Download flight records before updating the obstacle database, otherwise data will be lost. Obstacle database files can be purchased on our FLARM webshop (http://shop.flarm.com). The obstacle database file has .ob2 extension. Copy the file to the top level directory, don't use sub-directories. Don't modify filenames. Delete files with the same extension. To start an update, insert the card into FLARM and interrupt power for at least 5 seconds. The update then takes several minutes, depending on the size of the file; progress is shown on the display. The card may remain in the device after updating and during operation.

Configuring the device

If at power up on the microSD card a file named `flarmcfg.txt` is detected, it will be processed as configuration commands. The file can be created with the FLARM Configurator:

http://flarm.com/support/tools-software/

Basic data entries and the SD-card configuration file can also be made with the free **FlarmTool** software.

For easy task declaration IGC-enabled units, use the free online-tool **FlarmCfg** (http://www.segelflug-software.de/flarmcfg/), using the microSD card.

The corresponding offline-version (http://www.segelflug-software.de/prod_flarmcfgtool.php), the free PDA software tools **SeeYou ConnectMe** (http://www.naviter.si/products/connectme.php) or **pocket*StrePla-Connect** (http://www.strepla.de/StrePla4/english/pS_connect/), and many of the other, partially commercial products on the market.

7. Start-Up

FLARM is always switched on if the unit is connected to an adequate power supply.

Immediately after it has been switched on, there is a short beep while all LED light up in all available colours, followed by a green binary presentation of the hardware-version during the system self-test. The self-test mode lasts for about 8 seconds, depending upon the size of the obstacle data bank.

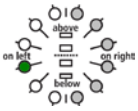
`0x03` Hardware Version 3 (only green)

This is followed by another short beep, followed by a presentation of the firmware version: The first six LEDs clockwise represent the minor version in red, the other LEDs clockwise the major version in green.

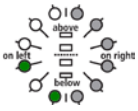
If the firmware version is not indicated and the beep sound is not emitted, the unit is not ready for operation.

Firmware version 3.xx (operational only to March 2008)

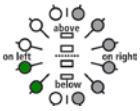
Firmware version 4.xx (operational only to February 2011)



Firmware version 5.xx (till March 01, 2015)



Firmware version 6.xx

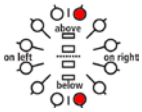
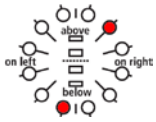
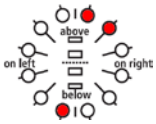
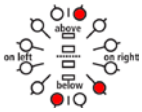
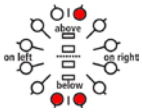
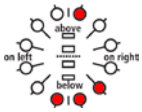


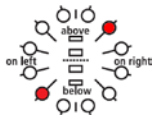
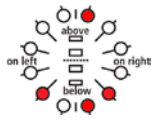
Then FLARM shifts to normal operation and waits until it has acquired an adequate GPS position fix. When switching on, this procedure can take *several minutes*. Without a proper GPS position fix, the unit is not ready for operation. **Before departure the pilot must ensure that at least the Power-, GPS- and Send-LED are all continuously on**. This state must be preserved during the whole flight to ensure correct operation.

8. Fault Finding

If a fault should occur during start-up self-test or subsequent operation, then all four green status LEDs will flash in unison for 30 seconds, while the red collision LEDs will give a binary indication of the most serious fault. The fault display can be stopped before 30 seconds has elapsed by pushing the button.

For safety reasons FLARM will not start up if there is a fault. FLARM may not be used if a fault has been reported or indicated. Limited operation is possible if there is an indication of a problem with the obstacle data bank or data recorder.

0x11	Fault: Firmware out of date (needs GPS reception)	*No operation*	
0x12	Fault: Firmware integrity violation (only on IGC-units)	*No operation*	
0x21	Fault: Low Voltage	*No operation*	
0x31	Fault: Internal GPS communication	*No operation*	
0x32	Fault: Faulty GPS configuration	*No operation*	
0x41	Fault: Internal radio communication	*No operation*	
0x42	Indication: Another FLARM unit with the same Radio ID was received.	*Operation possible*	
0x43	Indication: Wrong ID Configuration	*If the warning disappears after 30 seconds, the operation possible, otherwise operation is NOT possible*	
0x51	Fault: General internal communication	*No operation*	
0x61	Fault: Flash memory	*No operation*	
0x71	Fault: Pressure sensor	*No operation*	

0x81	Indication: Obstacle database problem	Operation possible	
0x82	Indication: Obstacle database out of date	Operation possible	
0x91	Indication: Flight recording not possible	Operation possible	
0x93	Indication: Engine-noise recording not possible (only on IGC-units)	Operation possible	
0xA1	Indication: Error with SD-card configuration file	Operation possible	
0xB1	Indication: Obstacle license not valid	Operation possible	
0xF1	Fault: Other fault	*No operation*	

The communications faults itemised above indicate if internal modules within FLARM are not communicating correctly with each other. For reasons associated with the system, neither poor GPS-reception nor reduced radio range cannot be detected by a single unit alone.

9. Status-Display

The green Status Display LEDs operate as follows; normal operating mode is underlined:

- **Receive**: Lights up when a signal is detected from another aircraft less than the configured range (default is 3 km) away, with a height separation of less than 500 m; otherwise the LED is dark. If the warning is temporarily suppressed (see below) but signals are still received from other aircraft, then the LED flashes.
- **Send**: Lights constantly during operation and indicates that the on-board FLARM is transmitting. Transmission requires GPS reception.
- **GPS**: Lights constantly during operation (with very brief interruptions once per second). If the LED is constantly dark and flashes briefly once per second, then there is no GPS reception. When switching on this condition can take several minutes.
- **Power**: Lights constantly during operation. If the LED flashes, then the power supply has dropped below 8 V. FLARM will not operate below 8 V DC.

The 'Receive' and 'Send' LEDs give no indication of FLARM's transceiver range.

10. Push Button

The push button can be used to select the following functions:

- **Brief Push** (<0.8 s) changes the volume from <*loud*> to <*medium*> to <*quiet*> to <*silent*> (and <*loud*> again). A short sound is emitted at the new volume selected. The default setting is <*loud*>.

- **Longer Push** (2 s) changes mode between <*Nearest*> and <*Collision*> when airborne. Visual confirmation. Default setting <*Nearest*>.
- **Longer Push (5 - 8 s, only on the ground)** activates the receiver self-test: Two seconds after the button is released, FLARM will show how many other FLARM are received with reduced sensitivity (50% of the normal range). It will then emit a long beep and light one vertical LED for every 10 and a short beep and one LED of the compass rose for every single received aircraft (e.g. 14 received FLARM is: "beeeeep bep bep bep bep", with one vertical and 4 LED's from the compass rose). After the self-test, FLARM switches back to normal operations. Note that for other units to be displayed these must be running.
- **Double Push** suppresses optical and acoustic warnings for five minutes. Suppression is followed by declining melody, normal setting followed by a rising melody. A double push terminates the suppressed operation at once.
- **Long Push** (>11 s): Re-boot. This procedure is recommended if a fault is apparent. No confirmatory sound signal.
- **Very long push** (>20 s) brings FLARM back to the factory settings. The very long push deletes all configurations that have been loaded by the user. Few seconds sound confirmation signal.

11. Aircraft Collision Warnings

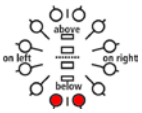
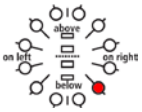
An illuminated red LED indicates the approximate bearing to an aircraft currently posing the biggest threat of collision. The bearing is *relative to the track.* This indication is inaccurate if there is a strong wind, if the aircraft is in a sideways yaw / slip, or if ground speed is very low (e.g. when a helicopter is in the hover). The display is refreshed every second.

The unit emits an audio warning (beep) tone at the same time as the flashing red optical warning. The time between the warning and possible collision is brief, just a few seconds. Warnings of fixed obstacles are given slightly earlier.

Horizontal indication

The twelve bicolour LED show a compass rose, i.e. the birds view on the traffic situation. 'Top' is track-up according the own aircraft. Each LED covers an equal-sized horizontal sector of 30°.

If the threat is moderate (less than 19 - 25 seconds to possible collision), a single LED lights up; in the case of a medium threat (less than 14 - 18 seconds) then two diodes light up; if the threat is imminent (less than 6 - 8 seconds) three LEDs. The threat is at the centre of the illuminated block. The flash and beep frequency increases with the threat.

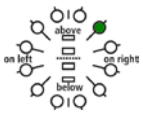
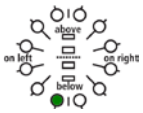
Moderate threat from ca. 3 o'clock (less than 19 - 25 seconds to calculated collision)	Slow flash at 2Hz	
Moderate threat from 1 to 2 o'clock (less than 19 - 25 seconds)	Slow flash at 2Hz	
Medium threat from 1 o'clock (less than 14 - 18 seconds)	Medium flash at 4Hz	
Immediate threat from 1 to 2 o'clock (less than 6 - 8 seconds)	Rapid flash at 6Hz	
Medium threat from the rear, 5 to 7 o'clock	Medium flash at 4Hz	
Moderate threat from the rear right, 4 to 5 o'clock	Slow flash at 2Hz	

Vertical indication

The vertical bearing is indicated by a vertical line of four red LEDs and show the bearing relative to a horizontal plane. This is independent of the aircraft's climb angle. The uppermost or lowest LEDs illuminate when the bearing exceeds 14°. The LED flash frequency is identical and synchronous with that of the horizontal display.

Traffic indication (only in Nearest-mode)

In Nearest-mode the closest aircraft is shown in green as long as no warning is necessary. Traffic indications don't flash, there is no sound and the distance is not shown.

Traffic around 2 o'clock	No flashing	
Traffic around 7 o'clock	No flashing	

12. Obstacle Warnings

The .ob2 obstacle data bank has over 35,000 obstacles[3]. The current data bank can be purchased on FLARM webshop (http://shop.flarm.com).

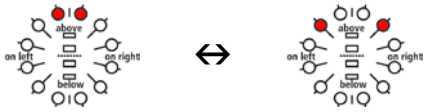
The FLARM display flashes when there is warning of obstacles. The warning always relates to obstacles straight in-line with the current flight heading. In other words there is no horizontal or vertical bearing given to the obstacle. The threat level depends upon the time remaining to impact; the flash and beep frequency increases with reducing distance from the obstacle. The display is refreshed every second.

A warning is given if an aircraft flies under a cable or power line.

An acoustic warning (beep) is given at the same time as the flashing fixed obstacle warning. The time between warning and possible collision is brief, just a few seconds. Warning levels start around 19 s, increase around 14 s and again 9 s.

Obstacles are indicated as follows:

A toggling pair of two LED's is shown, with the toggle frequency depending on the threat.



[3] For details on the data sources and status, consult the ‚Obstacle Data Format Specifications' manual.
Neither FLARM Technology nor these organisations accept any responsibility for the accuracy, completeness or up-to-date status of the data or any direct or indirect damage resulting from using such data. Official data sources only collect data which have been reported by those who own, construct or operate constructions which represent an obstacle, and do not check these reports.

13. Operating Limitations

FLARM is designed and built as a non-essential 'situation awareness only' unit to only support the pilot, and cannot always provide reliable warnings. In particular, FLARM does not give any guidance on avoiding action. Under no circumstances should a pilot or crewmember adopt different tactics or deviate from the normal principles of safe airmanship. Even with FLARM installed, you remain responsible for flying the aircraft and ensure the safety of passengers and other traffic. The use of FLARM is solely at the discretion of the commander and his delegated crew member. Operation must be preceded by thorough familiarisation by the commander or his delegated crew member with the Operating Manual.

FLARM will only give warnings of other aircraft that are likewise equipped with a compatible unit. FLARM does *not* communicate with Mode A/C/S transponders and is not detected by ACAS/TCAS/TPAS or Air Traffic Control. Likewise FLARM does not communicate with FIS-B, TIS-B or ADS-B.

Compatible FLARM units must be within range in order to provide a warning. The range is very much determined by the type, installation and position of the radio antennae, plus the relative positions of the two aircraft. Under *optimum* conditions the internal antennae can give a head-on range exceeding 5 km; normally, range is about 3 km, which is adequate for light aircraft and sailplanes. The radio signals can only be received by *line of sight*. There is no FLARM signal between two aircraft on opposite sides of the same mountain.

FLARM has to know its *current* position in order to operate. For this reason, FLARM will only operate in the presence of good quality three-dimensional GPS reception. GPS reception is greatly influenced by the installation and position of the antenna, and aircraft attitude; furthermore, it requires that the US-American GPS-system is fully operational. This is particularly true during turns, when flying close to mountain slopes and in areas known for poor reception. If the installation is poor the GPS signal quality may be reduced. In particular, there can be rapid degradation of height calculations. FLARM resumes operation as soon as the GPS reception quality is adequate.

Movements calculated by the GPS relate to a fixed system of *terrestrial* coordinates. In strong wind there may be a substantial difference between aircraft heading and track, leading to a distortion of the threat bearing. If the wind speed is one third of True Airspeed (TAS) and the yaw-free aircraft Heading is 90° out of wind, then the threat indication displayed has an error of about 18°. If the wind is very strong, the Track can deviate up to 180° from Heading. Under such circumstances and when circling, the calculation and warnings given are unusable.

When close up, when two aircrafts are at the same or similar height, or GPS reception is poor, the vertical bearing indication is imprecise and fluctuates.

FLARM calculates the predicted flight path of the aircraft for the next 18 seconds. This prediction is based on immediate past data, current position- and movement data, plus a movement prediction model that is *optimised for the respective user*. This forecast is associated with a number of uncertainties that increase with an extension of the forecast time. There is no guarantee that an aircraft will actually follow the predicted flight path. For this reason, the warning issued will not be accurate in all cases. In sport flying flight path predictions of more than 30 seconds are *unusable*. This is particularly true for sailplanes and hang gliders. For this reason, the radio range is generally adequate.

Warnings are given at *very short notice*. The threat intensity (pitch of the warning tone, LED block width, flash interval) flags up the threat (collision time point), but not the geometric distance. FLARM only issues a warning if the calculation forecasts a *considerable* threat. For this reason, it is usual - depending upon the mode selected - that no warning is given about the presence of other aircraft, in spite of the fact that signals have been correctly received.

When a number of moving threats or fixed objects are within range, then FLARM gives warning *only* of the most dangerous *in accordance with the threat calculation algorithm.* The pilot is unable to confirm receipt of this warning, nor is he able to call for presentation of further threats. In spite of the warning issued for one other aircraft or fixed objects, it is quite possible that there are several further aircraft or fixed objects that represent a greater threat than that which has been signalled. When the unit simultaneously detects a threat from moving and fixed obstacles, then the warning issued relates to the earliest likely collision.

FLARM indicates the rough position of the aircraft or obstacle that currently represents the biggest threat, in accordance with the algorithmic calculation. In the case of fixed obstacles, the unit does not signal a bearing. FLARM does not indicate where the closest proximity may occur, nor does it signal avoiding action. Whether and how avoiding action is taken is solely a matter for the pilot, who must base his decision on his own observation of the airspace. In taking his decision, he must comply with the Rules of The Air and ensure that no additional hazard is caused by his action. Depending upon the phase of the flight, FLARM uses different forecasting methods, movement models and warning calculations, to provide the pilot with the best possible support without causing a distraction. For example, when a sailplane is circling, the system sensitivity is reduced. These models and processes are optimised, but are nevertheless a compromise. As seen by the pilot these models are the source of 'false alarms'; i.e. FLARM would give warnings of 'threats' that would not subjectively be regarded as a real danger. It is quite possible that FLARM will not give warning of the highest threat, or will give any warning at all.

Obstacle warnings (e.g. cables, antenna masts, cable cars, avalanche dynamite wires, power lines) are dependent on the information having been stored *correctly* in the internal data bank. The unit cannot give warning of any fixed object that has either been incorrectly stored, or not stored at all. No data bank is complete, up-to-date and correct. Obstacle information stored has usually been simplified; for example, FLARM assumes that a power wire is slung absolutely straight between two fixed points with no sag. Likewise, data for power lines and cable cars does not include all intermediate masts. In addition, FLARM data does not include terrain data and no such warnings are possible.

FLARM radio communications take place in a license-free band in which there is general freedom to transmit and receive. This means that the band is also available to a number of other uncoordinated users. FLARM has no exclusive right to the use of this band and there is no guarantee that FLARM will not be subject to interference by third parties.

There are national differences in frequency allocation and operating conditions between countries. The aircraft commander and user are solely responsible for ensuring that their use of FLARM conforms with local regulations. No radio licence is required for FLARM in Switzerland, Germany and France.

The radio transmission protocol employed places *no limit* on the number of units that may be operated within a given range. However, an increasing number of units within range is associated with a reduction in the probability that a single coded signal will be received ('graceful degradation'). The probability is small that subsequent signals will not be received from the same transmitter. FLARM is designed to receive and process signals from up to 50 aircraft within range. A high number of FLARM units within range has no effect on range.

The transmitter has ***no effect*** on what the receiver in the other aircraft does with the data. It is possible that this data may be captured and stored by other aircraft, or by ground stations, or used for other purposes. This opens up a range of possibilities, some of which may be in the pilot's own interest, (e.g. automated generation of an sailplane launch logging system, aircraft tracking, last position recovery), while others may not be (e.g. detecting tailing of other aircraft, airspace infringements, failure to take avoiding action prior to a collision). When FLARM makes a transmission, the signal also bears a unique identification code that can trace to the pilot or aircraft registration.

Operation of FLARM is limited to non-commercial day VFR flights. FLARM may not be used for navigational purposes or aerobatics.

FLARM has not been certified in line with the usual aviation procedures, however tests in line with DO-160/F on high/low ops temperature, high/low ground survive temperature, pressure altitude, magnetic effects, emission of radio frequency energy, electrostatic discharge and flammability have been conducted. The FLARM firmware development is in-line with typical methods applied for industrial electronics.

Operation of FLARM is forbidden in the USA or Canada or in aircraft registered in the USA or Canada.

FLARM Technology Ltd., its associates, owners, staff, management, development team, suppliers, manufacturers and data suppliers accept no responsibility for any damage or claims that may arise from use of FLARM.