ASK21 spin exit difficulties

1 Factual information

1.1 Pre-history of flight

In September 2009, the annual instructors' day focused on the spin basic instruction for glider trainees. The Swiss regulator requests that the basic pilot license program includes at least 2 flights with spin exit maneuvers. The instructors' day objectives were to harmonize the pedagogic, flying technique and operational procedures to ensure a high level of safety in our school operations.

The main consensus was that an instructor should demonstrate "3 turns" spin before giving the hand to the trainee for the exit. Also an altitude of 1300m/AGL for dual spins program (1 left and 1 right) was seen as a good value. The program discusses only the spin on ASK21 that is our basic school glider. As per the AFM, it has been reviewed that rudder against the rotation has to be applied first at full deflection and then after a short pause (2 sec = ~ ½ turn) the stick has to be relaxed to neutral position.

Each instructor flew this exercise in the afternoon and no issue has been reported by participants. The weight and balance was available under a computed Excel table that corresponded to the last weighing report and was double checked with the AFM. It must be noted that no issue has been raised since this ASK21 glider came back from a 3000h revision with new Gelcoat and new weighing data in January 2009.

The concerned instructor conducted this exercise since more than 30 years, mostly on ASK21, for a total estimated to 500 spins without any issue. This instructor gave emphasis in basic training to spin exits and therefore many "1 turn" spins were demonstrated prior trainees executed the exits. Therefore, only 200 spins can be claimed to be "3 turns" spins.

1.2 History of flight

In October 2009, the trainee needed to accomplish this exercise, as part of the emergencies training, that is mandatory prior the first solo flight. The instructor provided detailed instructions on the spin phenomena and the standard exit maneuvers. The mission was to have a "3 turns" spin left and a "3 turns" spin right as agreed during the September instructors refresher.

The weight and balance has been computed with the same table used during the instructors' day. With the trainee estimated at 71 Kg with parachute and the Instructor at 80 Kg with the parachute (and no further ballast in the front seat) the tail additional ballast of 3.0 Kg was requested to ensure sustained spin. As for light persons the sustained spin margin reduces, we installed a tail ballast of 4 Kg. This was coherent with the AFM and well in front of the sustained spin center of gravity range for this ASK21 (See Tec analysis).

As usual a special safety briefing was given to the trainee fasten in the front seat. The briefing was repeated a second time due to some distractions from the environment in the first dry evacuation drill. If necessary, a loud and clear commando "Bale out, Bale out" to evacuate the glider would be given by the instructor. The instructor fixed 500m/AGL as an evacuation altitude if spin would not be stopped.

The tow climbs 50m above the school recommendation at 1350 m/AGL. We did all checks after towing and before spin as usual.

The first spin was engaged left at 1300m/AGL. The first 3 turns were very typical with the famous longitudinal oscillation of +- 15° and periodicity (nose down 1 turn, up 1 turn and down 1 turn). The amplitude of the oscillation was average due to low pilots and ballasts weights. The trainee executed perfectly the exit maneuver on command after 3 turns. The glider exited the spin after ¾ turn totally conventionally.

The second spin was engage right at an altitude of 1000m/AGL. The spin entry behavior was very similar to the first spin left. **The longitudinal oscillation this time disappeared during the 2nd and 3rd turn (or a very small oscillation amplitude had a periodicity extending over several turns and was therefore undetectable).** The nose down attitude (about 40°) was similar to the average on the left spin. The trainee executed the exit maneuver exactly as the previous one. But after 1 turn nothing happened. The instructor pushed the left rudder for 1 additional turn to ensure full rudder was applied and this was the case. It was particularly noticeable that no more longitudinal oscillation was present and we were fixed at about 40° pitch down. The instructor required that the trainee released all controls and set again the controls in right spin commands for another ½ turn. Then he re-executed the spin standard exit maneuver as per the ASK21 AFM - with a strong emphasis on the 2 sec short elevator pause (1/2 turn) - but nothing happened even after more than 1 1/2 turns. No sign like aerodynamics noise, controls forces or longitudinal attitude indicated that something would change soon. The instructor was ready in his mind to give the commando to evacuate the glider. Despite the AFM "Warning: Full forward stick may retard or even prevent recovery!" – USAF report specifies: "without full rudder" - he decided to try a last maneuver and pulled the stick full aft center and then pushed frankly to full front center for 1-2 sec. After this short pause he reverted slowly back to ¾ front stick. The objective was to induce a longitudinal axis change, keeping full rudder left. This seems to work as the glider increased slightly the pitch, some aerodynamics noise changed and control forces recovered slowly. We were now at 500m/AGL and the instructor decided to cancel his intention to evacuate due to the clear signs of recovery! 1/2 turn after, the glider recovered in a standard manner living us a 400m/AGL margin after 9 turns in a right spin.

The rest of the flight was uneventful and the trainee could make a normal landing.

1.3 Personal Info

The Instructor:

- 4500 hours in gliding experience
- Current training was 150 hours last 12 months on glider
- Instructor since 30 years (most of instruction on ASK21)
- Basic flight testing knowledge
- Acrobatics level 1 and 2 qualified and current about spin
- About 500 spins on ASK21.
- Weighed after flight 82 Kg with the parachute (instead of 80 Kg estimated)

The Trainee:

- Training phase "not far from solo flight".
- No other flying experience.

- Weighed after the flight 69 Kg with the parachute (instead of 71 Kg estimated).

1.4 Aircraft Information

- Equipment list 20.01.2009.
  Empty weight & CG: 398.6 Kg, 748.2 mm aft of reference point
- The ASK21 had gone through a 3000h check during winter 2008-2009. A totally new Gelcoat was applied during this process in a qualified organization.
- Mass and balance have been made and are signed off by authorized personal. The data were absolutely coherent with the previous mass and balance.
- The elevator, ailerons and the rudder deflections were perfectly within their tolerances as given in the Maintenance Manual (MM). Report after 3000 h check is available and tolerances have been verified by the author of this report. The tolerances are on the side that gives most authority of controls.
- The elevator and ailerons were perfectly tightened with fabric tapes. The rudder was tightened with V form Teflon bands inside the vertical stabilizer on both sides of the control surface.
- The wings-fuselage interstices were tightened with plastic tapes with the exception of a short 20 cm crack in the tape at the top forward left wing edge.
- The wheel protection was in place.
- No element that could have disturbed the aerodynamic flow on the tail could be identified.
- Flarm equipped, but data were not downloaded (possibility was forgotten). However, with a default sampling of 2 sec not much could have been analyzed in such a spin and information retrieval would not have contributed to more accuracy in this report.

1.5 Meteorological Information

It was a typical wonderful autumn day with clear weather, no cloud and no thermal in the region of the airfield. The wind was SW for 10 Km/h maximum on ground and no turbulence until 2000m QNH. Ground temperature at the time of flight was about 16°C.

1.6 Research

It is not the first time that such an occurrence happened in spin training. Precise statistics on spin training accidents are not available on the web. Nevertheless, several accidents and incidents descriptions look very similar to this case but not necessarily on ASK21.

Might be one of the most studied case is the TG-9 (ASK21) Trainer Glider of the US Air Force spin accident in 1988. A complete spin flight test campaign followed this accident and has been released a year later (AFFTC-TR-89-27).

15 years ago, we also had a very similar case with another instructor in our club. Nevertheless on this flight, the wheel cover was not in place and the wheel turbulence effect on the T tail had not been further studied. It cannot be completely excluded that the wheel could induce some turbulences affecting aerodynamics flows on the T tail. Since this day and as a operational precautionary measure, we never again attempted spins without the wheel cover.

We got also an information that an identical spin exit difficulty has been reported in 2009 with an ASK21 in Germany.

1.7 Additional Information

Since this incident, the club flight operations has been re-adapted toward the initial habit of this instructor. First a “3 turns” spin at minimum 1300m/AGL and second only a “1 turn” spin at minimum 1000m/AGL. Also a minimum of 75 Kg in the front seat has been defined in order to increase the momentum of inertia (Iyy) and to avoid flatter and faster rotating spins. Since, several spin exercises with very light pilots have been flown by this instructor with the unmodified ASK21 and no particular exit difficulties have been experienced.

2 Analysis

2.1 Technical aspects

There is no evidence of any technical anomaly on this ASK21. Plenty of spins have been trained since the last 3000 hours and nothing particular had been reported.

The center of gravity was perfectly in the forward sector of the sustained spin area. See fig4 below extracted from the USAF report and the calculation correlation from the ASK21 AFM.

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II.7 IN FLIGHT CENTER OF GRAVITY RANGE

The approved in flight C.G. range is from 9,21 (234 mm) - 18,46 inches (469 mm) behind the datum line; equivalent to 20 % - 41,1 % of the MAC = 44,13 inches (1121 mm). With a 0,31 inches (8 mm) behind leading edge center part of the wing.

Fig 1: Extract of the ASK21 AFM

Vrille en ASK 21

Lest de queue en [Kg] : GPQueue = (GP1*rp + GP2*ri + GP3*rb + Grüst (Kmin - rg)) / rq

Pilote Poids équipé	x	Kg	GP1	Elève levier moyen + 0.4 (dossier = 1.650; sans dossier = 1.585)	1.617	m	rp																									
Instructeur Poids équipé	y	Kg	GP2	Instructeur levier + 0.4 (dossier négligeable)	0.480	m	ri																									
Bagage Poids	0	Kg	GP3	Bagage levier + 0.4	0.150	m	rb																									
Planeur Poids à vide	398.6	Kg	Grüst	CG min arrière pour vrille soutenue	0.400	m	Kmin																									
Charge Util Max	201.4	Kg	GPUmax	CG à vide	0.748	m	rg																									
Lest de queue Max	12	Kg	GPQmax	Lest de queue levier + 0.4	4.929	m	rq																									

<-- Instructeur Siège Arrière [Kg]	--> Elève Siège Avant [Kg]																Avec Lest de queue VNE = 200 Km/h et acrobaties interdites !															
	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
70	0.0	0.3	0.6	1.0	1.3	1.6	2.0	2.3	2.6	2.9	3.3	3.6	3.9	4.2	4.6	4.9	5.2	5.6	5.9	6.2	6.5	6.9	7.2	7.5	7.9	8.2	8.5	8.8	9.2	9.5
71	0.1	0.4	0.7	1.1	1.4	1.7	2.0	2.4	2.7	3.0	3.4	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.6	7.0	7.3	7.6	8.0	8.3	8.6	8.9	9.3	9.6
72	0.2	0.5	0.8	1.2	1.5	1.8	2.1	2.5	2.8	3.1	3.5	3.8	4.1	4.4	4.8	5.1	5.4	5.8	6.1	6.4	6.7	7.1	7.4	7.7	8.1	8.4	8.7	9.0	9.4	9.7
73	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.6	2.9	3.2	3.6	3.9	4.2	4.5	4.9	5.2	5.5	5.9	6.2	6.5	6.8	7.2	7.5	7.8	8.1	8.5	8.8	9.1	9.5	9.8
74	0.4	0.7	1.0	1.4	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.6	5.0	5.3	5.6	5.9	6.3	6.6	6.9	7.3	7.6	7.9	8.2	8.6	8.9	9.2	9.6	9.9
75	0.5	0.8	1.1	1.5	1.8	2.1	2.4	2.8	3.1	3.4	3.7	4.1	4.4	4.7	5.1	5.4	5.7	6.0	6.4	6.7	7.0	7.4	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0
76	0.6	0.9	1.2	1.6	1.9	2.2	2.5	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.2	5.5	5.8	6.1	6.5	6.8	7.1	7.5	7.8	8.1	8.4	8.8	9.1	9.4	9.8	10.1
77	0.7	1.0	1.3	1.6	2.0	2.3	2.6	3.0	3.3	3.6	3.9	4.3	4.6	4.9	5.3	5.6	5.9	6.2	6.6	6.9	7.2	7.6	7.9	8.2	8.5	8.9	9.2	9.5	9.8	10.2
78	0.8	1.1	1.4	1.7	2.1	2.4	2.7	3.1	3.4	3.7	4.0	4.4	4.7	5.0	5.4	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.6	9.0	9.3	9.6	9.9	10.3
79	0.9	1.2	1.5	1.8	2.2	2.5	2.8	3.2	3.5	3.8	4.1	4.5	4.8	5.1	5.5	5.8	6.1	6.4	6.8	7.1	7.4	7.7	8.1	8.4	8.7	9.1	9.4	9.7	10.0	10.4
80	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.3	3.6	3.9	4.2	4.6	4.9	5.2	5.5	5.9	6.2	6.5	6.9	7.2	7.5	7.8	8.2	8.5	8.8	9.2	9.5	9.8	10.1	10.5
81	1.1	1.4	1.7	2.0	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.6	6.0	6.3	6.6	7.0	7.3	7.6	7.9	8.3	8.6	8.9	9.3	9.6	9.9	10.2	10.6
82	1.2	1.5	1.8	2.1	2.5	2.8	3.1	3.4	3.8	4.1	4.4	4.8	5.1	5.4	5.7	6.1	6.4	6.7	7.1	7.4	7.7	8.0	8.4	8.7	9.0	9.4	9.7	10.0	10.3	10.7
83	1.2	1.6	1.9	2.2	2.6	2.9	3.2	3.5	3.9	4.2	4.5	4.9	5.2	5.5	5.8	6.2	6.5	6.8	7.2	7.5	7.8	8.1	8.5	8.8	9.1	9.4	9.8	10.1	10.4	10.8
84	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.6	4.0	4.3	4.6	5.0	5.3	5.6	5.9	6.3	6.6	6.9	7.3	7.6	7.9	8.2	8.6	8.9	9.2	9.5	9.9	10.2	10.5	10.9
85	1.4	1.8	2.1	2.4	2.8	3.1	3.4	3.7	4.1	4.4	4.7	5.1	5.4	5.7	6.0	6.4	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.6	10.0	10.3	10.6	11.0
86	1.5	1.9	2.2	2.5	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.1	5.5	5.8	6.1	6.5	6.8	7.1	7.4	7.8	8.1	8.4	8.8	9.1	9.4	9.7	10.1	10.4	10.7	11.1

Fig 2: Extract of Club Spin Table (At the responsibility of the commander to cross check with the AFM and latest data available).

	Weight [Kg]	Arm [m]	Momentum [Kgm]
Empty weight	398.6	-0.7482	-298.233
Pilot Front	71.0	1.2170	86.407
Pilot Rear	80.0	0.0800	6.400
Baggage	0.0	-0.2500	0.000
Tail Weights	2.9	-5.329	-15.454
Total	552.5	-0.3998	-220.880

	Weight [Kg]	Arm [m]	Momentum [Kgm]
Empty weight	398.6	-0.7482	-298.233
Pilot Front	71.0	1.2170	86.407
Pilot Rear	80.0	0.0800	6.400
Baggage	0.0	-0.2500	0.000
Tail Weights	4.0	-5.329	-21.316
Total	553.6	-0.4096	-226.742

Fig 3a 3b: 3a the crosscheck that the table is correct; 3b the estimated flown CG

	Weight [Kg]	Arm [m]	Momentum [Kgm]
Empty weight	398.6	-0.7482	-298.233
Pilot Front	69.0	1.2170	83.973
Pilot Rear	82.0	0.0800	6.560
Baggage	0.0	-0.2500	0.000
Tail Weights	4.0	-5.329	-21.316
Total	553.6	-0.4137	-229.016

Fig 3c: The really flown CG

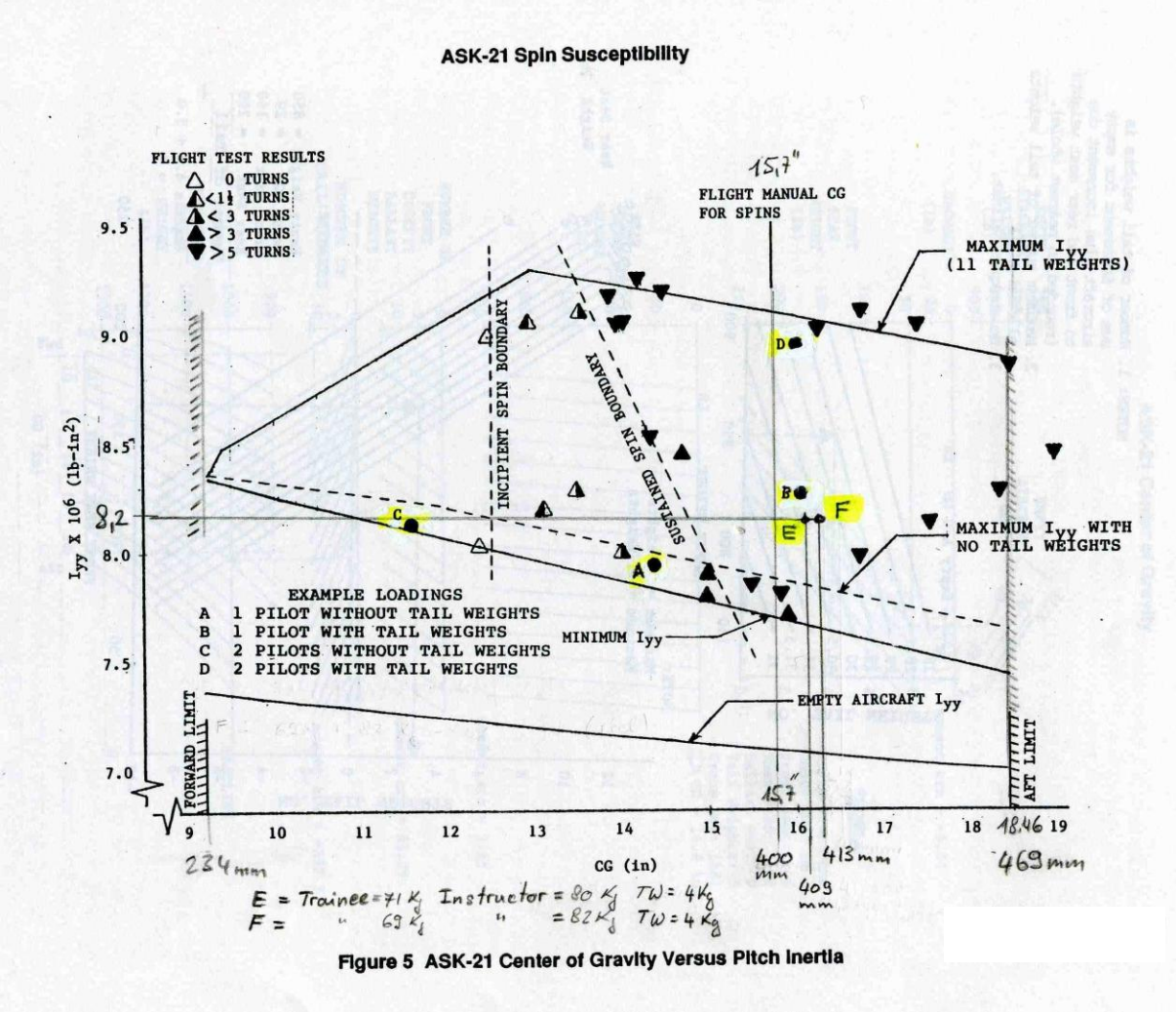

Figure 5 ASK-21 Center of Gravity Versus Pitch Inertia

Fig 4: Extract of USAF report AFFTC-TR-89-(27 July 1989) with incident data

Basically the AFM formula to calculate spin tail weight brings the flight CG to 400mm aft of the reference point (on figure 3a above). The figure 4 indicates graphically the position of CG

estimated (409mm) and real (413mm) during this flight. This is on the very safe side of the sustained spin envelop where the maximum aft CG is 469mm! Please note that the momentum of Inertia (Iyy) of 8.2 [Lb-in2] has been estimated with the formulas given in the USAF report page 51.

2.2 Operational aspects

The instructor was fully following the recommendation of its club and climbs to 1350m/AGL for two “3 turns” spins training.

The spin entries use a consistent method. The speed is reduced from about 10 Km/h over the stall at 1 Km/h per sec. When in the stall, the stick is moved frankly backward to its stop and in sequence the full rudder is applied. The pitch attitude increase is very moderate through this maneuver (5-10°).

The first spin exercise was a catch because it works as per the book.

These exit difficulties seem to happen rather after 3 turns when the spin fully develops and gets a stabilized regime **without longitudinal pitch oscillations**. The USAF report stated that the amplitude could be small at forward spinning CG and the period extends over several turns what could be coherent here. It must be noted that we attempted to exit the spin over 6 turns and during 5 turns unnoticeable pitch change was observed. We might have been a bit busy though.

The spin account could be detailed as following:

Action	Nb of turns	Height [m/AGL]
Start spin		1000
Spin turns demo	3	820
Trainee spin exit	1	760
Instructor full rudder	1	700
Instructor in spin Cmd	0.5	670
Instructor spin exit	1.5	580
Instructor aft-forward + pause	1	520
Instructor stich back 3/4 - signs of exit	0.5	490
Spin exit	0.5	400
TOTAL	9	600

This situation looks like the results of a chaotic behavior. It is probably extremely rare that the spin development follows this track. From our very small local experience, an estimated of once every 1’000 full developed spins might create such difficulties.

Therefore, it means that the glider should always be able to exit the spin, but the main question is the amount of time and therefore the height reserve plan for the flight. Also it must be clear that the instructor cannot wait indefinitely until the glider starts to respond. This especially true when things go wrong and special maneuvers need to be attempted. The action on the elevator during the last turn was clearly efficient and save the day.

2.3 Human Factors aspects

The emergency procedure was well drilled on ground what was an excellent factor to keep the crew very calm. However, it is well known that the "good" spins are extremely comfortable what represents a hidden danger because things are going quite fast in the reality (4sec per turn and 60-70m/turn loss). The spin exits attempts had been given enough time to show signs of recovery. The decision to search for an alternative maneuver before baling out is seen as correct. Important was to keep the full rudder deflection during the attempt. Also the decision at 500m/AGL to wait for the recovery due to the clear signs of spin exit was more than adequate. Without those signs the instructor would have immediately given the commando to bail out.

3 Conclusion

Spinning is a complex phenomenon with exchanges of aerodynamic and inertia energies. The author is suggesting that in extremely rare occurrences (1/1000th) and in specific mass and balance conditions, full developed spins exit maneuvers as determined during the initial certification (or conducted during the USAF flight test campaign) are not properly working or need far more time than indicated (clearly more than 1 ½ turns). Therefore the AFM needs better guidance from the type certification holder for such difficult spin exits.

The spin could finally be safely recovered due to the sufficient initial altitude planned for this exercise but no reserve existed anymore.

3.1 Findings

- Maximum Take off mass was within limits authorized.
- The tail ballast was within AFM limits and respected not lifting parts mass.
- The center of gravity was in the safe range of the ASK21 sustained spinning envelope.
- No technical issues were found on this ASK-21.
- The spin entries left and right was executed with the exact same method.
- The spin development under the same conditions was extremely different between the first left spin and the second right spin.
- The left spin development and exit were absolutely standard.
- Development of right spin was very different than left spin and 6 additional turns were necessary to execute the right spin exit.
- Preparation was adequate and was conforming to all recommendations.
- The conservative chosen altitude for spin training was just enough to overcome such a difficulty.

3.2 Causes

The cause is attributed to a particular and very rare behavior of the ASK21 when exiting full developed spins with no more - or apparently no more – longitudinal pitch oscillation. This phenomenon seems to be more prone at forward sustained spin CG with relatively low momentum of inertia (light pilots).

4 Safety recommendations

4.1 Recommendations 1 (Operational recommendation)

The Swiss Federal Office of Civil aviation (FOCA) should provide precautionary guidance to all schools in Switzerland that need to routinely train spins for the acquisition of a glider license. We could recommend that during a flight, only one “3 turns” spin is executed at a minimum of 1300m/AGL and that the second spin has only “1 turn” at a minimum of 1000m/AGL. This way the spin cannot fully develop and it is in principle easier to exit it. This would also perfectly achieve our objective to teach trainees to exit a spin as early as possible. In addition, it provides more height and time if anything should go wrong or difficult. Trainees are also learning and their maneuvers cannot be expected to be perfect.

4.2 Recommendations 2 (Occurrence tracking)

EASA should verify with the Type Certificate holder how many occurrence reports of this nature exist as of today and accurately follow up on this issue. Due to the rare nature of this event, it might be interesting to inform all ASK21 owners with a Safety Information Bulletin (SIB) or a manufacturer Service Information Letter (SIL) for the operators to more accurately report such events to the authority.

4.3 Recommendations 3 (AFM)

The Type Certification holder should improve the AFM and provide more information to the pilot to cover such spin exit difficulties. An abnormal spin exit method should be provided.

The question to have new AFM limitations on minimum altitudes for spin entries remains open.

5 Change records

Issue	Date	Changes
1.0	15.11.2009	Initial report
1.1	20.12.2009	English corrections
1.2	25.05.2010	Content clarifications
1.3	08.03.2012	Text readability improvement. No basic content change except §1.7 “additional information”.

- End -