IGC-APPROVALS FOR GNSS FLIGHT RECORDERS – SUMMARY

This document is dated 28 February 2013 and adds the Flight Recorder aspects of powerFlarm-IGC.

The last version of this document was dated 14 February 2014, added important security updates to the earlier FLARM-IGC recorder and three other recorders that use FLARM-IGC as the main recorder module. It should also be noted that on 1 October 2012, IGC-approval was withdrawn from 7 types of FR, and IGC-approval levels changed for others. This was as a result of the 2011 ANDS/GFAC security paper that was approved by the IGC Bureau and the 2012 IGC Plenary.

Contents

FAI & IGC Web References:

FAI Links to approval documents: www.fai.org/igc-documents then look for "GNSS Recording Devices"

IGC table of approved Recorders: select "GNSS Recording Devices", then look for "IGC-approved Flight Recorders", "Free Software", "Technical Specifications", as required

GFAC web site for FR documents: www.ukiws.demon.co.uk/GFAC

TYPES OF FLIGHT RECORDERS - 52 listed, 7 withdrawn in 2012, 45 IGC-approved

The table lists types of Flight Recorder in alphabetical order of Manufacturer.
Production status should be confirmed with manufacturer. See also the notes after the table.

	Manufacturer (alphabet order)	Type of Recorder	In Production	IGC-approval Level	MG engine recording System (where fitted)	Date of latest approval. Click to download document
1	Aircotec	XC Profi (Gliders)	Yes	All Flights	Aircotec ENL	30 May 2006
2	Cambridge	CAI 10	No	Up to Diamonds	Cambridge ENL system 1	01 October 2012
3	Cambridge	CAI 20	No	Up to Diamonds	Cambridge ENL system 1	01 October 2012
4	Cambridge	CAI 25	No	Up to Diamonds	Cambridge ENL system 1	01 October 2012
5	Cambridge	CAI 302	Yes	All Flights	Cambridge ENL system 2	12 April 2007
6	Cambridge	CAI 302A (without display)	Yes	All Flights	Cambridge ENL system 2	12 April 2007
7	ClearNav Instruments	ClearNav-IGC	Yes	All Flights	ClearNav ENL	20 April 2011
8	DSX	T-Advisor (with DSX Traffic Alert function)	Yes	All Flights	Not fitted	12 April 2008
9	DSX	Tracer (T-advisor without Traffic Alert function)	Yes	All Flights	Not fitted	12 April 2008
10	DSX	SaFly (with satellite-based tracking system)	Yes	Up to Diamonds	Not fitted	15 Sept 2011
11	EDIATec	ECW100F (with Flarm-IGC module)	Yes	Up to Diamonds	Triadis ENL	14 February 2013
12	EW	EWFR A	No	Approval Withdrawn 1 October 2012	Microswitch and cable	01 October 2012
13	EW	EWFR B	No		Microswitch and cable	01 October 2012
14	EW	EWFR C	No		Microswitch and cable	01 October 2012
15	EW	EWFR D	No		Microswitch and cable	01 October 2012
16	EW	microRecorder	Yes	All Flights	EW ENL	20 Nov 2008
17	FLARM	Flarm-IGC (with Traffic Alert function)	Yes	Up to Diamonds	Triadis ENL	14 February 2013
18	FLARM	PowerFlarm-IGC (with Traffic Alert function)	Yes	Up to Diamonds	Triadis ENL	28 February 2013
19	Garrecht	Volkslogger VL1.0	No	All Flights	Garrecht ENL	20 January 2008
20	IMI	Erixx V1.0	Yes	All Flights	Not fitted	7 June 2008

21	LXNAV d.o.o.	Nano	Yes	All Flights	LXNAV ENL	01 October 2012
22	LXNAV d.o.o.	LX8000	Yes	All Flights	LXNAV ENL & MOP for jets	31 January 2012
23	LXNAV d.o.o.	LX8000F (with Flarm Traffic Alert function)	Yes	All Flights	LXNAV ENL & MOP for jets	31 January 2012
24	LXNAV d.o.o.	LX8080F with Flarm	Yes	All Flights	LXNAV ENL & MOP for jets	31 January 2012
25	LXNAV d.o.o.	LX9000 & LX9000F with Flarm	Yes	All Flights	LXNAV ENL & MOP for jets	31 January 2012
26	LX Navigation	LX20 first batch 1997 (without RSA security)	No	Approval withdrawn 1 October 2012	LXN ENL	01 October 2012
27	LX Navigation	LX20 with RSA security (Hardware Version 3 and later)	No	Badges (all)	LXN ENL	01 October 2012
28	LX Navigation	LX20-2000	No	Badges (all)	LXN ENL	01 October 2012
29	LX Navigation	LX21	No	Badges (all)	LXN ENL	01 October 2012
30	LX Navigation	DX50	No	Badges (all)	Not fitted	01 October 2012
31	LX Navigation	LX5000IGC	No	Badges (all)	LXN ENL	01 October 2012
32	LX Navigation	Colibri V1.0 (hardware Versions 1 & 2)	No	Badges (all)	LXN ENL	05 November 2012
33	LX Navigation	Colibri V4 (Hardware Versions 3 and later)	Yes	All Flights	LXN ENL	05 November 2012
34	LX Navigation	Colibri 4F (with Flarm Traffic Alert function)	Yes	All Flights	LXN ENL	05 November 2012
35	LX Navigation	Colibri II	Yes	All Flights	LXN ENL	01 October 2012
36	LX Navigation	LX7000	No	All Flights	LXN ENL	22 January 2012
37	LX Navigation	LX7007	Yes	All Flights	LXN ENL	22 January 2012
38	LX Navigation	LX7007F (with Flarm Traffic Alert function)	Yes	All Flights	LXN ENL	22 January 2012
39	LX Navigation	LX7007FC with Flarm	Yes	All Flights	LXN ENL	22 January 2012
40	LX Navigation	Mini Box Flarm-IGC (with Traffic Alert function)	Yes	Up to Diamonds	LXN ENL	14 February 2013
41	LX Navigation	Red Box Flarm-IGC (with Traffic Alert function)	Yes	Up to Diamonds	LXN ENL	14 February 2013
42	New Technologies	NTE Easy	Yes	All Flights	NTE ENL	10 January 2007
43	New Technologies	NTE Easy Matchbox	Yes	All Flights	NTE ENL	8 August 2005
44	Peschges	VP8	No	Badges (all)	Cable to motor or microswitch	1 October 2004
45	Print Technik	GR1000	No	Approval Withdrawn 1 October 2012	Print Technik ENL	01 October 2012
46	Print Technik	GR1000A (with RSA security)	No		Print Technik ENL	01 October 2012
47	Scheffel	Themi	Yes	Badges (all)	Not fitted	5 May 2003
48	Streamline Digital Instruments (SDI)	PosiGraph V1.0	No	Badges (all)	LXN ENL	01 October 2012
49	Streamline Digital Instruments (SDI)	PosiGraph V2	No	All Flights	LXN ENL	01 October 2012
50	Triadis	Altair V1.0	Yes	All Flights	Triadis ENL	14 February 2009
51	Zander	GP940	No	Badges (all)	Zander Vibration system	01 October 2012
52	Zander/SDI	GP941	Yes	All Flights	Zander ENL	10 June 2007

Notes to the table of Types of GNSS Recorders:

1. Motor Glider Means-of-Propulsion (MoP) recording – the ENL system. Details on MoP recording are in the full version of each approval document, with figures recorded during GFAC tests. The Engine Noise Level (ENL) system is where the noise level at the recorder is recorded with each GNSS fix in the form of three numbers from 000 to 999. This is the IGC-preferred system for Motor Gliders with engines that produce significant noise in the cockpit, because it does not require wiring external to the recorder or any other actions by the pilot, and is self-checking because an ENL value is recorded with each fix, even during quiet flight.

1.1 Low-ENL figures. Motor Gliders that have engines that do not record sufficiently high ENL numbers with the FR in the cockpit must **either** mount the complete FR near the jet pipe of a jet engine or the propeller of an electric engine, **or** use an FR with an IGC-approved MOP (Means-of-Propulsion) sensor connected to the FR by cable, the MOP sensor being mounted in a position to receive high MOP values whenever the engine is run. In the latter case, three MOP numbers are recorded in the IGC file as well as ENL. See Annex B to the Sporting Code, para 1.4.2.4.

2. Levels of Approval. IGC has established three levels of approval to which different types of flight apply. For details, see Annex B of the Sporting Code for Gliding, para 1.1.4.

2.1 All Flights approval. Type of recorders given IGC-approval for "all flights" must comply with all of the provisions of the IGC Technical Specification as it applies at the time that the approval is first given.

2.2 All Badges approval. This applies to types of Recorders that do not fulfil the Specification in some areas at the time of approval. However, it has been decided that they may be given an approval that excludes World Record flights but includes all IGC/FAI Badges and Distance Diplomas. For evidence for competition flights, see para 3 below.

2.3 Diamonds-level approval. This is for FAI Silver, Gold and Diamond badge flights only, although for competitions see para 3 below. It is used for types of Recorders that have significant differences to the Specification at the time of approval but it is decided that a limited approval can be given rather than a refusal.

3. Competition Flights. Types of recorders that may be used for evidence in a competition are at the discretion of the competition organisers and may include one or more of the above IGC-approval levels if the organisers agree. The organisers may operate under other rules such as those in Annex A of the Sporting Code for Gliding which applies to World Championships and other competitions that also use Annex A rules. Annex A specifies the use of IGC-approved Recorders but does not (at the time or writing) specify the approval level so all approval levels may be used under Annex A rules, subject to any local rules. Outside competitions to Annex A rules, other rules and procedures may be made by the National Airsport Control (NAC) authority or other competition organizer.

3.1 On-Line Competitions (OLCs). An OLC is a "De-centralised Competition" where participants file IGC flight data by email under the rules of the particular OLC organiser. OLCs are not official IGC competitions and their rules may, or may not, conform to IGC criteria such as Annex A to the Sporting Code for Gliding. Unlike a Centralised Competition, pilots do not all fly from one site with a specific task set on each day.

4. Grandfather Rights. This term describes a system where the level and other provisions of an IGC-approval are continued without alteration even though the Technical Specification is changed with time (generally, provisions are increased). For details, see Annex B of the Sporting Code for Gliding, para 1.1.4.5.

MANUFACTURERS - 19 listed, 2 withdrawn, 17 currently for IGC-approved FRs

S/N	Name of Manufacturer (alphabetical order)	Country	Manufacturer's web page	IGC Codes for the Manufacturer	
				3 letters	1 letter (for IGC file name)
1	Aircotec Flight Instruments	Austria	www.aircotec.at	ACT	I
2	Cambridge Aero Instruments	USA	www.cambridge-aero.com	CAM	C
3	ClearNav Instruments (ex Nielsen Kellerman)	USA	www.clearnav.net	NKL	K
4	DSX Data Swan	Switzerland	www.d-s-x.net	DSX	D
5	EDIATec (with Flarm Firmware)	Switzerland	www.ediatec.ch	FLA	G
6	EW Avionics	UK	www.ewavionics.com	EWA	E
7	Filser (Now Funkwerk, IGC approvals transferred to LXN, see note at end)	Germany	Now Funkwerk, see note after this table	FIL	F
8	Flarm Technology GmbH	Switzerland	www.flarm.com	FLA	G
9	Garrecht Avionik GmbH	Germany	www.garrecht.com	GCS	A
10	IMI Gliding Equipment	Czech Republic	www.imi-gliding.com	IMI	M
11	LXNAV d.o.o.	Slovenia	www.lxnav.com	LXV	V
12	LX Navigation	Slovenia	www.lxnavigation.si	LXN	L
13	New Technologies s.r.l.	Italy	www.ntsrl.it	NTE	N
14	Peschges Variometer GmbH	Germany	www.peschges-variometer.de	PES	P
15	Print Technik Ges.m.b.H	Austria	No longer making FRs. Approval withdrawn 1 Oct 2012	PRT	R
16	Scheffel Automation	Germany	www.themi.de	SCH	H
17	Streamline Digital Instruments (SDI)	Germany	www.sdi-variometer.de	SDI	S
18	Triadis Engineering GmbH	Switzerland	www.triadis.ch	TRI	T
19	Zander Segelflugrechner	Germany	www.zander-variometer.de	ZAN	Z

Note on ex-Filser recorders: Four types of recorders were originally badged under the Filser name, but Filser were taken over by Funkwerk Avionics in 2006 and no longer support these recorders. Since the original Design Authority for these recorders was LX Navigation, the IGC-approval documents were re-issued under the LX Navigation name.

PART 2 - DATES OF ISSUE OF IGC-APPROVAL DOCUMENTS

The following IGC-approval documents and updates have been issued on behalf of IGC by the IGC GNSS Flight Recorder Approval Committee (GFAC). This list is in reverse date order, the most recent approvals coming first, and goes back to the first IGC-approval in January 1996.

28 February 2013 – Flarm, Flight Recorder aspects of powerFlarm-IGC, initial approval
14 February 2013 – Update to FLARM-IGC recorder and others using it as the main recorder module. These are the Ediatec ECW100F, and the LX Navigation Mini-Box Flarm and Red Box Flarm
5 October 2012 - LX Navigaton Colibri approval updated with Hardware and Firmware versions for Models 1 & 4.
1 October 2012 - Changes as a result of the 2011 ANDS/GFAC Security paper that was approved by the IGC Bureau and the 2012 IGC Plenary:
Reductions in IGC-approval levels: Cambridge 10, 20, 25, Filser/LXN DX50, Filser/LXN LX20 (with RSA192), Filser/LXN LX21, Filser/LXN LX5000 IGC, LXN Colibri 1, SDI/LXN Posigraph, Zander GP940.
Withdrawal of IGC-approval due to low security: EW FR A-D with separate GPS receiver, Filser/LXN LX20 batch 1 without RSA, Print Technik GR 1000/1000A.
10 August 2012 – Notice of the changes on 1 October 2012 (see above)
29 May 2012 – Security update to EDIATEC ECW100F, LX Navigation Mini Box and Red Box Flarm
15 May 2012 - Flarm-IGC security update
31 January 2012 - LXNAV LX8000 and 8000F, addition of MOP box for jet-engined motor gliders
22 January 2012 – LX Navigation LX7007FC, initial approval
10 January 2012 – LXNAV LX9000, addition of MOP box for jet-engined motor gliders

20 November 2011 – LX Navigation Colibri II, initial approval issued
31 October 2011 – LXNAV LX8080F, addition of MOP box for jet-engined motor gliders
31 August 2011 – DSX SaFly, initial approval issued
20 April 2011 – ClearNav-IGC, name change from Nielsen Kellerman
14 March 2011 – LXNAV LX8080F, initial approval issued

31 August 2010 – LXNAV Nano, initial approval issued
30 June 2010 – LXN/Flarm Mini Box and Red Box, addition of ENL system
14 June 2010 – LXNAV LX9000, initial approval issued
25 April 2010 – EWA Models A-D approval. Garmin GPS60 added, also the list of permitted stand-alone GPS receivers are now in a separate, smaller document as Annex C to the main IGC-approval.
28 February 2010 – Zander GP940 approval changed to allow airborne engine run rather than only a ground run.

25 May 2009 – Nielsen Kellerman ClearNav-IGC, Version 1 of IGC-approval document issued
14 February 2009 – Triadis Altair V1.0, Version 1 of IGC-approval document issued

20 November 2008 – EW microRecorder – update to allow for low ENL readings in quiet flight
31 August 2008 – LXN Mini Box Flarm-IGC, Version 1 of IGC-approval document issued, to "Diamonds" level.
31 August 2008 – LXN Red Box Flarm-IGC, Version 1 of IGC-approval document issued, to "Diamonds" level.
14 June 2008 – EDIATec ECW100F, Version 1 of IGC-approval document issued, to "Diamonds" level.
7 June 2008 – IMI Erixx V1.0, Version 1 of IGC-approval document issued
25 April 2008 – LXN LX8000 and LX8000F, Version 1 of IGC-approval document issued
12 April 2008 – DSX 7100 T-Advisor series and DSX 8000 Tracer series, Version 1 of IGC-approval document issued
10 March 2008 – Flarm-IGC V1.0, Version 1 of IGC-approval document issued, to "Diamonds" level.
20 February 2008 – LXN (ex Filser) DX50, LX20, LX21, LX5000IGC update and change of name from Filser to LXN
20 January 2008 – Garrecht Volkslogger, update of wording

30 April 2007 – Cambridge 10, 20 & 25 updated
12 April 2007 – Cambridge 302 series updated
31 March 2007 – LXN Colibri 4F with Flarm, Version 1 of IGC-approval document issued
10 January 2007 – NT Easy, Version 1 of IGC-approval document issued

20 November 2006 – EW microRecorder, addition of EW engine noise recording system
20 August 2006 - Zander/SDI GP941, amendment with Firmware 2.11 on time recording
10 June 2006 - EW microRecorder, Version 1 of IGC-approval document issued
30 May 2006 - Aircotec XC Profi (Gliders), Version 1 of IGC-approval document issued
17 March 2006 - LXN 7007F with uBLOX board and internal FLARM module
24 February 2006 - LXN Colibri model 4 with uBLOX GPS receiver board

8 August 2005 - New Technologies (NTE) Easy Matchbox, Version 1 of IGC-approval document
20 July 2005 - LX Navigation LX7000 series, Version 2 with addition of LX7007
20 June 2005 - LX Navigation Colibri, addition of Colibri Version 4.

10 April 2005 - EW Models A-D, update of manufacturer details
10 April 2005 - Cambridge 10, 20 & 25, update of manufacturer details and notice of change of IGC-approval level.

1 October 2004 - PrintTechnik GR1000 and GR1000A Issue 3
1 October 2004 - Filser LX20 Issue 5
1 October 2004 - Peschges VP8 Edition 2A
20 September 2004 - Zander 940 Issue 2
12 September 2004 - Cambridge 10, 20 & 25, Issue 5
28 March 2004 - Cambridge 10, 20 & 25, Issue 4A
28 March 2004 - Filser LX20 Issue 5A
28 March 2004 - Peschges VP8 Edition 2
28 March 2004 - Prink Technik GR1000 Issue 2
1 February 2004 - LX Navigation LX20, "all badges" level for early standard without micro & RSA
1 January 2004 - Cambridge (Martinsville) 10/20/25 and 302 series withdrawn (company out of business)

25 November 2003 - Cambridge (Horn Lake) 10/20/25 and 302 series with Horn Lake address
25 November 2003 - Cambridge (Martinsville) 10/20/25 and 302 series with new manufacturer codes
25 August 2003 - Cambridge (Martinsville) 302 series, addition of simpler 302A model.
20 May 2003 - Cambridge (Martinsville) 10, 20 and 25, update to approval document
5 May 2003 - Scheffel Themi increased from Diamonds to "all badges" level
14 March 2003 - LX Navigation LX7000, new type of recorder, Version 1 of IGC-approval document issued
14 February 2003 - SDI Posigraph, introduction of Model 2
12 February 2003 - Zander/SDI GP941, introduction of A model with GPS15 board.
13 January 2003 - Cambridge (Martinsville) 302 series, introduction of ENL system

31 October 2002 - Scheffel Themi, Version 1 of IGC-approval document issued, to "Diamonds" level.
20 October 2002 - LX5000IGC, addition of 2002 model LX5000IGC-2 with higher resolution screen and extra button.

10 December 2001, updated approval documents issued for the following 5 types:
Filser DX50, Filser LX20, Filser LX5000IGC, LX Navigation Colibri, SDI PosiGraph
30 October 2001 - Cambridge 302, Version 1 of IGC-approval document issued
30 October 2001 - Zander/SDI GP941, Version 1 of IGC-approval document issued

15 May 2000 - Filser LX5000IGC series, addition of LX5000IGC-2 and update of earlier approvals.
21 Mar 2000 - Filser LX20, Version 3 including the LX20-2000 and updated wording
10 Mar 2000 - Amendment 3 to EWFR approval to add 2 new Garmin GPS units

19 Nov 99 - Amendment 2 to EWFR approval to add 5 new Garmin GPS units.
21 Jun 99 - Cambridge Issue 3 Including Pilot Event (PEV) Function and the Palm-Nav Display.
10 May 99 - Garrecht Volkslogger Model Vl1.0, Issue 2 including Motor Glider ENL Function
8 Mar 99 - Streamline Digital Instruments (SDI, Germany) PosiGraph Model 1.0, Version 1 of IGC-approval
29 Jan 99 - Amendment 1 to EWFR approval to add new Model D with improved memory.

16 Nov 98 - Filser DX50, Amendment 1 to allow for three tube static pressure system.
26 Oct 98 - LX Navigation Colibri 1.0, Issue 2 with ENL recording
31 Aug 98 - LX Navigation Colibri 1.0 Version 1 of IGC-approval document issued
24 Aug 98 - Issue 2 of EWFR approval to add model C, add additional Garmin GPS units, update the wording.
30 Jun 98 - Filser LX5000IGC, Version 1 of IGC-approval document issued
19 May 98 - Filser DX50, Version 1 of IGC-approval document issued
24 Apr 98 - Filser LX21, Version 1 of IGC-approval document issued
3 Apr 98 - Garrecht Volkslogger VL1.0, Version 1 of IGC-approval document issued

20 Jul 97 - Cambridge 10, 20, 25; Version 2 Approval, adding a 12 channel RX, variable time fixing, updated wording.
13 May 97 - Amendment to EWFR A/B approval to add Garmin 12XL to list of approved stand-alone GPS units.
19 Apr 97 - EW "EWFR A & B" for badges up to and including Diamonds, when connected by cable
to one of a list of approved GPS units, listed in the IGC-approval document
25 Mar 97 - Filser LX20 Version 2 Approval, with the addition of motor glider engine recording
20 Mar 97 - Print Technik GR1000, Version 1 of IGC-approval document issued

10 Nov 96 - Zander GP940, Version 1 of IGC-approval document issued
12 Aug 96 - Filser LX20, Version 1 of IGC-approval document issued
31 May 96 - Peschges VP8, Version 1 of IGC-approval document issued
16 Jan 96 - Cambridge Models 10, 20 and 25, Version 1 of IGC-approval document issued

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PART 3 - HISTORY OF GNSS AND ITS USE IN IGC

Contents: Definitions and descriptions – GNSS, General Principles of GNSS operation.
GPS/NAVSTAR, Beidou 2, Galileo, GLONASS,
1987-1991 - Early IGC Discussions
1992 - first commercial GPS recorder
1993 – Electronic Barographs with GPS input
1993 – World Gliding Championships in Borlange, Sweden
1994 - GPS Recorder for Omarama Worlds.
1993-94 - Development of the IGC flight data standard
1995 - January - New Zealand World Gliding Championships
1995 - March - IGC GFA Committee
1995-96 - Testing, issue of first IGC-approvals
1996 – Present Day - Annual Reports on GNSS Recording –
Recorder numbers approved in 2012, GFAC receives FAI Group Diploma

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GNSS. This stands for Global Navigation Satellite System and is the generic term for the specific systems described below.

Principle of operation – US GPS. Although this describes the US NAVSTAR/GPS system, other satellite navigation systems use similar principles although details such as frequencies will differ. A GPS receiver on the ground records the very small time-differences between low-powered transmissions at about 1500 MHz from the array of GPS satellites that are in view above the horizon at any one time. The satellites are in an orbit 55 degrees oblique to the equator at an altitude of about 20,200 km (12,552 Statute Miles). Today, 24 are normally active at any one time with some as in-orbit reserves (their transmission state is controlled from the ground). Each satellite has an atomic clock accurate to better than a nanosecond and its accuracy is monitored from the ground and updated as necessary. Due to earth shielding, a maximum of up to 12 transmitting satellites may be in view to a receiver at any one time. The exact number depends on where the receiver is placed on the earth's surface. Terrain shielding reduces the number of satellites in view, as does very high latitude. Satellite orbits are highly predictable, therefore, because a GPS receiver is constantly updated with GPS system information, it knows the exact position in space of each satellite at any one time. Each time-difference recorded by the receiver from a satellite provides a line-of-position which is used be the receiver's computer to construct the Most Probably Position (MPP) from the several available position lines for each fix. With 12-channel receivers operating in mid-latitudes, between 6 and 8 satellite position lines are typical for an individual fix. With sensitive receivers with good antenna layouts in clear horizon positions, 12 satellites have been observed to be locked on as far north as 51 degrees. A brief description of some GNSS systems follows, after there is a history of GNSS recording in IGC.

GPS/NAVSTAR. In 1973, the US Department of Defense (DoD) decided to develop the NAVSTAR system (Navigation System for Timing And Ranging), commonly referred to as GPS (Global Positioning System). From 1978, Block 1 GPS satellites were launched and the system first came on line in January 1980. It was initially for military use with receivers that had special codes to access the data. Later, civil GPS receivers were produced for general use but these were subject to a deliberate reduction in accuracy by the GPS controlling authority. The authority was originally the US Department of Defense (DoD) and later the US Department of Transportation (DoT) was added. The accuracy reduction was so that the military receivers would always have more accurate data and also that civilian receivers were less likely to be used for undesirable purposes such as disruption or terrorism. The accuracy-reduction system was called "Selective Availability" or SA and used a random short-term variation (wobble) of the timebase. Average error in lat/long for civilian receivers in these early days was measured by GFAC at about 50 metres for single fixes, reducing to about 40 metres as improved 12-channel receiver boards came on the market. Errors were recorded from a moving vehicle using several accurately-surveyed points on the ground at about 51N 001W and the overall average with SA was 44 m. When the SA system was withdrawn on 1 May 2000, GFAC accuracy results improved substantially, showing an average error at the end of 2000 of about 13m. Since then, average errors have improved to between 11 and 12m. The is probably due to improved processing within receiver boards, and the increased number of satellites whose data can be processed for each fix. The GPS system is updated as new satellites are put in orbit and old ones taken off-line.

Accuracy enhancement systems. Enhancements to basic system accuracy are provided by regional Satellite-Based Augmentation Systems (SBAS). These increase accuracy by monitoring errors at ground stations in the area concerned and making corrections available to compatible receivers. Such systems in service include WAAS (North America) and EGNOS (Europe). Other SBAS systems include GAGAN (India) and MSAS (Japan). A Ground-Based Augmentation System (GBAS) is being developed in Australia.

Beidou/Compass. This is the GNSS of the Peoples Republic of China (PRC). Initially five satellites were in orbit giving area enhancement (SBAS) data, and the full Beidou-2 GNSS system in the 2020s is planned to have about 30 satellites. See: http://en.wikipedia.org/wiki/Beidou_navigation_system

Galileo. In March 2002, the European Union (EU) and European Space Agency (ESA) agreed to produce a European GNSS, and the Galileo project was formally launched in May 2002 under EU Council Regulation EC 876/2002. There are intended to be 30 satellites at an altitude of about 22,200 km, in three groups at an orbital plane of 56 degrees. Galileo will under civil control and is intended to be interoperable with the Russian GLONASS and US GPS systems.
See: http://en.wikipedia.org/wiki/Galileo_(satellite_navigation)
and http://ec.europa.eu/enterprise/policies/satnav/galileo/index_en.htm

GLONASS. The Russian GNSS system, the initials standing for GLObal'naya NAvigatsionnaya Sputnikovaya Sistema (GLObal NAvigation Satellite System). The first satellite was launched in October 1982 and a full Constellation was completed in 1995. Over the years, agreements have been reached that bring the technical standards of the US GPS system and GLONASS to a similar level so that ground-based receivers can more easily receive both systems. See www.glonass-ianc.rsa.ru and http://en.wikipedia.org/wiki/GLONASS

USE OF GNSS IN GLIDING

1987-1991 - Early Discussions and Development. In 1987, discussions were held by the IGC Championships sub-committee on the potential use of GPS flight recorders for validation of flights and for display of position.

In 1991, Dr David Ellis of Cambridge Aero Instruments of Vermont, USA, presented a paper on GPS recording to the OSTIV Conference in Uvalde, USA, the site of the World Gliding Championships. This paper was based on GPS flight recordings made in April 1991 using equipment loaned to Cambridge by a development engineer at Trimble Navigation. Flights were made from Palo Alto airport in California with a Cessna 172 and demonstrated the feasibility of GPS recordings.

Also at Uvalde in 1991 were Alf Ingesson-Thoor and John Roake, the Directors of the future World Championships at Borlange, Sweden, in 1993 and at Omarama, New Zealand, in 1995. Bernald Smith (USA), then a Vice-President of IGC, heard Ellis' presentation and became an advocate of GPS recording. John and Alf then had meetings with Dave Ellis with a view to using GPS recording in future World Championships. At Uvalde, Bernald was responsible for photo evaluation and in a presentation described the work of his 15-person team, and said that if GPS recording could succeed, such a large team would not be required. Also, Bernald Smith and John Roake were particularly concerned with the problems of photo evaluation from wave flights at altitudes such as 20,000ft at the future 1995 WGC in New Zealand. Following the Uvalde OSTIV conference, Cambridge Aero Instruments produced a recording system consisting of a Garmin GPS-10 engine and a HP-95 pocket calculator. This was flown by John Good (USA) in a gliding competition at Matamata, New Zealand, in February 1992.

1992 - first commercial GPS recorder on the gliding market. A GPS recorder was developed by avionics supplier RD Aviation Ltd., of Oxford, UK. This was to a specification by its Managing Director Dickie Feakes who had been a glider pilot since the 1950s. This "RD Logger" was connected by cable to a stand-alone GPS receiver such as one of the Garmin range and was a simple memory module with no pressure altitude sensor or built-in security. The format of its data output was an ASCII file with the suffix "dat", short for data. The software compiler of this so-called "dot.dat" format was Vince May, the founder and owner of the UK company Skyforce, with inputs from Phil Jeffrey of the BGA Competitions Committee. The DAT format was later developed into the IGC data format that we use today. In the first year, the recorder was sold and badged by RD and in the second by Skyforce as the Skyforce Logger.

1993 – Electronic Barographs with GPS input. Two companies that had been producing electronic barographs, in 1993 developed versions with larger memory that would connect to a Garmin GPS receiver unit and record GPS fixes as well as pressure altitude. These companies were EW Avionics (UK, MD Wayne Richards) and Borgelt Instruments (Australia, MD Mike Borgelt).

1993 – Borlange World Gliding Championships. Trials supervised by Bernald Smith on behalf of IGC were made during the World Championships in Borlange, Sweden, using prototypes supplied free of charge to IGC from Dr Ellis' Cambridge Aero Instruments company in Vermont, USA. For the next Worlds in New Zealand, Director John Roake sent specifications to a number of manufacturers for GPS recorders to be used for scoring the Championships. The equipment was to be rented to pilots, not sold to the organizers, and was to be tested first in the next New Zealand Nationals and the "Kiwiglide" Pre-world competition. Cambridge made a bid along these lines with a rental price of US$200 per recorder. This was accepted.

1994 GPS Recorder for Omarama Worlds. In 1994, IGC approved the use of the Cambridge design of recorder as the primary recording system for the World Championships in 1995. This was after the tests mentioned above of 15 pre-production Cambridge Model 10 recorders in the 1994 New Zealand Nationals and 30 in the later pre-worlds ("KiwiGlide"). This IGC decision for the first time gave priority to GPS recording over photographic evidence. This recorder design, which became the Cambridge Model 10, included pressure altitude recording, both physical and electronic security, and had the GPS receiver and memory units in one sealed case (unlike the earlier RD/Skyforce, EW and Borgelt designs that were connected by cable to a separate GPS receiver such as one by Garmin). IGC was particularly sensitive to security issues after a case of cheating on photographic evidence at Borlange had resulted in a pilot being sent home. The Cambridge system used a microswitch to show whether the (sealed) case had been opened and an electronic checksum system to check whether the output data file was valid for use for flight

validation to IGC standards. Cambridge was to deliver the recorders for hire at Omarama in January 1995 to all championships pilots. These were stand-alone units with a large internal battery so that no changes to glider avionics or wiring would be required other than the need for the GPS antenna to be in a good position to receive signals (the antenna could be mounted either on the recorder unit or at the end of a cable).

1993-94 - Development of the IGC flight data standard. The IGC ASCII data format was developed during 1993 and 1994 from the BGA "dot.dat" format by a group of experts led by Bob Fletcher in the USA (then General Manager of Cambridge Aero Instruments) and Hans Trautenberg in Europe. The initial version of this data format was finalised by October 1994, used in the New Zealand world championships in January 1995, and was included in the new Annex B to the Sporting Code that was approved by IGC in March 1995. The original IGC file suffix was "GPS" but this was considered by the IGC GFA Committee to be too general and was changed to "IGC" later in 1995.

1995 - January - New Zealand World Gliding Championships. In January 1995 the World Gliding Championships were held at Omarama in New Zealand with John Roake as Director. Cambridge supplied all competitors with early versions of what would become their model 10 recorder, for which the software writer was John Good. This was the first time GPS recording had been used for scoring purposes in a World Championship. The Chairman of the IGC GNSS Committee, Bernald Smith, independently checked the GPS recorder results on behalf of IGC with a view to their future use for flights to IGC/FAI criteria.

1995 - January-March - Development of IGC procedures on GNSS recording. IGC officials at the New Zealand championships assessed the GPS recording in the championships as a success, and asked other IGC committees and technical experts to draft a definitive set of rules for more general use of GPS recorders in world gliding. The next IGC Plenary was only 6 weeks away on 17 and 18 March 1995 so this was a difficult task. The option of delaying until the next IGC Plenary was not really practical as this would have resulted in a delay of a further 12 months during which criticism would build up from those who wished to develop and use the new technology. Ian Strachan, then Sporting Code editor working for Tor Johannessen, had the task of making an initial draft and co-ordinating suggested changes. Fortunately he had some GPS knowledge, having previously tested some GPS recorders and been the author of an article on GPS recording in the UK magazine "Sailplane and Gliding". Bernald Smith, then Chairman of the IGC GNSS Committee, also took part in this process and drafted chapter 1 of the new IGC document. Intensive effort followed by these people and others, with the circulation of several drafts. A meeting was held on 15 March 1995 in Paris between IGC officials and potential recorder manufacturers. These activities resulted in a new Annex B to the Sporting Code for Gliding, in time to be approved by the IGC Plenary on 18 March 1995.

1995 - March - IGC GFA Committee. The IGC GNSS Flight Recorder Approval Committee (GFAC) was formed by IGC on 18 March 1995 at the same time that IGC approved the issue of the first edition of Annex B to the Sporting Code for Gliding. The first members of GFAC were Angel Casado (Spain), Arnie Hartley (Australia), Ian Strachan (UK), Kilian Grefen (Germany) and Mike Strang (USA). Shortly after, Ian Strachan was elected by the others as Chairman. Annex B to the Sporting Code for gliding gave GFAC the authority to test and evaluate GNSS Flight Recorders on behalf of IGC and to draft, finalise and issue documents giving IGC-approval for the use of such recorders for flights to IGC standards of evidence.

1995-96 - Testing, issue of first IGC-approvals. The first types of recorder were submitted to GFAC for testing later in 1995 and the first IGC-approval documents were issued in January 1996 for the Cambridge Models 10, 20 and 25. The Model 10 was the commercial version of the stand-alone recorders that were used in the Omarama Worlds in January 1995. Models 20 and 25 were developed during 1995 and were smaller versions that needed external power rather than the large internal battery of the Model 10. As well as built-in security, these all could store a list of turn points and flight declarations, and a separate screen could be connected by cable to display range and other data to the selected points. Cambridge later developed the Environmental Noise Level (ENL) system where noise level at the Recorder is detected and three ENL numbers are added to each fix on the IGC file. This is for recording the use of engine in motor gliders without needing wires outside the recorder case connected to microswitches to record engine or pylon operation, or the use of a vibration sensor that only works if the recorder is firmly connected part of the glider structure that transmitted engine vibrations.

After the IGC-approval of the Cambridge 10, 20 and 25, other approvals in 1996 were for the Peschges VP8, Filser LX20 and Zander GP940. For later GFAC activity, see page 6 and earlier pages above.

1996 – Present Day - Annual Reports on GNSS Recorder matters. The GFAC Chairman makes an annual report to IGC on GFAC and GNSS recorder matters. This is published in the Public Domain as part of the agenda for the annual IGC Plenary meeting. This report is updated at the meeting itself and such updates are published in the minutes. These reports, when combined with a list of all IGC-approval documents issued since January 1996 and listed on the web, give an account of the work that has been carried out by GFAC and others on behalf of IGC. In mid-2012 there were 51 IGC-approved types of GNSS recorder from 19 different manufacturers. Also in 2012 the IGC GFA Committee were awarded one of the FAI Group Diplomas for meritorious work on behalf of Sport Aviation.

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