AN ENGINEERS VIEW ON HOW THE SMOLENSK CRASH COULD TAKE PLACE

Glenn Arthur Jørgensen

Abstract

Many independent studies very different in nature point towards the same conclusion: that the wing of the TU-154 that crashed in Smolensk in 2010 was not cut by a birch tree. Black box data and studies clearly suggest that the plane instead was more than 30m and most likely 58 m above the ground of the birch tree officially claimed to have cut the wing and 30m north of this. Nevertheless the wing tip was separated from the rest of the plane at a distance of about 460m prior to the crash site. The evidence point toward the plane losing its wing tip in free air space where no obstacles were present.

A TU-154M plane or similar losing its wing unmotivated in free air space has never earlier been reported to happen on any of the commercial airplanes including all the thousand of built TU-154 planes flying many million miles in all types of rough weather around the globe. This point towards a provoked rather than unmotivated separation.

The work presented here describe some of the required steps and elements to consider when engineering such a crash and aiming to have it look like an accident as much as possible. The work takes a closer look at some of the details of the events, black box data, broken parts and aero dynamical data and presents some thoughts and field data/demonstrations suggesting why and how as seen from an engineer's perspective.

Keywords - Engineers view, Wing Damage, Roll, Smolensk, TU-154.

Streszczenie

Wiele analiz niezależnych od siebie i bardzo różnych co do swej natury prowadzi do tego samego wniosku, że: skrzydło TU -154, który rozbił się w Smoleńsku w 2010 nie zostało odcięte przez drzewo brzozy. *Dane z czarnej skrzynki i analizy wyraźnie wskazują, że samolot był ponad 30 m, a najprawdopodobniej ponad 58 m ponad ziemią w miejscu brzozy, o której oficjalnie twierdził się, że odcięła skrzydło i 30 m na północ od niej. Niemniej jednak końcówka skrzydła została oddzielona od reszty samolotu w odległości około 460 m przed miejscem katastrofy. Przedstawiono dowód na to, w jaki sposób samolot może stracić końcówkę skrzydła w wolnej przestrzeni powietrznej, gdzie nie ma żadnych przeszkód.*

Nigdy wcześniej nie odnotowano, aby samolot TU -154M lub podobny utracił swe skrzydło bez powodu w swobodnej przestrzeni powietrznej na jakimkolwiek z handlowych samolotów włączając wszystkie z tysiąca zbudowanych samolotów TU -154 latających wiele milionów mil we wszystkich typach surowej pogody na całym świecie. Wskazuje to na sprowokowane, a nie bezprzyczynowe oddzielenie skrzydła.

Przedstawiona praca opisuje kilka niezbędnych kroków i elementów, jakie trzeba wziąć pod uwagę, aby spowodować taką katastrofę mając na celu, by w największym możliwie stopniu wyglądała jak wypadek. Praca rzuca bliższe spojrzenie na pewne szczegóły wydarzenia, dane z czarnej skrzynki, rozbite części i dane aerodynamiczne i przedstawia pewne myśli i szereg danych i demonstracji sugerujących dlaczego i jak widocznych z inżynierskiej perspektywy.

Słowa kluczowe *– inzynierskie spojrzenie, uszkodzenie skrzydła, beczka samolotu, Smoleńsk, TU-154.*

1. INTRODUCTION

Many independent studies and observations very different in nature point toward the same conclusion, namely that the crash of the TU-154M plane on the 10th of April 2010 in Smolensk, Russia was not a result of the plane making contact with a birch tree in low height. Professor W. Binienda [1] was one of the first to put forward solid scientific work, showing the birch tree of interest needed be more than four times stronger, than even a very optimistic estimate of the actual trees strength in order to have a chance to cut through the wing as claimed by the Russian and Polish authorities. Aero dynamic studies [2, 3] clearly show, that the plane could not manage to hit the actual crash site from the distance of the birch tree, when making contact in 5 m height above local ground and at the same time demanding a loss of lifting capacity sufficient to explain the recorded roll speed of the plane. Both independent studies solving the equations of motion in very different manner lead to the same conclusion: the plane flew well above the birch tree claimed to cut the wing. The results presented in [2, 4] also show the plane lost wing area in at least two events, first the 5.5 m wing tip, then another about 4.5 m of the center wing section. In [2] it is demonstrated how the observed ground traces of the left wing and tail can only be explained, if the plane was rolled about 120° and lost about 10 m of the left wing. This is double the lost length than officially stated, and the result is very close to the results obtained through the totally independent aero dynamical studies. This is also in good agreement with the logged vertical acceleration sensor data recorded by the planes polish QAR black box. Here two large distinct drops are recorded with a 120m flight distance between the two (see Fig. 1).

Such drop in the vertical acceleration signal explains there were two momentary losses in the wings lifting capacity. The fact that 1.) all ground traces suddenly stop at the same point about 0.3s after the wing made its first ground contact and 2.) the plane is found demolished into between 20.000 to 60.000 parts [5] (see Fig. 2) without the formation of a crater in the relative soft ground points towards an explosion of the fuselage, while the fuselage is above the ground [4]. For comparison Professor K. Nowaczyk [5] has listed, that the terrorist attack, known as the Lockerbie crash, took place at about 10km height with use of explosives on board the plane loaded with fuel. The separated parts of the plane fell to the ground with high

Ms. Sc. Mech. Eng. Glenn Arthur Jørgensen (e-mail: gaj@xtern-udvikling.dk).

vertical speed. The investigation team managed to find 95% of the parts in total about 11.000 pieces. Aero dynamic calculations and black box data show, that the TU-154M plane in Smolensk had a relative low vertical speed (about 22m/s) at the time of impact falling from the stated 20m - 30m height into soft ground, which by no means can justify the plane breaking into the very high number of pieces.

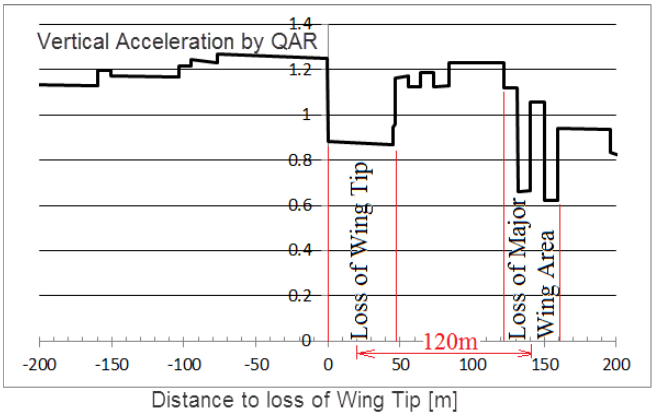

Fig. 1. The vertical acceleration data as logged by the Polish QAR black box. The distance flown by the plane between the loss of the wing tip and the loss of the major wing area is about 120m. Plane "flies" from left to right.

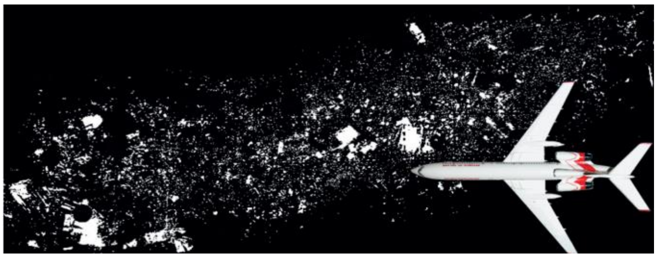

Fig. 2. A map of the debris found at the main crash site prepared for the Polish Archeologist report. The airplane in the bottom right corner shows the plane in the same scale [5].

By the official explanation [6] the passengers and crew on board were exposed to accelerations over 100g as the aircraft was destroyed on impact. No explanation in the official reports are given to how such large accelerations can take place ***without the formation of a crater*** from the 78.600kg plane hitting soft ground resulting in such 100g accelerations. Solid calculations of the plane hitting the ground resulting in the severe body accelerations show that at least a crater of 1m -2m should have been formed [1]. In [7] the damage of the left wing root and soil on the wheel sides is shown to fit with the hypothesis of a main fuselage explosion occurring at the time, where the ground traces suddenly stop. In [1] it is demonstrated, that the fuselage had to be opened prior to hitting the ground, in order to end with the fuselage sides outwards and not underneath as it actually was found [5] (see Fig. 3, Fig. 4, Fig. 5, Fig. 6). The findings of plane rivet in the body of one of the victims [8], the total scattering of neighboring plane parts and the findings of burnt aluminum parts and human body parts deep into the ground [9] of the crash site all support the hypothesis of near ground fuselage explosion(s). In [7] the trajectory found through the aero dynamical work show excellent agreement with the three distinct damaged vegetation zones as in the direction of the wind at the time of crash (see Fig. 7). The calculations agree well with a large number of observations and black box recordings, amongst them: The pilots calling a go-around at about H=100 m above the height of runway 26 as of the black box voice recordings, the zones of damaged vegetation, the final velocity towards the ground, the measured GPS positions, the logic and normal approach, the approach as recorded by the TAWS GPS heights and positions, the finding of wing parts prior to the birch tree and hanging loosely on the birch tree, the calculated vertical acceleration, the recorded FMS height and position, the calculated horizontal trajectory, the final heading of the plane, the position of the TAWS 38 event triggered by a "landed" signal, the erroneous behaviour of the left and right elevator signals following the second wing explosion and finally the wing trajectory and ground traces.

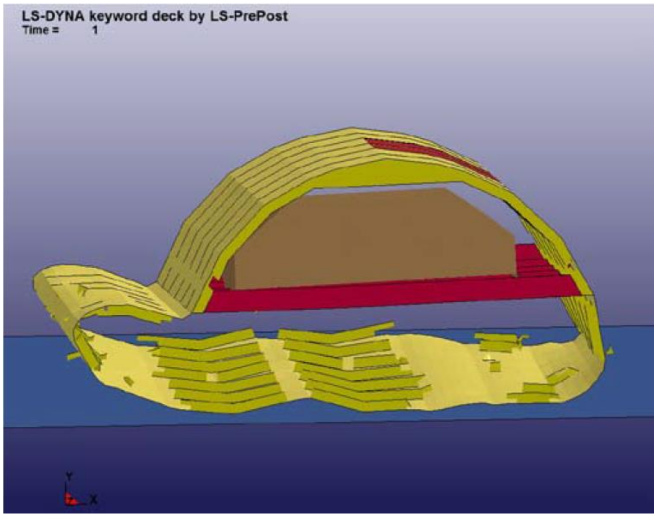

Fig. 3. Simulation of a vertical fall of the fuselage upside down without an explosion [1].

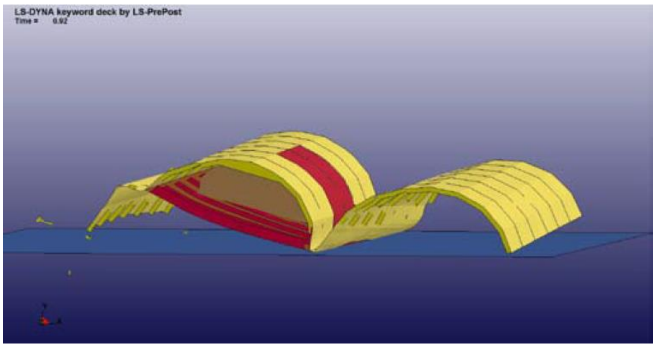

Fig. 4. Simulation of vertical fall of the fuselage upside down after the explosion [1].

Fig. 5. Part of the inverted hull. It is clearly opened (yellow line and arrow) [5].

Fig. 6. The front bottom section below the president's salon. The entire top section is pulverized and the window section was thrown outwards most likely caused by the high internal pressure at the near ground explosion. Note the windows have not been in ground contact [7].

2. DISCUSSION

2.1. Loss of wing area in free airspace

By the official explanations the left wing was damaged, and the wing tip was found on the ground about 300 m before the crash site. The studies listed above based on the black box data suggest the plane flew in free air when it lost lifting capacity, assumedly by loosing left wing area in at least two blows. *The question is then, how can a TU-154M plane loose its wing tip and additional wing area more than 30 m (most likely at H=58 m) above the ground in free airspace?* A TU-154M plane or similar losing its wing unmotivated in free air space has never earlier been reported to happen on any of the commercial airplanes including all the thousands of built TU-154 planes flying many million miles in all types of rough weather around the globe. This points towards a provoked rather than unmotivated separation most likely caused by the use of explosives.

2.2. Impact from a low flying TU-154M

The TU-154M has three Soloviev D-30KU-154 engines with a total thrust power of 309 kN or more than 30 tons of pressure [10]. The engines are located very close to each other at the tail of the plane. By the official data [6] the TU-154M had an inclination of 15° to 20° at the time it was claimed to hit the birch tree in 5 m height above the ground cutting off the left wing tip with the engines at full power in an effort to take off. By the American black box (TAWS) logging of the planes three GPS devices, the planes ground velocity was about 75 m/s at the time of the wing loss [11, 12]. Assuming the exit velocity of the turbine engines to be about 95 % the speed of sound or about 325 m/s and the exit thrust cone angle to be about 20°, the resulting thrust power as felt by ground obstacles will be more than 20 tons. A piece of the old Russian wood fence nearby the birch tree claimed to cut the wing would be in the direct shooting line of the three TU-154M engines as shown in Fig. 8.

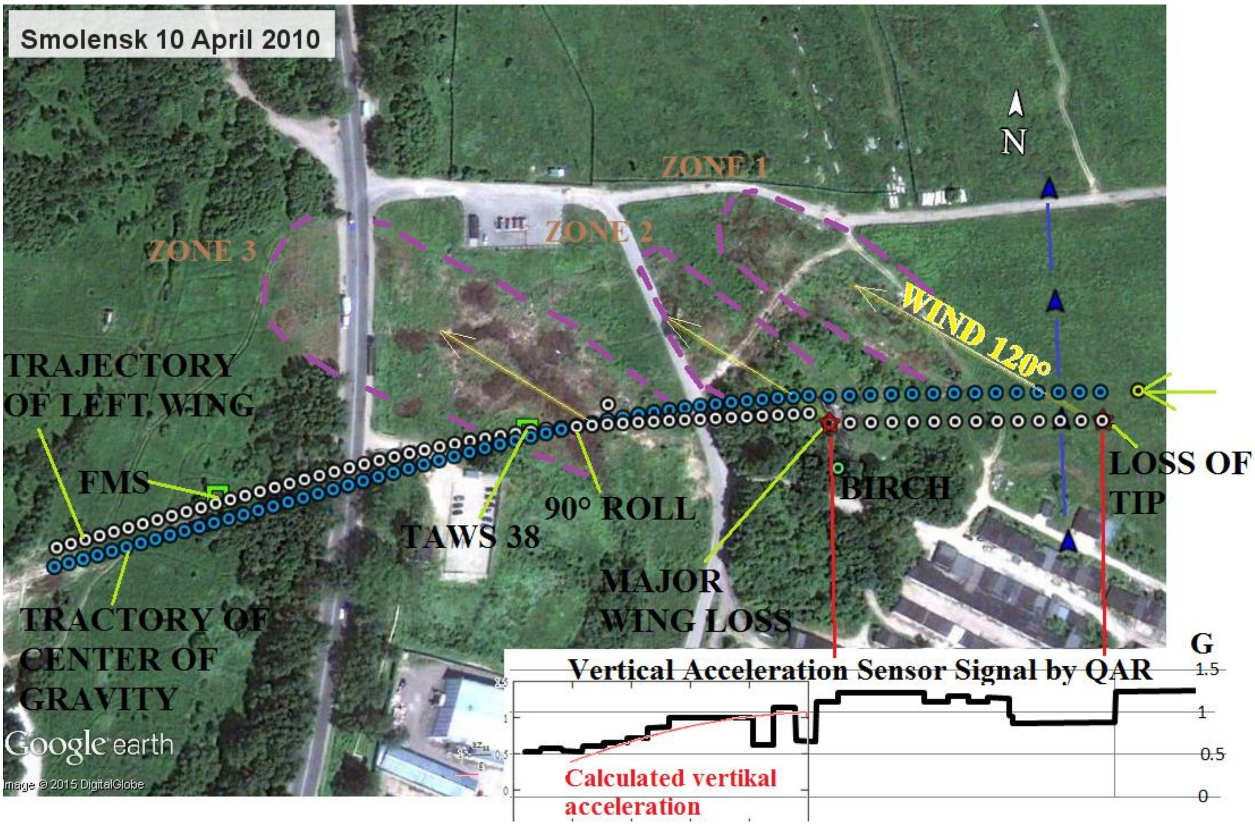

Fig. 7. The calculated trajectory for the center of gravity (blue) and the left wing tip (white). The satellite picture is from the 25th of June 2010 (two months after the crash). Notice the distinct and significant damage of vegetation in the three areas (zone 1, zone 2 and zone 3) circled by the dashed lines. Adding the recorded vertical acceleration signal by the Polish QAR (black line) and the wind direction of 120° show the clear correlation between the three distinct areas of vegetation damage to the approximate positions of 1. the loss of the wing tip, 2. loss of additional wing area and 3. the release of a large amount of fuel when the plane was rotated 90° most likely caused by a third explosion. This third explosion can together with the plane rotation explain why the TAWS38 event (landed) was initiated [7]. In agreement with the location of the damaged vegetation patterns the loss of the wing tip toke place 100m to 120 m earlier than the birch tree. The distance between the patterns corresponds to the flying distance between the two events (loss of wing lift) as recorded by the Polish QAR black box. The final calculated velocity (Vz=23 m/s) towards the ground at the "FMS" point agrees with the recorded value of Vz=22.2 m/s. The scenario can also explain why wing parts are found earlier than the birch tree. The calculated vertical acceleration (red line of bottom fig) shows same characteristic decline as the recorded signal.

Fig. 8. According to the official explanation the plane flew at this height with an inclination of 15° to 20° when the left wing hit the birch tree (the now broken one in the left part of this picture) in 5m height above the ground. Note the fence and shacks will by this story be in the direct line of fire of the planes thrust power.

Fig. 9. This bus was pulled 40m behind one 747 engine blowing with the thrust power of the TU-154M. The 11 ton bus was immediately airborne and thrown another 30m - 40m downstream flipping around. See the YouTube video: https://www.youtube.com/watch?v=mj_bB6cUWCs

Assuming a thrust impact zone length of say 40 m, which is a low estimate, the exposure time can be found as ΔT = 40 m/75 m/s = 0.53 s. Assuming the wood has a density of 800kg/m^3, which seems as a high value for the presumably old wood, it is relative easy to show, that the thrust power hitting such fence would accelerate the wood above 17m/s within even the first 0.1s of impact. With otherwords the fence would be torn apart and scattered over a. large area just as the small shacks and the roof of the shacks on the stated path of the plane flying past the claimed birch tree. The power of turbine engines is illustrated in [13], where first a classic American 11 ton school bus is towed 40 m behind the engine of a 747 plane. One 747 engine has approximately the same thrust power as all three TU-154M engines. The bus immediately becomes airborne (see Fig. 9) and is tossed 30-40 m downstream.

In the second demonstration a mini bus is located 18 m behind one Airbus 319 engine running in idle. The power of one Airbus 319 engine is nearly equal to the power of one of the three TU-154M engines. The Airbus engine is then ramped up, and as the engine speeds up the mini bus gets pushed back and tossed around more than 40 m to 50 m behind the engine. Fig. 10 shows the official state the old russian fence had after the plane was claimed to pass, with its three engines bursting directly towards this according to the official story. It seems on this background impossible, that the fence to the left and right of the laying portion would be standing, nor would the middle section just be tipped over. The author encourages the reader to watch the YouTube video [13] and judge for herself.

Fig. 10. The Russians claim this is what happened to the fence, which in that case has proven to be unbelievable strong.

3. Engineering such crime

3.1. No survivors

When engineering such crime it would first of all be important to reduce the probability of eventual survivors that could tell what actually happened *and be listened to by the world's audience*. This would require an effective way to eliminate the majority of passengers before or during the crash and in addition have a ground team ready for killing eventual survivors. There does not seem to be very many methods for killing 96 people that are distributed evenly throughout the plane, without this causing great suspicion, and the probably only ensured and well proven method would be to use distributed explosives, and detonate these when the plane hits the ground. This will make it difficult for eventual witnesses to distinguish if the explosion was caused by the plane hitting the ground with some remaining fuel onboard or by actual explosives.

3.2. Turn plane upside down

The main structure built to carry the loads of the plane is located below the passenger seats throughout the length of the plane connecting the lifting area (wings) with the cockpit, tail and engines. If the explosives needed to kill the people on board were detonated when the plane would be in its normal upright position (fuselage above the wings), the debris will tend to fly up and out in a huge circle as shown in Fig. 11, because of the main structure acting as a shield directing the pressure wave side wards and upwards. There are several advantages of rolling the plane upside down (fuselage below the wings) prior to the detonation as shown in Fig. 12. Firstly the debris would then be directed into the ground of the crash site, secondly this would probably minimize the chance of survivors and thirdly this could be used to explain to the public why the plane crashed.

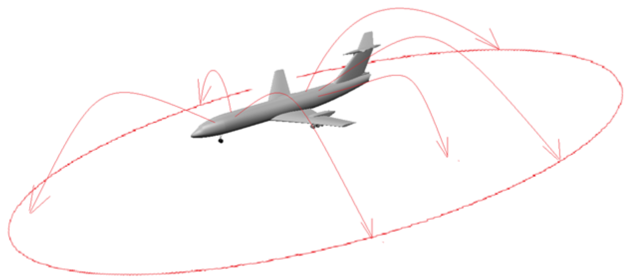

Fig. 11. Fuselage explosions occurring when the plane is in a normal flying position will tend to send parts upwards and outwards due to the main structure of the plane (passenger floor) acting as a shield and directing the pressure wave in this direction.

3.1. Cut off tail just prior to fuselage explosions

It could be an option to cut the tail from the rest of the airplane just prior to the ground crash. The reason for this would be to open the fuselage and allow the pressure wave from the distributed detonations intended to kill people to have an exit through the fuselage and out the back. This will tend to minimize the impact on the scattering of the fuselage. As a consequence all electrical power will shut down and logging of data to the planes black boxes will terminate prior to the final explosions, as the three engines located at the tail drive one of the three independent electric power generators each. Ground personnel should move any parts that accidentally fall of the tail during this operation closer to the crash site as soon as possible after the crash.

3.1. Timing of the explosions

The timing of the explosions can be done in a very simple way. The first wing cut at the desired position determined easily by a person on the ground maybe even assisted by the radar measurement from the airfield. It would be around the position the plane exits the middle marker zone, ideally when the plane has reached its minimum height during the go-around sequence. It would be required that the final activation is human made rather than automatic, just in case the decision maker for some reason chooses to call the event off in the last minute. This would require a radio activated trigger of the first explosion. The next wing explosion occuring a given pre-programed time ΔT=1.6s after the first. The third explosion designed to empty the main part of the fuel in the center tanks occuring again a pre-programed time say ΔT=1.6s after the second wing explosion. The final fuselage explosions cutting first the tail and then very short after creating a pressure wave from front to back killing people on board can be triggered using the same technology as for triggering the activation of airbags in all modern cars based on the detection of an extreme deceleration when the wing or tail makes ground contact. This method would only require human interference for the first button press, and ensure the final explosions take place close to the ground hidding these within the ground impact.

3.2. How to explain the plane roll

When planning such event, the roll of the plane can only be caused by two reasons. Either the pilots deliberately or by mistake through their controls made the plane roll or the plane experienced a mechanical failure such as loosing part of its wing area. Assuming nobody would believe that the pilots would roll the plane upside down by themselves, this leaves only the latter option. The loss of wing area on one side of the plane would result in an asymmetrical lift that could be used to try and give some form of explaination to why the plane rolled and crashed.

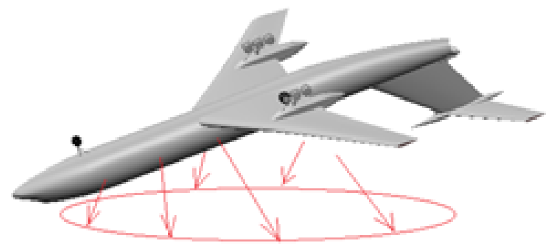

Fig. 12. Fuselage explosions occurring when the plane is in a upside down position will tend to send parts downwards into the ground due to the main structure of the plane (passenger floor) acting as a shield and directing the pressure wave in this direction.

3.1. How to explain the plane lost wing area

The plane could loose wing area due to several reasons. This could be caused by bad maintenance and overlooking a fatigue issue. Knowing the plane had been at the Russian aviation plant and had its wings taken apart only 6 months earlier, this might not be the best explanation for loosing wing area. Another explanation could be terrorists attacking from the ground, but this would not either be a very good explanation on say Russian ground that should be under full Russian control. A third explanation could be that the pilots flew the plane outside the allowed limitations. The TU-154M is well known for its robustness, and it would not seem very likely, that the pilots would expose the plane for the severe g-forces required, certainly not with the plane full of VIP's including the Polish president. Instead the explanation could be that the pilots hit an obstacle and cut off some wing area. The advantage of this being that all blame can be directed towards the pilots, and they will not be able to defend themselves.

3.2. Where to fake the wing cut

The aerodynamics [2, 4, 14] show that the loss of lift on the one side needs to be substantial and corresponding to about 10m of the wing length to ensure the plane will crash. The engineering challenge being, that the wing at this point is about 0.5m thick and 4.5m wide and the obstacles nearby the airfield only consist of medium sized trees and a single metal mast. It would not seem very likely, that a say 30-40cm birch tree (as claimed in [6]) or small metal mast structure would be able to cut through such massive aluminum structure built to carry 100 tons hitting at high speed. The proportions are shown in Fig. 13. The answer to this is therefore to cut the wing further towards the wingtip where it is thinner and less wide, and then removing the required additional wing loss in a separate operation.

Cutting the wing with a sharp cut, can easily be done by the use of explosives using a directional type explosives developed by the military and used for many years (see Fig. 14 ÷ Fig. 17). This would require the wing is taken apart and the explosives planted inside the wing. Here they are not likely to be exposed during the period from implementation and usage as this is inside the fuel tank and not easy to inspect in a normal routine check. The main challenge in cutting the wing being, that the slats located at the front edge of the wing are outward moving parts and any explosives needed to cut these at the desired position would easily be detected. The answer to this challenge is to take advantage of the natural points of division of the slats, where two neighboring slats are pushed towards each other.

Fig. 13. The birch tree claimed to have cut the wing was 30cm - 40cm in diameter. This is illustrated together with the wing of the TU-154M at the point the wing needs to be cut to force a roll of the plane as logged by the black boxes.

Fig. 18 shows the location of these points, and consideration is required to determine which of the four points to choose. The points noted as "A" and "B" are not good choices, as the wing is thick and wide here. The point "D" is not an option either, as the resulting lost wing area would be very minimal and the resulting angle of cut way out of line with the direction of flight. This leaves point "C" as the only point where to fake the cutting obstacle (tree/mast) entered the wing at the leading edge.

Now the question is where the birch tree or mast should exit the wing on the trailing edge of the wing. In order to fake this as perfect as possible, the natural exit point would be just behind the entrance point resulting in a cutting line in the direction of flight. The problem with this approach is that the outer interceptor and outer flaps located at this point are **moving parts, and any explosives mounted to cut these** would easily be spotted. The only possible exit point without a "moving part problem" for such fake cut would be, at the section between the outer interceptor and the aileron. See Fig. 19. The result is that there only exists one possibility for the fake cut as shown in Fig. 20. Note that this faked line of cut makes an unexplainable angle of nearly 20° with the direction of flight and results in an unexplainable non-cut slat edge, but remember there exists

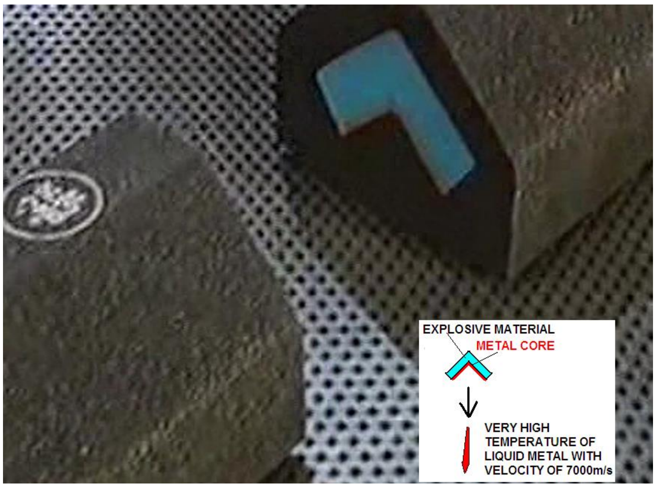

Fig. 14. The directional type explosives will send a liquid metal off with 7000 m/s cutting through almost anything. They can be formed in almost any shape and are found in a large variety of sizes. The metal core is typically copper but can also be aluminum. Traces of the metal will be found on the edges of the cut (exploded) parts.

Fig. 15. The explosive can be formed in almost any shape. Here prepared to cut through a steel pipe [15].

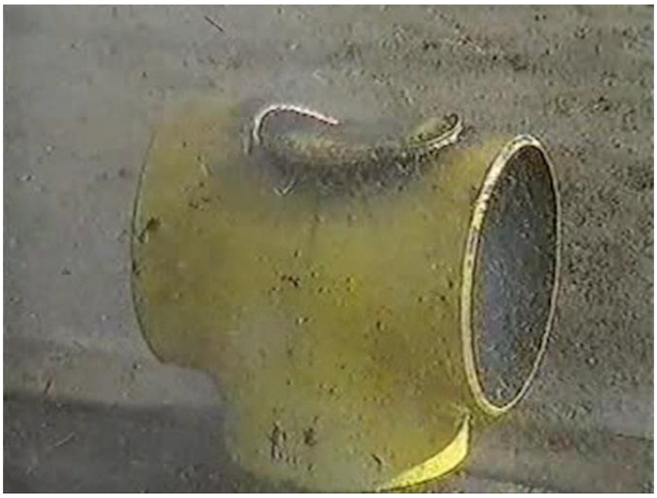

Fig. 16. The circular hole is cut with a sharp edge without throwing the parts around. Traces of the metal core of the directional explosive will deposite on the edges of the cut surfaces, in this case copper. Directional explosives can be found, where the metal core is aluminum matching the material of the wing better. The remainings of the plane will therfore contain valuable investigative information.

Fig. 17. An experiment performed in 1991 by the British Defense Research Agency [15].

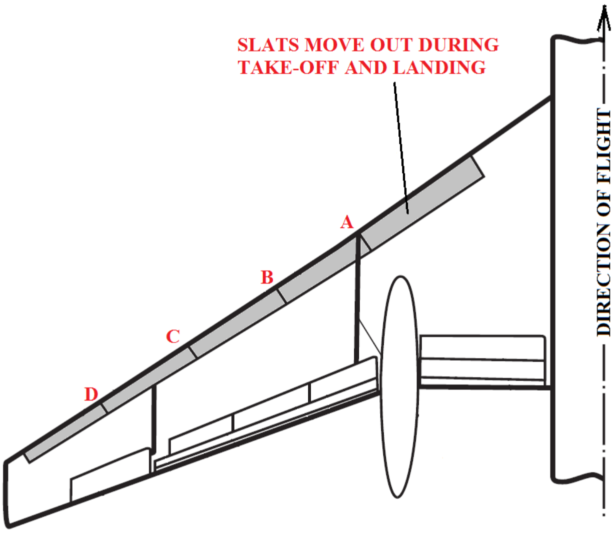

Fig. 18. The slats move out during take-off and landing, and cutting these moving parts with explosives would be complicated and invovle a big risk of detection. At the points A to D a natural division already exists from manufacture [16].

no alternative. This can be compared to the line of cut of the wingtip from Smolensk (see Fig. 21) and the close up picture of the slat edge (see Fig. 22).

3.3. How to remove the additional wing area

From the aerodynamics it is clear, that removal of the wing tip itself will not force the plane to crash, even if the pilots are prevented by low hydraulic pressure to counteract the moderate roll of the plane. An additional wing loss is required in order to force the crash and make it impossible for the pilots to counteract the roll. Such wing loss will make it impossible for the pilots to avoid the crash even in the event they have full hydraulic power [4]. This additional loss of left wing area can be done using ordinary explosives rather than directional explosives. The advantage hereof is, that this is much simpler to implement and the wing damage will better resemble damage caused by

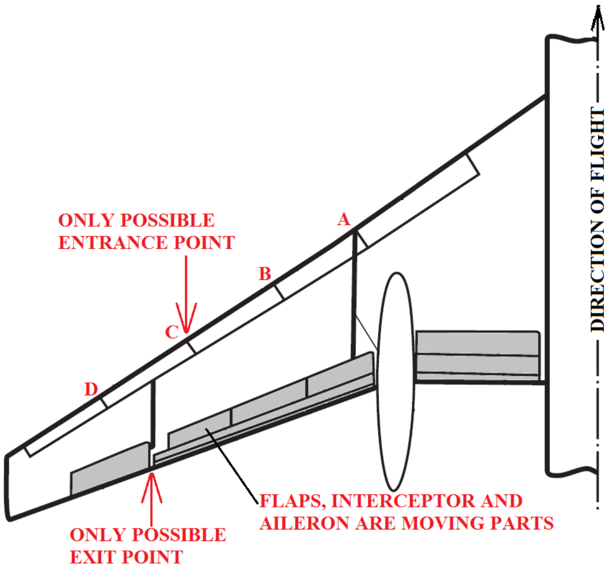

Fig. 19. Point C is the only option available for the fake entrance. On the trailing edge the aileron, flaps and interceptors are moving parts, and cutting through these moving parts with explosives would be complicated and invovle a big risk of detection. The only possible exit point is between the outer interceptor and aileron.

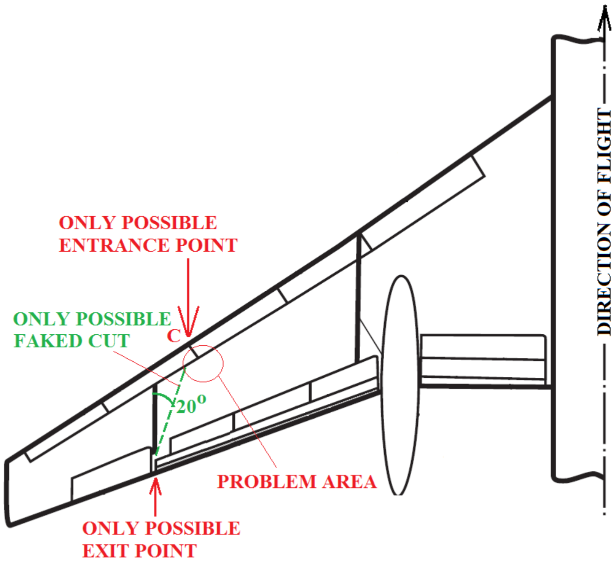

Fig. 20. The green dashed line shows the only possible choice of the faked cut. This line makes an angle of about 20° with the direction of flight. Note also there is expected to be an unavoidable problem area marked with the red circle, where the edge of the slat does not fit with the line of cut.

a fuel tank explosion. This fall back explanation (fuel explosion) can later be useful, when independent investigations prove to the public the birch tree/mast hypothesis is impossible.

3.1. Location of the crash site

The crash site would need to be close to the airfield runway, as the chosen explanation of hitting an obstacle will require a low altitude of the plane, and the plane altitude is only low during take-off and landing. The crash has to occur during the low altitude of landing rather than during take- off, as it will be very difficult to explain how the plane during take-off should get near a mast or tree, just as a low visibility at take-off at the most would prevent the plane from departing. The ideal crash site would be into an area of

Fig. 21. The wing tip from P101 is cut along the line going from the natural division between the slats (point C) to the edge of the aileron. The crash engineer would warn that no good explanation can be given to the public for this issue .

Fig. 22. The slat edge is clearly out of line with the line of cut. This is an unavoidable problem. The crash engineer would warn that no good explanation can be given to the public for this issue .

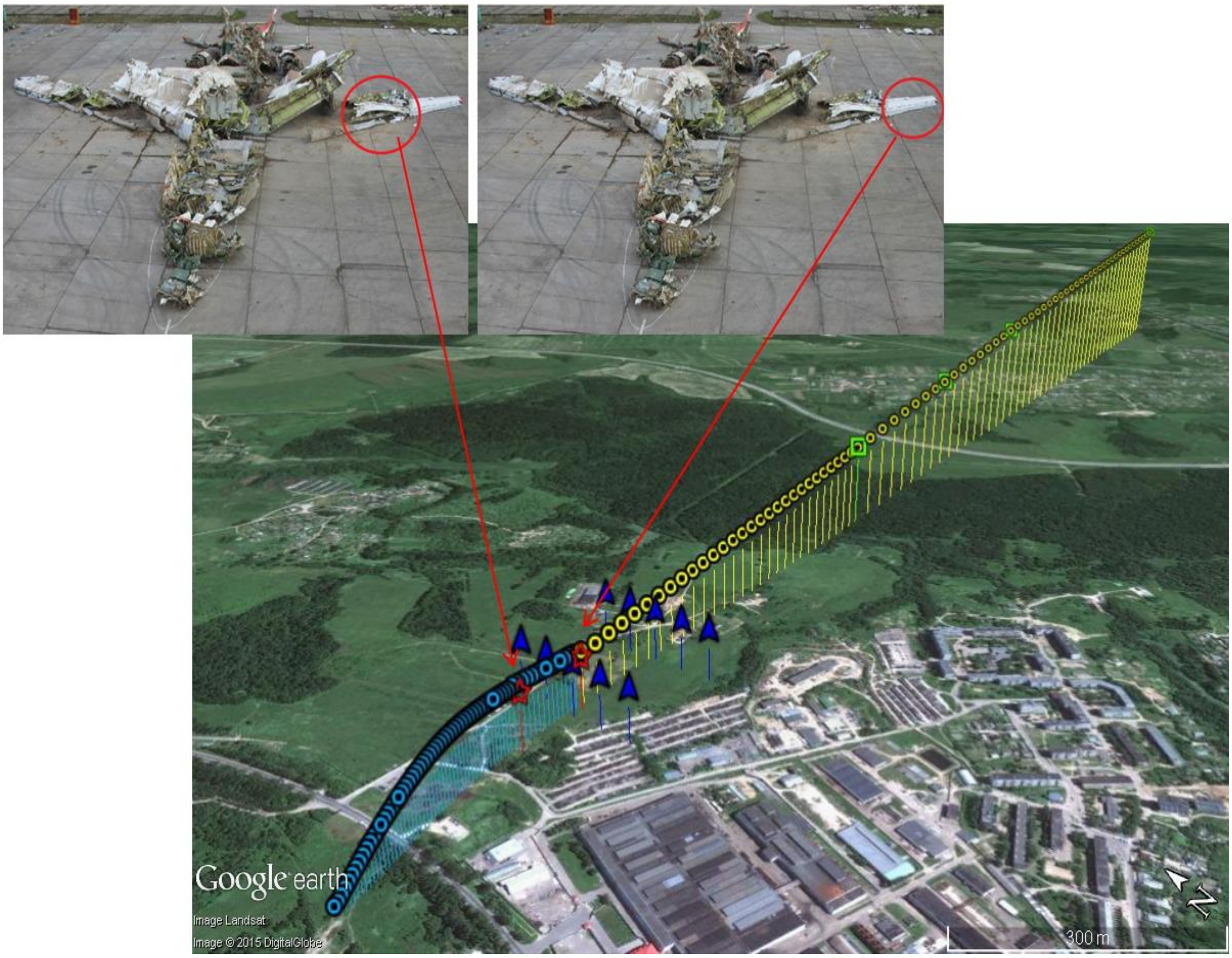

Fig. 23. The plane can be brought to crash at the desired location for the entire range of heights. All the planner has to do is rely on the competent pilots bringing the plane within the upper and lower glide paths, of course aided by the tower tracking the planes height by radar and ground personnel, and keeping the plane "on course" and "on path". Here is shown where the wing tip was lost and where the central wing part was damaged. The green squares are GPS logged positions and heights and the blue triangles show the middle marker entry and exit [7].

sufficient size to allow for the resulting uncertainty of the actual crash location, and at the same time a location, where the crash and final explosions can somewhat be hidden to the public (behind trees and in fog). This is important in order to screen the hit team eliminating eventual survivors. The hit team will need to be ready to pull out from close by, as they will have the minimal time window to do their job, before the crash drags unwanted attention or the official rescue team needs to move out. The hit team should be removed of any possibility to take pictures. They would need some appropriate protection against being hit by the scattering of parts taking into account any unintended errors in the location of the crash. In order to protect the ground personel further, the main portion of the remaining fuel should be dumped during the final seconds of flight in time prior to the ground explosions. These requirements listed above make it inappropriate to have the plane crash short in line with the runway. Even though the plane will make a sideways movement of around 30m to 40m as a result of the severe roll of the plane, this will not be sufficient to satisfy the above mentioned requirements. Therefor the planes glide path needs to be offset from the runway centerline by about another 30m to 70m to the chosen side. The actual direction of landing on the particular day of the event will depend on the direction and strength of wind the particular day. Therefor actions should be taken to ensure a crash site fulfilling the above mentioned requirements is available in all cases. In Smolensk for instance this will require both wings are loaded, as an approach towards runway 26 (RWY26) will require a left roll and thereby a damage of the left wing, whereas an approach towards runway 08 (RWY08) will require a right roll and thereby a damage of the right wing. This is as such not an unforcable obstacle, but besides doubling the work during implementation, it will require that the explosives located in the undamaged wing are detonated as the first part during the final ground crash. It is necessary to detonate the unused wing explosives before the fuselage explosives, as the ignition devices best located in the plane could be damaged by the fuselage explosion, if done in the opposite manner. In such case the undetonated wing explosives could be found at the crash site and the explosives in the right wing would remain undetonated. The biggest problem with this double sided approach being how to explain why the wing fragments show so the large similarity (see Fig. 24) between the left and right wings given they officially experienced very different impacts at crash, as the left wing has made contact with the obstacle and later hits into the ground and the right wing is in free air at all times. No really good answer exists for this "explanation" problem. The detonation of the right wing will make a forth cloud of fuel that will tend to cover the entire area after the crash as it sinks down over the site. Other considerations with respect to the selection of crash site are of logistic nature. It should be avoided to block the operation of the airfield in the following months after the crash, and it should be easy to access the area with the machinery required in the following clean-up process.

3.1. Initial boundary conditions

During the approach the pilots will to a **large extent control the main parameters of** importance such as plane speed and height. Here the goal from the engineering perspective is to have the plane crash at the desired position in all expected initial boundary conditions. Aero dynamical calculations show that all that is required to obtain this, is to rely on the pilots being competent, i.e. the plane is within the lower and upper glide paths with speeds within the allowed range [7] and maybe a slight adjustment of the timing of the loss of wing area according to the height. This timing can require ground personnel located near the middle marker as previously mentioned. In addition the planes height can be monitored by the airfield radar, and necessary corrections can be given to the pilots if this is required making sure the plane is "on path" and "on course" (see Fig. 23). The pilots should be encouraged to bring the plane down to at least the decision height of 100 m above RWY26 in order to minimize the risk of the plane crashing at an unwanted position, and the triggering of the wing loss should wait until it is sure the pilots have aborted the approach and initiated the "go-around".

Fig. 24. The left and right wings show great similarity. Both are divided into: wing tip, center section in small pieces and the wing root. According to the official explanation the right wing was in free air all the time, and the left wing supposedly hit first a birch tree and later ploughed into the ground. The expected wing destruction should therefore be very different for the two sides left and right.

3.1. Plane preparations

The most elaborate preparation of the plane would be to

a) Prepare the wings with the directional type explosives for cutting the wing tip and the center explosive for removing the additional wing area. This will require the wings to be taken apart.
b) Prepare the plane with the wiring required for detonating the distributed explosives. This should be done in a manner to allow a later easy plug-in of explosives in the fuselage just prior to the selected day of execution. This because it would be very risky to have the fuselage explosives in place during the 6 months from installation to execution, as the plane might be used to fly with the president of a foreign country, who's security service is doing their job.

Both jobs will require the plane being prepared at an aviation plant under the planners control without the overview of any eventual guards of the plane. Here it would help to minimize the number of trusted guards taking care of the plane, which requires control of the security planning. The explosives in the wing should be passivated in the time between the service at the aviation plant and the day of execution, and only activated just prior to the planned event. Activation could be done the night before the flight, together with the implementation and plug-in of the distributed explosives intended to kill the majority of the passengers. This would require the three to four hours undisturbed access to the plane, and the logging of who is accessing the plane taken out of service. The required sequrity check that normally should take place prior to a VIP flight needs to be taken under control, avoiding the use of any explosive detection dogs.

3.2. Other considerations

It will be essential to control and manipulated the voice recordings adding the navigator reading of heights and silencing the communication between the crew the final 9 s. As the main explanation is built around a story of incompetent pilots it is crucial to remove any communication showing the pilots initiated the go-around. If the pilots manage to change the flaps setting from the landing configuration of 36° to the go-around configuration of 28° the flaps spindle should be manually rewinded after the crash to avoid any question of the pilot's actual intention to do go-around. The rewind will require the flaps spindle mechanism is undamaged.

The first minutes needed for the hit team to operate can be accomplished by leading the official airport emergency team in the wrong direction. After the hit team has done their work eliminating eventual survivors, the next team in place should be the clean-up team. They can work in parallel with the fire fighters/emergency team. Of obvious reasons there will be no need for a real rescue team with medical background, so any such services jumping to perform rescue should immediately be directed back to their bases. The responsibility of the clean-up team will be to locate eventual hardware that might reveal the use of explosives and/or the manipulation of the altimeter signals going to the TAWS black box. They should be prepared and have the appropriate blue prints of the plane. Later the third cover-up team can remove edges and fuselage windows etc. containing information of the nature of the destruction.

Road block units should be available along the main road passing the airport to both sides of the airport, in the event the plane unintended crashes too short.

3.3. Medical examinations

It would be important to prevent the normal medical examinations recommended by the Chicago Convention such as X-ray or MR scanning, examination of lunge tissue, eardrums etc. that could give evidence of the main explosions. According to the laws of Poland, it is obligatory to have a statement of the cause of death before burying a dead person. This would be one reason to have Poland to withdraw from the investigation team, even though such agreement to step back could give serious reason to charge the Polish party (Prime minister later European President Donald Tusk) making such agreement of neglecting the interests of Poland. This can by Polish law be punished with up to 10 years prison. Another big challenge would be to avoid the relatives to take matters into their own hands once the bodies are sent back to Poland. This is a challenge the parties cooperating in Poland must deal with, best done by forbidding anyone to open the coffins of their loved ones and taking advantage of people being in a state of shock. One reason to avoid dragging out the return of the bodies is that they as time goes will tend to pull out of the state of shock. Later it should be made very difficult to do exhumations dragging the permission of these to the point where the probability of the soft body tissue revealing information is negligible.

3.4. Generation of local fog.

The operation and alibi of blaming the pilots for the crash are to some extent depending on the ability to cover the airfield with a local fog. The lack of visibility is the keystone in the story of how the pilots could bring the plane close to the ground in a location, where an obstacle of some size can be found. Despite the fog it will in all cases be very difficulte to come up with an explaination to why the pilots will want to decent 1-2km short of the runway given they know exactly where above ground the plane is and have this confirmed by the three independant GPS units on board. It is known, that the Russians have the capability for covering large areas with fog in order to make it impossible for enemy planes to laser aim their desired target [17]. A NATO pilot has basically only two allowed methods when striking his target. The most precise being a GPS controlled air to ground missile. This requires that the missile can receive the required amount of GPS satellite signals for the precise navigation after being fired from the plane. Jamming the GPS net is very easy though. This can be done in many kilometers distance with commonly available equipment purchased for less than 50USD and driven by a small 12V supply. Even worse the GPS signals can be spoofed, i.e. the missile can be guided to hit a different location, than the pilot had planned. If the GPS method will not work, the pilot must have visual sight of his target, or he is not allowed to shoot. Therefore the capability to cover a large area with fog can be a very simple and low cost protection against enemy attacks acting under a moral codex (not shooting in the blind). The Russians have demonstrated the ability to produce large amounts of fog, using a fog generator based on a turbine jet engine (TMC65) (see Fig. 25 and Fig. 26).

Fig. 25. An earlier serial produced version of the Russian truck based TMC65 fog generator.

Fig. 26. The newer Russian TMC fog generator in action. For video see [18].

Water mixed with fog enhancers like Nebol [19] is injected into the hot air stream of the turbine engine, bringing the relative humidity of the warm airstream close to 100%. Once the airstream leaves the turbine, the air starts rapidly to cool, and big amounts of fog is generated. The optional fog enhancer consists of a special blend of long chained alcohols and helps making a uniform droplet distribution that will stay stabile in the atmosphere for a longer period [19]. The technology was developed by the Germans just around the second world war, and besides for military use this technology is now commonly used in the agriculture fields for frost protection and disease control. In YouTube video [20] a small Russian land based truck mounted fog generator shows it has an overwhelming capacity. The demonstrated fog generator TMC 65 seems built based on a jet turbine with an estimated maximum 1000 kg force. If the same technology is mounted on an IL-76 plane the four Aviadvigatel PS-90 turbine engines with a total of 58.000 kg force would be able to produce about 58 times the amount of fog pr. time unit compared to the truck based version. This would be sufficient to cover the airfield or a medium sized city within minutes. The IL-76 would be ideal for this purpose, as it has a 42 ton payload capacity, i.e. it can load the amount of water necessary for the fog generation. During moderate winds the fog can be started in the night and maintained inside the already created fog when needed. The pilot flying the IL-76 should be a pilot with local knowledge as the final test flight and tree cutting will be within the fog at low altitude. This final flight should be performed shortly before the target plane arrives. Alternatively the fog can be generated by some ground based TMC65 units depending on the strength of the wind.

4. Facts of the Smolensk Crash

4.1. Survivors

Within an hour after the crash a video [20] was uploaded to YouTube appeerently taken by a random russian passerby walking in the area using his smartphone camera. The video itself is unlikely to have been frauded within the short timeframe, as the position of the individual parts of the plane was unknown to the public so soon after the crash. The sound track was later officially investigated by an institue in Krakow and found to be true and unmanipulated. Judging by the location of the major parts of the plane, the passerby approached the scenery from the southside within minutes after the crash. In the background moving objects - apperantly ground personell - approach rapidly from the left, i.e. from the airport side. Russian and perhaps also Polish voices are heard. Then four distinct shots sound followed by a clear laughter from one or more of the Russian voices. The analysis of the shot sounds reveal they are made by use of a light hand weapon. Unfortunatly the quality of the sound record does not allow to reveal which type of light hand weapon is used. The Russians then leave the scenery rapidly to the same side they arrived. The recordings end. Later the fire fighting team arrives. The small fires seen in this video do not resemble the fire one should expect from 8-9 tons of fuel, and this confirms the hypothesis of the third zone of damaged vegetation being caused by a large fuel spill (see Fig. 7).

The resque team approaching from Smolensk 15 minutes after the crash was directed back to their bases with the message, that their service was not required. This despite the fact that bodies were still laying face down more than 45 minutes after the crash. At the time the resque team was re-directed back to their bases, it seems very unlikey that all victems were located and examined, i.e. there did not exist the basis for such dramatic decision given the russian decision making authourities were motivated to enhance the likelyhood of surviviors.

4.2. The plane break-up

By the official Russian investigation the plane was rotated with a left roll of about 150° at the time of ground impact [6]. The passengers and crew located in the presidential salon and the tail section were amongst the most damaged. Analysis of the tail section [7] together with the ground trace analysis [2] indicate the tail was separated from the fuselage just prior to ground contact. Such separation could only be done by the use of explosives at the tail region, and this can explain why the passengers and crew in this region were so badly damaged and body parts were found scattered over a large area and deep into the ground.

The black box data clearly show two distinct drops in the vertical acceleration sensor signal (see Fig. 1) with a distance of flight of about 120 m. A drop in the vertical acceleration is associated with a loss of lifting power of the wing. Following the second loss of wing area, the left rudder actuator shows an sudden and short erratic behavior for a short time not following the path of the right rudder actuator nor the commanded actuator signal. This can indicate, that parts from the left wing lost at this point colloid with the left tail section. When separating from the rest of the wing the wing fragments will tend to move upwards as a result of the aerodynamic force and explosive pressure forces acting on these. The tail of the TU-154M is a traditional "T" type, i.e. the horizontal section of the tail is located higher than the main wing section and thereby in the path of parts leaving the main wing. The left rudder actuator signal again makes erratic behaviour about 120m prior to the crash site. By satelitte photos taken the 11th of April and 12th of April it is demonstrated, that the left horizontal tail wing hit the ground between this position and the crash site, but *was moved by the Russians on the night between the 11th and 12th April to the crash site position*, the latter position claimed to be the official position of this part.

Parts of the left wing are found at locations *only possible if they were separated from the plane earlier than the birch tree, i.e. incompatible with the official explanation.*

The line of cut of the wing tip is located at the only possible position for a pre-loading with explosives as described in chapter 3.7 and forms the predicted 20° angle and location with the direction of flight. No official explanation exsists for this large 20° discrepancy.

In the left inner flap is found to be in a position of 28° whereas the right flap is in a position of 36° [21]. Assuming it very unlikely that such difference exists during normal flight, this points towards a manipulation of the flaps after the flight ended. The self-locking spindle system excludes this happening during the crash itself. This could point towards the change occuring after the crash. The damage of the left spindle that was present after the crash makes it unlikely that this side could be manipulated. The conclusion of this that the flaps most likely were in a position of 28° prior to the wing loss, and therefore configured by the pilots for the go-around (flaps setting 28° for go-around) rather than for a landing (flaps setting is 36° for landing). Fig. 27 show the plane as it makes the first ground contact. The edge of the shortened left wing is expected to be bent backwards, and this can be observed in Fig. 28. Also the signs of ground contact and the parts with no sign of ground contact shown in Fig. 28 agree with the hypothesis of a wing loss of about 10 m wing.

4.1. The approach

The flight engineer of the YAK-40 plane Remigiusz Mus, that landed about an hour prior to the arrival of the TU-154M stated under oath within a few hours after the crash, that he had been listening in on the radio communication between the tower and the pilots of the TU-154M during the approach. The YAK-40 plane was parked near the tower and he was for planning reasons interested in the actual time of arrival of the president. He was able to speak and understand russian, and was the first polish witness who arrived to the crash site. According his statement:

1. Tower gave the pilots permission to decend below the 100 m allowance earlier transmitted.
2. The first Russian team of personell had laptops with blueprints of the plane, and seemed focused on locating hardware rather than locating eventual survivors.

Unfortunatley this flight engineer was found hung outside Warszawa on Oct. 28th 2012 shortly before a new round of hearings by the Polish authorities were to begin [22]. The official reason of death by the Polish authorities was suicide, despite his collegues and family claim he showed no sign of depression or tiredness of life.

By the QAR black box data the pilots could nearly compensate for the loss of the wing tip counteracting the roll of the plane to about 20° at the time of the second loss of lifting power. This correlates very well with the theoretical calculations assuming the pilots could manage to utilize the aileron and outer interceptor of the right wing after a human and mechanical latency of 0.3 s [7].

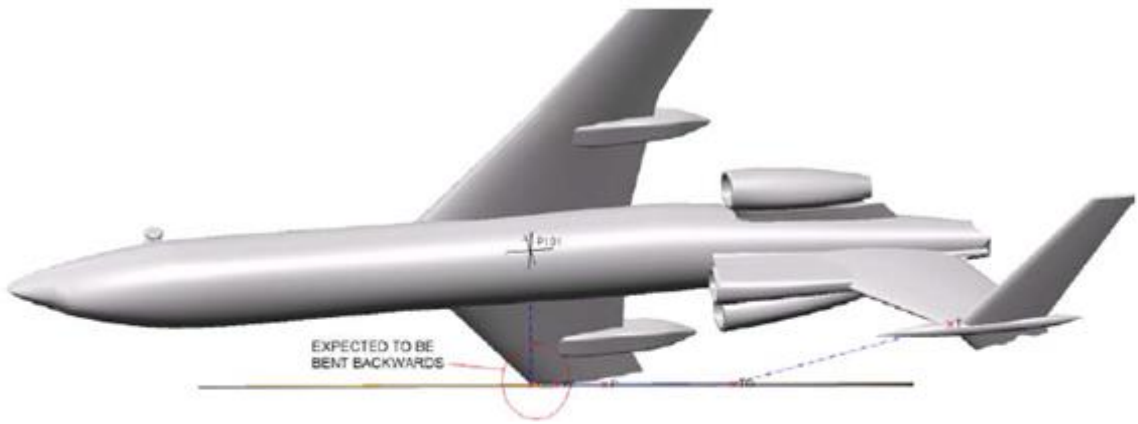

Fig. 27. The corner of the shortened left wing is expected to be bent backwards when making ground contact.

Fig. 28. The edge of the left wing root is bent backwards and shows clear sign of ground contact, so does the inner part of the slat, where the nabourgh part of the slat shows no sign of ground contact. The bottom part of the middle section of the wing shows sign of ground contact, where the top part broken in fine sharp edged debris characteristic by explosion like described in Fig. 27. These observations agree with the hypothesis of wing loss by two explosions put forward in [2] and [7].

The theoretical calculations of the final trajectory of the flight working backwards from the site of crash shows the plane was at least 30 m and more likely 58 m above the runway 26 and 30 m north of the birch tree claimed to cut the wing. This correlates well with GPS positions and heights logged by the planes black box system [7].

The radio communication shows clear signs of being manipulated [23].

1. Sudden abrubt frequency shifts are observated in the the background noise at places that seem cut,
2. The power spectrum shows clear cuts,
3. The signal amplitude of the two pilot microphones and the cockpit microphone all three experience a tremendous reduction between the few minutes from communicating with the Minsk ground control and the communication at Smolensk allowing for manipulation of the navigators voice reading the heights of the plane.
4. The communication pattern and cockpit workflow as claimed by the Russian authorities does not resemble the normal communication and workflow.
5. There is total silence the final 8-9 seconds of flight until the screams of the crew are heard, assumably just prior to the crash.

The black box recordings from the YAK-40 plane containing the radio communications could reveal important information; but so fare the Polish authorities have without any reason denied to make these available to the public.

Signs of vegetation damage are observed in three distinct areas located 120 m apart at positions where fuel spillage from the left wing are expected to occur with a wind direction of about 120° (see Fig. 7). The two first locations are in good agreement with the hypothesis of two wing explosions, the first cutting the wing tip and the second 120m further downstream removing the central part of the wing. The third zone much larger and intense than the two first zones described above and starting another 100m closer to the crash site around the position of the TAWS 38 event as measured by the planes GPS units correlate with the sudden and momentanious release of a significant amount of fuel. This pointing towards a third explosion at this point. This third explosion most likely explaining the triggering of the "landed" sensor system of the TU-154M due to the mechanical distrubance of the explosion together at a time, where the sensor system is sensitive to such as a result of the plane rotation of 90° or more.

4.1. Service of the airplane prior to the flight

The plane had its final overhaul at the Samara Aviakor Aviation Plant in Russia about 6 months prior to the flight on the 21.12.2009 [7]. Among other work the left and right wings were dismantled, serviced and then reinstalled. The Polish security service and authorities had choosen not to provide sufficient Polish security personell to allow a 24-7 survelliance of the plane during this Russian overhaul.

The Samara Aviakor Aviation Plant is part of a larger cooperation owned by Oleg Deripaska known as one of the 20 richest persons in Russia and a good friend of Vladimir Putin.

Prior to the flight on the 10th of April, the presidents plane was parked within the restricted and secured area, and any access to this area should normally be logged. This logging system was out of order on the 9th and 10th of April [24, 25, 26] officially due to some planned server maintenance. This was planned *by the security service* and initiated for the 9th and 10th of April despite the well known plans for the VIP flight on the 10th, and without the implementation of an alternative logging system (manual nor automatic). The plane was officially serviced by a team of technicans during 01:30 hour and 04:00 hour on the morning of the 10th of April 2010 before the presidents flight. The plane that was intended to fly the commanding polish military generals from Warszaw to Smolensk experienced a sudden and unexpected failure on the morning of the 10th. As the generals had the order by the minister of defense Bogdan Klich to follow him to Katyn, this failure forced the commanding generals into the same plane as the president and his group, after which Bogdan Klich stood back from the journey himself. The TU-154M had shortly in advance been prepared with 10 additional seats. It is at this moment unknown where the additional seats that seem to have been prepared for this occasion came from, and who initiated this expansion.

4.2. Examination of the victims

The Polish team of doctors heading for Smolensk just following the crash was called back by the Polish authorities even though Poland had the full right to participate in the investigations. Later the present now former Prime Minister Donald Tusk made a verbal agreement with Vladimir Putin allowing the Russians to take the full control of the investigations with Putin as top leader of the investigations.

The victims were not X-rayed. Lung tissue neither ear drums were investigated in order to reveal any use of explosives.

The coffins came back to Poland sealed with the prohibition against opening them. The medical reports came from Russia up to two years later, and several numbers of the victims families asked the Polish authorities for permission to make exhumations, as the reports could be documented to contravene knowledge concerning their beloved ones. The Polish authorities were very reluctant to granting these permissions, and only six families were after years process allowed. In all six cases the exhumations showed the person in the coffin was not the person stated by the Russians. During one exhumation an aluminum rivet fell to the floor from the remains of the body. In one other coffin tree branches and cigarette buds were loaded together with a headless body of an unknown person [27].

4.1. Other facts

The fog was local with its center at the end of RWY26. An IL-76 was observed approaching the RWY26 two times. The first time the plane came very close to the ground, and the YAK-40 crew witnessing this state they were afraid the wing of the IL-76 would hit ground during the right turn over the RWY 26 when departing the final time.

The pilot of the IL-76 was Oleg Frolov from a branch of the 708th Military Transport Aviation Regiment. Oleg Frolov was a former pilot based in Smolensk assumedly with good knowledge of the local area around the Smolensk airfield.

A pilot from an unknown plane communicated to the Smolensk tower just minutes before the arrival of the president's plane at UTC 06:27:58,8 "Finished drop". "Down to the East", which was recorded by the TU-154M black boxes.

In command of the operation called "Logika" leading the presidential approach from Moscow was General Vladimir Benedictov another friend of Putin. His orders were effectuated through a third person *illegally present* in the control tower Nikolaj Krasnokutski. Krasnokutski played a very active roll including communicating directly with the pilots even though he had no license or permission to do such. From the transcriptions of the telephone conversations to and from the tower it is revealed that Nikolaj Sypko from Tvere Airbase also played a role in the communication between center "Logika" and Krasnokutski [28] General Benedictov, Krasnokutski, Sypko and Frolov are stated to have a history together with roles at different levels using the Military Transport Aviation Fleet of IL-76 planes to smuggle alcohol, drugs and weapons.

Legally present in the control tower was tower leader Pawel Plusnin and approach controller Viktor Ryzenko. From the analysis done by Sehn Institute in Kracow of the tower communications with the pilots of the approaching TU-154M a fourth voice was also identified belonging to major Lubancev [28].

A member of the Polish parliament Sejm who arrived one day earlier by train witnessed that units of armed Specnaz (Russian special troops) were located along the road Kutusova with about 200m intervals something that was not the case when President Vladimir Putin arrived for his visit three days earlier [29].

5. Concluding remarks

It is clear that such operation would require assistance from key people within the Polish Security Service and within the Polish political sphere. The first political task to accomplish would be to prepare for taking control of the political institutions, here first of all the presidency and preparing for controlling mainstream media. Then politicians need to ensure the targeted victims and mainly these are on board the targeted plane. It would be mandatory that the commanding military generals are brought on board as well, as they eleswise would be a serious threat to the following process of cover up and prevent the participating Polish parties taking the full control of the country in the critical time following the operation. The security service would have the task of ensuring the plane is serviced at the right time and location and with the limited number of Polish security during the critical operations at the aviation plant. They also needed to ensure access to the plane just prior to the date of execution. After the assassination, the political climate must be controlled, such it would be political incorrect to discuss the matter in an academic manner, limiting the access to main stream media for key experts. Later a strategy of tiring the public with the matter can be beneficial.

References

[1] Wiesław K. Binienda „*Analiza Dynamiczna Zniszczenia Struktury Samolotu TU-154M W Smolensku 10 Kwietnia 2010*", Materiały Konferencyjne, Konferencja Smolenska I, 2012

[2] Glenn A. Jørgensen „*Reconstruction of Trajectories of Tu-154M in Smolensk During Last Seconds of Flight"*, Materiały Konferencyjne, Konferencja Smolenska II, 21-22.10.2013, ISBN 978-83-936018-1-3

[3] Grzegorz Kowaleczko „*Rekonstrukcja Ostatniej Fazy Lotu Samolotu TU-154M.*", 31-dec-2013. (Published 04.01.2014).

[4] Glenn A. Jørgensen „*CFD Assesment of Aerodynamic Degradation of the TU-154M Plane",* Materiały Konferencyjne, Konferencja Smolenska, 20.10.2014.

[5] Kaximierz Nowaczyk „*Vladimir Putin's Russian Government Inquiry Into the Crash of the Polish Air Force One In Smolensk, Russia, April 10, 2010*", 2014, ISBN 978-83-933564-7-8

[6] „*Final Report Eng. Ver. Jan. 10th 2011*", Interstate Aviation Committee, Air Accident Investigation Commission.

[7] Glenn A. Jørgensen „*The Last Seconds of Flight of the Tu-154M in Smolensk 10th of April 2010",* Materiały Konferencyjne, Konferencja Smolenska, 20.10.2014.

[8] http://niezalezna.pl/34158-npw-w-ciele-ofiary-katastrofy-byly-nity

[9] http://www.naszdziennik.pl/polska-kraj/68279,smolenski-raport-archeologow.html

[10] http://en.wikipedia.org/wiki/Tupolev_Tu-154

[11] „*Taws Data Extraction for NTSB Identification: ENG10SA025, Original*", Universal Avionics Systems Corporation June 28, 2010.

[12] „*FMS Data Extraction for NTSB Identification: ENG10SA025, Original*", Universal Avionics Systems Corporation June 25, 2010.

[13] https://www.youtube.com/watch?v=mj_bB6cUWCs

[14] Glenn A. Jørgensen „*CFD results for TU-154M in landing configuration for an asymmetrical loss in wing length". Rev H.* 06.02.2014.

[15] Orica Denmark, 2014.

[16] В. П. Бехтир, В. М. Ржевский, В. Г. Ципенко „*ПРАКТИЧЕСКАЯ АЭРОДИНАМИКА САМОЛЕТА, Ту-154М*",.

[17] Glenn A. Jørgensen, Private interview with Danish F16 Pilot, 2014.

[18] https://www.youtube.com/watch?v=LQF8hsitxvY

[19] http://www.igeba.de/en/products/carrier/nebol.html

[20] https://www.youtube.com/watch?v=4rn4YXinczw

[21] „*Materiały Konferencyjne, Konferencja Smolenska 22.10.2012*", Warszawa, 2013

[22] http://smolenskcrash.eu/news-48-key-witness-found-hanged.html

[23] Anna Gruszczynska-Ziokowska, publ. in „*Materiały Konferencyjne. III Konferencja Smolenska, 20.10.2014*".

[24] http://niezalezna.pl/35867-tajemnicza-awaria-na-okeciu-przed-wylotem-tu-154

[25] http://www.naszdziennik.pl/polska-kraj/17836,rejs-z-wylaczona-kontrola.html

[26] http://www.se.pl/wiadomosci/polska/kolejna-tajemnica-wokol-smolenska-co-nie-dzialalo-na-okeciu-przed-wylotem-tupolewa_295982.html

[27] Documentary film "*Give us back Anna Walentynowicz*" 2014 Solidarni 2010.

[28] "*Zbrodnia Smolenska-antomia zamachu*"

[29] Antoni Macierewicz, eyewitness. Came to Smolensk on the 9th by train.