History of Solar flight

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1. The conjunction of two pioneer fields, electric flight and solar cells

The use of electric power for flight vehicles propulsion is not new. The first one was the hydrogen-filled dirigible *France* in year 1884 that won a 10 km race around Villacoulbay and Medon. At this time, the electric system was superior to its only rival, the steam engine but then with the arrival of gasoline engines, work on electrical propulsion for air vehicles was abandoned and the field lay dormant for almost a century [2].

On the 30th June 1957, Colonel H. J. Taplin of the United Kingdom made the first officially recorded electric powered radio controlled flight with his model "Radio Queen", which used a permanent-magnet motor and a silver-zinc battery. Unfortunately, he didn't carry on these experiments. Further developments in the field came from the great German pioneer, Fred Militky, who first achieved a successful flight with a free flight model in October 1957. Since this premises, electric flight continuously evolved with constant improvements in the fields of motors and batteries [12].

Radio Queen, 1957

Gerald Pearson, Daryl Chapin and Calvin Fuller, inventors of photovoltaic technology, 1954

Three years before Taplin and Militky's experiments, in 1954, photovoltaic technology was born at Bell Telephone Laboratories. Daryl Chapin, Calvin Fuller, and Gerald Pearson developed the first silicon photovoltaic cell capable of converting enough of the sun's energy into power to run everyday electrical equipment. First at 4%, the efficiency improved rapidly to 11% [13]. Two more decades will be necessary to see the solar technology used for the propulsion of electric model airplanes…

2. Premises of solar aviation… with model airplane

On the 4th of November 1974, the first flight of a solar-powered aircraft took place on the dry lake at Camp Irwin, California. **Sunrise I**, designed by R.J. Boucher from Astro Flight Inc. under a contract with ARPA, flew 20 minutes at an altitude of around 100 m during its inaugural flight. It had a wingspan of 9.76 m, weighed 12.25 kg and the power output of the 4096 solar cells was 450 W [2]. Scores of flight for three to four hours were made during the winter, but Sunrise I was seriously damaged when caught flying in a sand storm. Thus, an improved version, **Sunrise II,** was built and tested on the 12th of September 1975. With the same wingspan, its weight was reduced to 10.21 kg and the 4480 solar cells were able this time to deliver 600 W thanks to their 14% efficiency. After many weeks of testing, this second version was also damaged due to a failure in the command and control system. Despite all, the history of solar flight was engaged and its first demonstration was done.

Sunrise II, 1975

Solaris, 1976

On the other side of the Atlantic, Helmut Bruss was working in Germany on a solar model airplane in summer 1975 without having heard anything about Boucher's project. Unluckily, due to overheating of the solar cells on his model, he didn't achieve level flight and finally the first one in Europe was his friend Fred Militky, one year later, with **Solaris.** On the 16th of August 1976, it completed three flights of 150 seconds reaching the altitude of 50 m [1].

Solar Solitude, 1996

Since this early time, many model airplane builders tried to fly with solar energy, this passion becoming more and more affordable. Of course, at the beginning, the autonomy was limited to a few seconds, but it rapidly become minutes and then hours... [1].

Some people distinguished themselves like Dave Beck from Wisconsin, USA, who set two records in the model airplane solar category F5 open SOL of the FAI. In August 1996, his **Solar Solitude** flew a distance of 38.84 km in straight line and two years later, it reached the altitude of 1283 m [14,15]. But the master of the category is still Wolfgang Schaeper who holds now all the records in this category: duration (11 h 34 mn 18 s), distance in a straight line (48.31 km), gain in altitude (2065 m), speed (80.63 km/h), distance in a closed circuit (190 km) and speed in a closed circuit (62.15 km/h). He achieved these performances with **Solar Excel** form 1990 to 1999 in Germany [16].

Solar Excel, 1990

MikroSol, PicoSol, NanoSol 1995-1998

One can mention as well the miniature models **MikroSol, PicoSol** and **NanoSol** of Dr. Sieghard Dienlin [17]. PicoSol, the smallest one, weighs only 159.5 g for a wingspan of 1.11 m and its solar panels can provide 8.64 W.

3. The dream of manned solar flight

After having flown solar model airplanes and proved it was feasible with sufficient illumination conditions, the new challenge that fascinated the pioneers at the end of the 70's was manned flights powered solely by the sun.

On the 19th of December 1978, Britons David Williams and Fred To launched **Solar One** on its maiden flight at Lasham Airfield, Hampshire [2,8]. First intended to be human powered in order to attempt the channel crossing, this conventional shoulder wing monoplane proved too heavy and thus was converted to solar power. Thus, the concept was to use Ni-Cd battery to store enough energy for short duration flights. Its builder was convinced that with high-efficiency solar cells like the one used on Sunrise, he could fly without need of batteries, but their exorbitant price was the only limit.

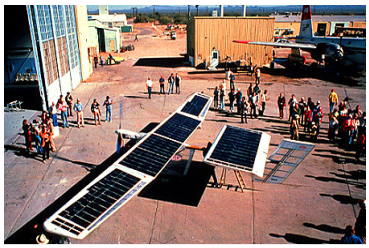
Solar Riser, 1979

On April 29, 1979, Larry Mauro flew for the first time the **Solar Riser**, a solar version of his Easy Riser hang glider, at Flabob Airport, California. The 350 W solar panel didn't have sufficient power to drive the motor directly and was here again rather used as a solar battery charger. After a three hours charge the Ni-Cd pack was able to power the motor for about ten minutes. His longest flight covered about 800 m at altitudes varying between 1.5 m and 5 m [2].

Gossamer Penguin, 1980

This crucial stage consisting in flying with the single energy of the sun without any storage was reached by Dr. Paul B. McCready and AeroVironment Inc, the company he founded in 1971 in Pasadena, California. After having demonstrated, on August 23, 1977, sustained and maneuverable manpowered flight with the Gossamer Condor, they completed on June 12, 1979 a crossing of the English Channel with the human-powered Gossamer Albatross. After these successes, Dupont sponsored Dr. MacCready in an attempt to modify a smaller version of the Gossamer Albatross, called **Gossamer Penguin**, into a man carrying solar plane. R.J. Boucher, designer of Sunrise I & II, served as a key consultant on the project. He provided the motor and the solar cells that were taken from the two damaged versions of Sunrise. On the 18th of May

1980, the Gossamer Penguin, with 13 years old MacCready's son Marshall onboard, realized what can be considered as the *world's first piloted, solar-powered flight*.



Solar Challenger, 1981

However, the Gossamer Penguin was not safe for a pilot flying at more that a few feet. The Dupont Company, encouraged by the results of the Gossamer Penguin, sponsored MacCready for building a new solar airplane that would cross the English Channel. The **Solar Challenger** was a 14.2 m wingspan high-wing monoplane with 16'128 solar cells offering 2500 W at sea level. On July 7, 1981, it flew from Puntoise-Cormeilles near Paris to Manston RAF Base near London in 5 hours 23 minutes covering 262.3 km, with solar energy as its sole power source and no onboard energy storage system.

Solair I, 1981

As they were in England, the members of Challenger team were surprised to hear for the first time about a German competitor who was trying to realize exactly the same performance at the same time from Biggin Hill airport. Günter Rochelt was the designer and builder of **Solair I**, a 16 m wingspan solar airplane based on the Canard 2FL from AviaFiber that he slightly modified and covered with 2499 solar cells providing 1800 W. He invited members of the Solar Challenger team to visit him and R.J. Boucher, who accepted the invitation, was very impressed by the quality of the airplane [2]. However, with a little more than half the wing area of solar cells, Solair I didn't have enough energy to climb and thus incorporated a 22.7 kg Ni-Cd battery. Rochelt didn't realize the channel crossing this year but on the 21st of August 1983 he flew in Solair I, mostly on solar energy and also thermals, during 5 hours 41 minutes.

Sunseeker, 1990

In 1986, Eric Raymond started the design of the **Sunseeker** in the United States**.** The Solar Riser in 1979, Solar Challenger two years later and a meeting with Günter Rochelt in Germany had convinced him to build his own manned solar-powered aircraft. At the end of 1989, the Sunseeker was test flown as a glider and during August 1990, it crossed the USA in 21 solar-powered flights with 121 hours in the air.

Icare 2, 1996

In Germany, the town of Ulm organized regularly aeronautical competitions in the memory of Albrecht Berblinger, a pioneer in flying machine 200 years ago. For the 1996 event, they offered attractive prizes to develop a real, practically usable solar aircraft that should be able to stay up with at least half the solar energy a good summer day with clear sky can give [19]. This competition started activities round the earth and more than 30 announced projects, but just some arrived and only one was ready to fly for the final competition. On the 7th of July, the motorglider **Icaré 2** of Prof. Rudolf Voit-Nitschmann from Stuttgart University won the 100,000 DM price [3,20]. Two other interesting competitors were **O Sole Mio** from the Italian team of Dr. Antonio Bubbico and **Solair II** of the team of Prof. Günter Rochelt who took profit of the experiences gained with the Solair I. Both projects were presented in an advanced stage of development, but were at the time of the competition not airworthy. The first flight of Solair II took place two years later in Mai 1998.

Solair II, 1998

4. On the way to high altitude long endurance (HALE) platforms and eternal flight

Pathfinder, 1994-1998

After the success of Solar Challenger, the US government gave funding to AeroVironment Inc. to study the feasibility of long duration, solar electric flight above 19.812 km (65000 ft). The first prototype HALSOL proved the aerodynamics and structures for the approach, but it suffered from it subsystem technologies, mainly for energy storage, that were inadequate for this type of mission. Thus, the project took the direction of solar propulsion with the **Pathfinder** that achieved it first flight at Dryden in 1993. When funding for this program ended, the 30 m wingspan and 254 kg aircraft became a part of NASA's Environmental Research Aircraft Sensor Technology (ERAST) program that started in 1994. In 1995, he exceeded Solar Challenger's altitude record for solar-powered aircraft when it reached 15'392 m (50'500 ft) and two years later he set the record to 21'802 m (71'530 ft). In 1998, Pathfinder was modified into a new version, **Pathfinder Plus**, which had a bigger wingspan and new solar, aerodynamic, propulsion and system technologies. The main objective was to validate these new elements before building its successor, the Centurion**.**

Centurion was considered to be a prototype technology demonstrator for a future fleet of solar-powered aircraft that could stay airborne for weeks or months achieving scientific sampling and imaging missions or serving as telecommunications relay platforms [18]. With a double wingspan compared to Pathfinder, it was capable to carry 45 kg of remote sensing and data collection instruments for use in scientific studies of the Earth's environment and also 270 kg of sensors, telecommunications and imaging equipment up to 24'400 m (80'000 ft) altitude. A lithium battery provided enough energy to the airplane for two to five hours flight after sunset, but it was insufficient to fly during the entire night.

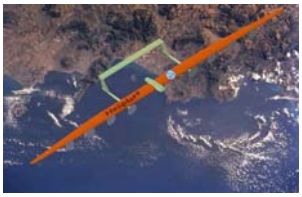
Centurion, 1997-1999

Helios, 1999-2003

The last prototype of the series designated as **Helios** was intended to be the ultimate "eternal airplane", incorporating energy storage for night-time flight. For NASA, the two primary goals were to demonstrate sustained flight at an altitude near 30'480 m (100'000 ft) and flying non-stop for at least 24 hours, including at least 14 hours above 15'240 m (50,000 ft). In 2001, Helios achieved the first goal near Hawaii with an unofficial world-record altitude of 29'524 m (96'863 ft) and a 40 minutes flight above 29'261 m (96'000 ft). But unfortunately, it never reached the second objective as it was destroyed when it fell into the Pacific Ocean on June 26, 2003 due to structural failures.

In Europe, many projects were also conduced on high altitude, long endurance (HALE) platforms. At the DLR Institute of Flight Systems **Solitair** was developed within the scope of a study from 1994 to 1998 [9,21]. The solar aircraft demonstrator was designed for year-around operations in northern European latitude by satisfying its entire onboard energy needs by its solar panels. So far, a 5.2 m wingspan SOLITAIR proof-of-concept model aircraft was built with adjustable solar panels for optimum solar radiation absorption. Flight tests were achieved and various projects are still carried out on this scaled version [7].

Solitair, 1998



Heliplat, 2000

The Helinet project, funded by a European Program, ran between January 2000 and March 2003 with the target to study the feasibility of a solar-powered High Altitude Platform of 73 m wingspan and 750 kg named **Heliplat**. It was intended to be used for broadband communications and Earth observation. The project involved ten European partners and led to the construction of a 24 m wingspan scale prototype of the structure. Politecnico di Torino, the overall coordinator, is still leading research on Heliplat and also on a new platform named **Shampo** [9,10].

But the objective of Helios to prove the feasibility of eternal flight for an unmanned airplane was reached on the 22nd of April 2005. Alan Cocconi, president and founder of AcPropulsion, flew his **Solong** during 24 hours and 11 minutes using only solar energy coming from its solar panels and also thermals, currents of warm air rising from the desert floor. The 4.75 m wingspan and 11.5 kg airplane confirmed its capabilities two months later, on the 3rd of June, with a flight lasting 48 hours and 16 minutes taking place in California's Colorado Desert.

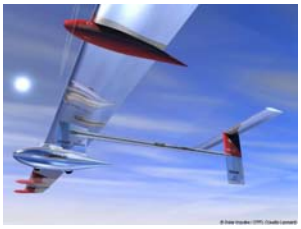
Solong, 2005

Zephyr, 2005

QinetiQ, a British company, is also very active in the field of solar HALE platforms. Two **Zephyr** aircrafts were first trialed in New Mexico in December 2005, achieving a maximum duration of 6 hours and reaching an altitude of 7'925 m (26'000 ft). After an 18 hours flight in July 2006, One Zephyr exceeded the official world record time for the longest duration unmanned flight with a 54 hour flight in New Mexico on the 10th of September 2007, reaching a maximum altitude of 17'786 m (58,355 ft). Weighting only 30 kg for 18 m wingspan, the aircraft used solar power for the ascent, reverting to lithium-sulphur battery power as dusk fell. QinetiQ expects in the future flight duration of some months at an altitude above 15'240 m (50'000 ft) [22].

Zephyr has recently been selected as the base platform for the Flemish HALE UAV remote sensing system **Mercator** in the framework of the Pegasus project [23]. The targeted platform should be able to carry a 100 kg payload in order to fulfill its missions that are forest fire monitoring, urban mapping, coastal monitoring, oil spil detection and many others…

The next dream to prove continuous flight with a pilot on board will perhaps come true with **Solar-Impulse** [27], a project officially announced in Switzerland in 2003. A nucleus of twenty-five specialists, surrounded by some forty scientific advisors from various universities like EPFL, is working on the 80 m wingspan, 2000 kg lightweight solar airplane. After the manufacturing of a 60 m prototype in 2007-2008 and the final airplane in 2009-2010, a round-the-world flight should take place in May 2011 with a stopover on each continent.



Solar-Impulse, 2009

Sky-Sailor, 2004

Another place where solar airplanes will play a major role is planetary exploration. In 2004, the **Sky-Sailor** project [28] funded by the European Space Agency was started at the Swiss Institute of Technology in Lausanne (EPFL) with the objective to study and develop a fully functional demonstrator on Earth of solar-powered airplane for the exploration of Mars. Compared to rovers or other aircraft proposals for the red planet, Sky-Sailor would fly during some months and cover very large areas, achieving simple scientific missions. The first prototype, weighting 2.4 kg for a wingspan of 3.2 m, was successfully tested during an autonomous flight of more than 27 hours in June 2008. It proved for the first time the feasibility of continuous flight without using altitude gain or thermal soaring.

Of course the History is still going on. In early 2007, the DARPA announced the lunch of a new solar HALE project [29]. The Vulture air vehicle program is an exploratory development program to develop the capability to deliver and maintain a single 453 kg (1000 lb), 5 kW airborne payload on station for an uninterrupted period of at least 5 years…

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Solar Powered Aircrafts Flown To Date

Version 2.02, July 2008

This research was achieved in the framework of the Sky-Sailor Solar Airplane Project at ETHZ. Its goal is to list and study all the solar airplanes that were built and flown.

Nr.	Name	Year	Designer, Manufacturer	Source	Wingspan [m]	Mean Chord [m]	Length [m]	Wing Area [m2]	Aspect Ratio []	Empty Weight [kg]	Total Weight with Pilot/Payload [kg]
					Wing & Fuselage					Weight	
1	Sunrise	1974	R.J. Boucher from Astro Flight, USA	Book "Solar Modellflug", page 9	9.75	0.86	4.38	8.36	11.4	12.25	
2	Sunrise II	1975	R.J. Boucher from Astro Flight, USA	Book "Solar Modellflug", page 9	9.75	0.86	4.38	8.36	11.4	10.21	
3	Solaris	1976	Fred Militky, Germany	Book "Solar Modellflug", page 10	2.06	0.20		0.41	10.3	0.61	
4	Ra	1977	Prof. Dr. V. Kupciks	Book "Solar Modellflug", page 12	1.37	0.12	0.84	0.16	11.9	0.19	
5	Utopie	1977	Dr. Roland Stuck, France	Book "Solar Modellflug", page 13	2.53	0.20	1.32	0.51	12.6	0.97	
6	Solar-Student	1978	Prof. Dr. V. Kupciks	Book "Solar Modellflug", page 14	1.96	0.22	1.04	0.43	8.91	0.93	
7	Solar One	1978	David Williams and Fred To	R. J. Boucher, History Of Solar Flight, AIAA Paper 84-1429, June 1984	20.72	1.17	6.70	24.15	17.8	104.32	?
8	Solar-X4	1979	H. Schenk	Book "Solar Modellflug", page 15	2.50	0.17	1.13	0.42	14.8	0.85	
9	Solar Silberfuchs	1979	Günter Rochelt	Book "Solar Modellflug", page 17	4.00	0.25	1.52	1.00	16	2.10	
10	Solar Riser	1979	Larry Mauro	http://www.airventuremuseum.org/collection/aircraft/UFM-Mauro Solar Riser.asp	9.14	1.04	2.44	9.52	8.78	55.8	124.7
11	Solar-HB79	1980	Helmut Bruss	Book "Solar Modellflug", page 16	2.80	0.24	1.45	0.67	11.7	1.51	
12	Solair I	1980	Günter Rochelt	http://www.delago.de/solair/ESol2-7.htm	16.00	1.38	5.40	22.00	14	120.00	200.0
13	Gossamer Penguin	1980	Dr. Paul B. MacCready from Aerovironment	http://www1.nasa.gov/centers/dryden/pdf/120308main_FS-054-DFRC.pdf	21.64	2.63		57.00	8.22	30.84	67.7
14	Solar-HB80	1981	Helmut Bruss	Book "Solar Modellflug", page 19	2.84	0.23	1.48	0.65	12.5	1.72	
15	Solar Challenger	1981	Dr. Paul B. MacCready from Aerovironment	http://www1.nasa.gov/centers/dryden/pdf/120308main_FS-054-DFRC.pdf	14.80	1.48	9.22	21.83	9	99.79	153.0
16	Solus Solar	1984	Helmut Bruss, F.W. Biesterfeld	Book "Solar Modellflug", page 20	3.20	0.29	0.88	0.93	11	2.20	
17	Poly	1986	Helmut Bruss	Book "Solar Modellflug", page 21	3.24	0.29	0.88	0.97	10.8	2.48	
18	Combi	1987	Peter Hartwig	Book "Solar Modellflug", page 23	2.96	0.26	0.85	0.77	11.4	2.29	
19	Solariane	1987	Franz Weissgerber, Ernst Schöberl	Book "Solar Modellflug", page 24	3.08	0.28	1.72	0.85	11.2	1.80	
20	Helios (model)	1989	Erich Töpfer	Book "Solar Modellflug", page 26	2.14	0.18		0.39	11.8	1.40	
21	Bloch	1989	Edwin Bloch	Book "Solar Modellflug", page 26	2.90	0.24		0.70	12	1.25	
22	Grosholz	1989	Rainer Grosholz	Book "Solar Modellflug", page 26	3.07	0.19		0.60	15.8	1.85	
23	Combi 2	1989	Helmut Bruss	Book "Solar Modellflug", page 28	2.95	0.28	1.54	0.77	11.3	1.70	
24	Ikaros	1989	Franz Weissgerber	Book "Solar Modellflug", page 26	2.50	0.23		0.58	10.8	1.80	
25	Bleher	1989	Wolfgang Bleher	Book "Solar Modellflug", page 26	2.00	0.24		0.49	8.18	1.37	
26	Romarino	1989	Urs Schaller	Book "Solar Modellflug", page 26	2.00	0.20		0.40	10	1.80	
27	Sol-e-moi	1989	Alfred Hitzler	Book "Solar Modellflug", page 26	3.00	0.17		0.50	18	2.10	
28	Wolf	1989	Josef Wolf	Book "Solar Modellflug", page 26	3.00	0.21		0.63	14.3	1.60	
29	WS-Solar	1989	Wener Schleidt	Book "Solar Modellflug", page 26	2.50	0.22		0.55	11.3	1.55	
30	Ariane Ultra	1989	Franz Weissgerber	Book "Solar Modellflug", page 26	1.98	0.21	1.14	0.41	11	3.02	
31	Solar Voyager	1990	Volker Klein	Deutsche Museum, Flugwerft Schleißheim	3.20	0.25		0.79	13	1.30	
32	Mardini	1990	Hans-Jakob Sommerauer	Book "Solar Modellflug", page 29	2.40	0.25		0.60	9.6	2.50	
33	Sollisolar	1990	Edwin Bloch	Book "Solar Modellflug", page 29	2.98	0.23		0.69	12.9	1.23	
34	PB 26-FL	1990	Marco Buholzer	Book "Solar Modellflug", page 29	2.60	0.22		0.58	11.8	2.30	
35	Solarbaby	1990	Werner Dettweiler	Book "Solar Modellflug", page 29 & 106	1.70	0.16		0.28	10.4	1.25	
36	Bleher	1990	Wolfgang Bleher	Book "Solar Modellflug", page 29	2.00	0.22		0.44	9.03	1.55	
37	Uccello	1990	Josef Kapfer	Book "Solar Modellflug", page 29	2.70	0.23		0.63	11.5	1.90	
38	Sole Florentino	1990	Franz Weissgerber	Book "Solar Modellflug", page 29	2.50	0.17		0.43	14.6	1.20	
39	Soli	1990	Ernst Schöberl	Book "Solar Modellflug", page 29	2.08	0.18		0.38	11.5	1.50	
40	Playboy	1990	Thomas Bley	Book "Solar Modellflug", page 29	2.40	0.19		0.45	12.8	1.35	
41	WS12 (then WS16)	1990	Dr. Wolfgang Schaeper	Book "Solar Modellflug", page 29	2.50	0.16	1.10	0.41	15.2	0.84	
42	Solar Flyer	1990	Peter Hartwig	Book "Solar Modellflug", page 104	2.64	0.23	1.48	0.61	11.5	1.60	
43	Blue Chip	1990	Hans W. Müller	Book "Solar Modellflug", page 108	2.20	0.23	1.25	0.50	9.66	0.75	
44	Solarmax	1990	Erich Töpfer	Book "Solar Modellflug", page 110	3.48	0.30	1.59	1.04	11.6	2.54	
45	Sollisolar 89-2	1990	Edwin Bloch	Book "Solar Modellflug", page 111	2.98	0.23	1.34	0.68	13.1	1.24	
46	Phönix	1990	Jens Stattler	Book "Solar Modellflug", page 112	2.62	0.21	1.29	0.56	12.2	1.18	
47	Sunseeker	1990	Eric Raymond	http://www.solar-flight.com/sslink.html						?	?
48	Solar UHU	1991	Graupner (Ref. 4274)	http://members.ebay.co.uk/ws/eBayISAPI.dll?ViewUserPage&userid=airxav	2.30	0.23	1.20	0.53	10	1.45	
49	Blue-Wing	1991	Norbert Ladenburger, Germany	"Aufwind", Issue 2, 1992	2.34	0.18	1.05	0.42	13	0.75	
50	Solar Schilti 1	1991	Jean-Pierre Schiltknecht	FMT Sonderdruck aus FMT 1-4/1992	1.74	0.19	1.16	0.34	9	0.70	
51	Solar Schilti 2	1991	Jean-Pierre Schiltknecht	RC Modely, Issue 4, 1997	1.99	0.18	1.05	0.36	11.1	0.82	
52	Silizi Solar	1991	Horst Groner	Flug- und Modelltechnik 423-4/91	2.25	0.21	1.30	0.47	10.7	1.08	
53	Solix	1991	Ernst Schöberl	Flug- und Modelltechnik 443-12/92	2.37	0.20	1.30	0.48	11.8	1.05	
54	Solar mini challenger	1992	Astro Flight	http://www.bekkoame.ne.jp/~sakazaki/fwind/list-e.html	1.55	0.18		0.28	8.5	0.94	
55	Rival-8 Solaris	1992	Palo Lishak, Slovakia	http://www.rcgroups.com/forums/showthread.php?t=291266	1.96	0.22	1.13	0.43	8.91	0.66	
56	Pathfinder	1994	AeroVironment, NASA	http://www1.nasa.gov/centers/dryden/pdf/120308main_FS-054-DFRC.pdf	29.50	2.40	3.60	70.80	12.3	207.00	252.0
57	MikroSol	1995	Sieghard Dienlin	http://home.main-rheiner.de/sieghard.dienlin/	1.13					0.19	
58	Solair II	1996	Günter Rochelt	http://www.delago.de/solair/ESol2-7.htm	20.00	0.86	6.12	17.00	23.5	140.0	230.0
59	Icare II	1996	UNI Stuttgart, Rudolf Voit-Nitschmann	http://www.uni-stuttgart.de/wechselwirkungen/ww2001/nitschmann.pdf	25.00	1.03	7.70	25.70	24.3	270.00	360.0
60	Lo 120 Solar	1996	Hugo Post	Book "Fliegen mit Licht", page 123	15.46	1.03		16.00	14.9	?	
61	Solarflugzeug	1996	Uwe Heinemann	Book "Fliegen mit Licht", page 123	18.00	1.50		27.00	12	190.00	280.0
62	O sole mio	1996	Dr. Antonio Bubbico	http://www.uni-stuttgart.de/wechselwirkungen/ww2001/nitschmann.pdf	20.00	1.23		24.50	16.3	130.00	220.0
63	Solar Solitude	1996	Dave Beck	http://personalpages.tds.net/~dbeck/	2.70	0.20		0.55	13.3	2.00	
64	NanoSol	1996	Sieghard Dienlin	http://home.main-rheiner.de/sieghard.dienlin/	1.11					0.16	
65	Centurion	1997	AeroVironment, NASA	http://www1.nasa.gov/centers/dryden/pdf/120308main_FS-054-DFRC.pdf	61.80	2.40	3.60	148.32	25.8	533.00	862.0
66	Trosollmuffel	1997	Bernd Bossmann	http://www.delago.de/ariane/EIntmod.htm	2.50	0.25		0.62	10.1	1.14	
67	Global Flyer	1997	Helmut Bruss	FMT Magazine, Issue 7, 1998	2.50	0.23	1.20	0.57	11	1.04	
68	Pathfinder Plus	1998	AeroVironment, NASA	http://www1.nasa.gov/centers/dryden/pdf/120308main_FS-054-DFRC.pdf	36.30	2.40	3.60	87.12	15.1	247.50	315.0
69	Solar Excel	1998	Wolfgang Schaeper	http://il-windpower.homelinux.net/SunSailor/cf2000.pdf	2.10	0.16	1.02	0.35	12.8	0.72	
70	Solitair	1998	DLR Institute of Flight Systems	http://www.dlr.de/ft/desktopdefault.aspx/tabid-1358/1891_read-3339/	5.20					?	
71	PicoSol	1998	Sieghard Dienlin	http://home.main-rheiner.de/sieghard.dienlin/	0.99					0.13	
72	LFMA	1998	Louis Fourdan, Michel Astier, France	Louis Fourdan	1.90	0.25		0.47	7.76	1.20	
73	Helios	1999	AeroVironment, NASA	http://www1.nasa.gov/centers/dryden/pdf/120308main_FS-054-DFRC.pdf	75.30	2.48	3.60	186.60	30.4	600.00	930.0
74	Sunrazor (Sunriser)	2000	Patrick Berry	The Sunriser - A Design Study in Solar Powered Flight.pdf	2.70	0.30		0.81	9.06	1.10	
75	Goldcap 2	2001	Helmut Bruss	http://www.dienlin.de/sieghard/ModellTechnik/Bildergalerie.html						?	
76	Solarus	2001	Jonas Romblad	http://www.rcgroups.com/forums/showthread.php?t=136218	2.30	0.19		0.44	12	0.48	
77	FlyG	2002	Royal Institute of Technology, KTH	http://130.237.36.221/cdio/old_projects/sap/index.html	6.00	0.60	2.70	3.60	10	10.00	
78	Solar Pleaser	2003	Unknown	http://www.rcgroups.com/forums/showthread.php?t=88868	1.04	0.15	1.01	0.15	7	0.25	
79	No Name	2003	Matt Keennon	http://aero.stanford.edu/Reports/AIAA20040001b.pdf	0.14	0.015	0.12	0.00	9.33	0.0017	
80	Solar Splinter	2003	Paul Breed	http://www.rasdoc.com/splinter/	4.27	0.35	2.13	1.50	12.2	4.50	
81	Sol-Mite	2004	Ralph Bradley	http://www.parmodels.com/ralphs_models.htm	0.81	0.12		0.10	6.5	0.13	
82	Sky-Sailor	2005	André Noth, Walter Engel, Roland Siegwart, E	http://sky-sailor.epfl.ch	3.20	0.24	1.82	0.78	13.2	2.50	
83	Zephyr	2005	QinetiQ	http://www.qinetiq.com	18.00	1.55		27.90	11.6	30.00	
84	Solong	2005	Alan Cocconi from AcPropulsion	http://www.acpropulsion.com	4.75	0.32		1.50	15	12.60	
85	NanSun	2006	Troy Tegeder	http://contentdm.lib.byu.edu/ETD/image/etd1723.pdf	3.20	0.40	2.60	1.28	8	4.10	
86	Howie Mark	2006	Louis Dube, Joshua Alves, Corey Ohnstad	University of Nevada	2.43	0.20		0.49	12.2	0.45	
87	SunSailor	2006	Technion IIT, Haifa, Israel	http://il-windpower.saymoo.org/SunSailor.html	4.20	0.32	2.20	1.35	13.1	3.60	
88	Aphelion	2006	Carl Engel and Adam Woodworth from MIT	http://www.rcgroups.com/forums/showthread.php?t=572000	3.13	0.22		0.70	14	?	
89	2.765 g Solar MAV	2007	Brian Daniels	http://www.rcgroups.com/forums/showthread.php?t=731011	0.14	0.04	0.15	0.0057	3.41	0.0022	
90	SolFly	2007	Helmut Schweig	http://www.rcgroups.com/forums/showthread.php?t=691420	0.07					<0.001	
91	Micro-Mite	2007	Ralph Bradley	http://www.parmodels.com/ralphs_models.htm	0.20	0.05		0.01	4	0.0095	
92	Sun-Surfer I	2007	Niels Diepeveen, ETH Zürich	http://sky-sailor.epfl.ch/publications.htm	0.77	0.00	0.73	0.07	8.5	0.12	
93	Sun-Surfer II	2007	Beat Fuchs, ETH Zürich	http://sky-sailor.epfl.ch/publications.htm	0.78	0.11	0.74	0.09	7.03	0.188	

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