1. MAK – Interstate Aviation Committee
   KBWL LP - Polish Air Incident Investigation Committee

2. Parts of Presentation
   First impressions
   Results of analysis:
      Horizontal trajectory
      The likelihood of a roll to the left
      TAWS #38
   Hypothetical two explosion draft report

3. Are MAK and KBWL reports trustworthy? There are sufficient grounds for asking this question. Since the very first moments after the incident, the media were full of contradictory accounts, as is often the case in similar circumstances. However, in this particular case some of the information reaching us from the crash site was particularly disturbing. The following pictures can serve as an example.
   Does this look like a properly secured air crash investigation site? Especially considering the fact that the crash involved a number of highest-level officials of the Polish government?
   Serious questions as to the professionalism of the official investigation undertaken by the Russian air transportation authority chaired by T. Anodina.

4. This short video illustrates such professionalism. Neither report contains any analyses of the wreckage.

5. Shortly after the crash, some media published satellite pictures of the incident site, taken by the GeoEye satellite. (Unfortunately none of these pictures were taken on the day of April 10, 2010.) Those pictures show, for example, that the ground position of the plane's left horizontal stabilizer changes between April 11 and April 12. It has been moved about 20 meters closer to the main part of the wreckage. This raises a natural question:
   Where exactly has this part been on the day of April 10?

6. Not only does the report not answer the question, but it raises new ones. It includes the ground position of the left stabilizer as seen on April 12 as the original position in which the part has been found.
7. The final seconds of the flight are obviously critical and call for especially careful analysis. In an Annex to the report, we read that the "Committees investigating air incidents involving fatalities place great care in including all relevant information from all possible sources". Therefore it is highly surprising that Jerzy Miller's committee, in its reconstruction of the final seconds of the flight, has uncritically used pictures made on site by a Russian amateur photographer Sergey Amielin as the main source of its analysis, without even knowing the precise parameters of the camera they were made with or the position of the photographer.

8. Flight Data Recorders:
   Black Box MŁP-14-5 (Russia)
   ATM-QAR Quick Access Recorder (Poland)
   Flight Management System (FMS) (USA)
   Terrain Awareness and Warning System (TAWS)

9. On this slide is presented an example of important differences between data in the Russian and the Polish report. The angle-of-attack values are taken from a Russian and a Polish recorder, respectively. Both devices are merely data recorders and not measurement devices. Those differences (here, over 100%) are not explained.

10. Conclusion:
    The final reports of both MAK and Polish Air Incident Investigation Committee do not include any information as to the methodology of the analysis or provide any data which would make the analysis replicable.
    Data recovered from some of the aircraft's recording devices have been subject to arbitrary alterations and some of the data (FMS and TAWS logs) have not been included in the analysis.

11. Due to these factors we have used TAWS and FMS logs as basis for our analysis. Data from the aircraft's Flight Management System (FMS) and Terrain Awareness and Warning System (TAWS) have been recovered by a team of experts working for the instruments' manufacturer – Universal Avionics Systems Corporation based in Tucson, Arizona.
    The decoded logs from these devices have been made publicly available by the Polish Air Incident Investigation Committee as late as September 5, 2011. The MAK report only mentions these logs time, without releasing their contents.
    Data Extraction Statement:
    The amount of raw binary data that was captured electronically is very large. UASC software engineering can convert additional parameters to human-readable format if they are needed for the investigation

12. MAK added 3 seconds to real UTC time recorded in log files, the Polish investigating committee has added 6 seconds to most of the FMS and TAWS log times, both without releasing any further details. Naturally, a synchronization process should be uniform across all shifted time points. However, the Polish investigating committee has added 5.5 (instead of 6) seconds to TAWS log no. 35.

13. This reconstructed vertical trajectory can be used to show that the aircraft could not have made a complete roll to the left after impacting the birch tree, because a complete roll would have to result in the change of its heading prior to TAWS log #38

14. Track Rate Computed rate of change of true track, in degrees/sec.
    Track rate is used to determine if the aircraft is turning. TAWS Alert Log #38 confirms that the aircraft did not change magnetic course 140 meters past the birch tree.

15. Conclusion
    The horizontal plane trajectory of Tu-154M, reconstructed from TAWS alert logs, does not change 140 meters after the birch tree which, according to MAK and KBWL, has impacted the aircraft's left wing.
    Impacting the tree resulting in separation of part of the wing and an uncontrolled roll would also have to result in altering the aircraft's horizontal plane trajectory. Such change in trajectory is inconsistent with TAWS Alert Log #38

16. Was there a possibility of a roll to the left after losing part of the wing?
    Are flight parameters reported by MAK as evidence of an uncontrolled roll to the left consistent with what we know about the aerodynamics of this particular type of aircraft?
    This part of the analysis confronts MAK and KBWL reports with a technical description of the aerodynamic properties of a Tu-154M aircraft (see references).

17. As any aircraft, Tu-154M is characterized by a certain critical value of the angle of attack above which the airflow separates from the wings, which causes loss of lift and stalls the aircraft.

18. Angle of attack directly affects the lift and drag coefficients. Tu-154M 101 was reportedly rolling to the left at the same time when the angle of attack was increasing, which would cause an additional decrease of lift.

19. Taking into account the effects of the aircraft rolling to the left as well as losing a considerable amount of airfoil surface, we can conclude that the critical angle of attack would have been exceeded one second after left wing's impacting the birch tree.

20. The behavior of the aircraft after losing part of the wing has also been analyzed by a team of researchers lead by prof. Brawn of the University of Akron. The analysis was a mathematical model of changes in airflow caused by loss of part of the wing.

21. The calculations show that the aircraft is being influenced by two major forces, causing it to roll to the left and pitch downwards at the same time. This is inconsistent with MAK and KBWL accounts.

22. Answers:
    If Tu-154M 101 had lost part of its left wing on impact with the tree, it would have to roll to the left, pitch downwards, and impact the ground no later than one second after hitting the tree.
    Flight parameters reported by MAK and KBWL describe a roll to the left event which is inconsistent with technical accounts of aerodynamic properties if this type of aircraft.

23. Both MAK and KBWL omit TAWS #38 event landing completely; however, the geographic area of its occurrence has received some attention. This can be seen by comparing April 2010 satellite images of this area with later ones from June that same year. Trees have been cut and grass has been burned. Examples:

24. In MAK report graph the blue line (TAWS baro-altitude) does not contain any explicit information from TAWS #38 or any of the FMS logs

25. This slide shows the method used by KBWL to disguise the existence of this data. The fact of this disguise suggests that KBWL is fully aware of the fact that this data is inconsistent with their final conclusions.

26. Vertical acceleration chart published by MAK shows two peaks occurring in very fast succession (on the order of one tenth of a second). These changes of acceleration have been caused by a downwards-acting force.

27. KBWL report shows similar sudden peaks of roll left (not reported by MAK). The peaks of those two functions are correlated. The following animation gives an idea of how abrupt such changes in acceleration are in the case of an 80-ton aircraft.

28. Visualization

29. Analytical Service Company major area of expertise is the dynamics of structures and mechanical systems including: Aerospace Structures and Explosive Effects on Structures.

30. Data for analysis has been submitted by the Parliamentary Commission. The left wing, view from the bottom. The parts are pieced together based on images from the day of the incident.

31. Phase I
    Internal or external explosion in front of the left wing.
    Phase II
    Internal explosion in central position in airframe.

    The loss of the wing's leading edge near the fuselage and the entire left-most part of the wing had two aerodynamic effects: loss of lift on the left side and increase of drag. The first effect induces roll to the left, while the second one induces a change in magnetic heading.

32. Phase III
    The rear part of the airframe with wings and vertical stabilizer rolls to the left independently of the front part which stays in its natural position
    Phase IV
    Impact with the ground: only the rear part of the fuselage is inverted.

    Angular momentum about the roll axis breaks the fuselage apart completely, separating the front of the fuselage from the rear, with the rear continuing to roll to the left.

33. Cokpit and front part of fuselage are not inverted. Rear parts of the fuselage in inverted position.

34. Summary of Results
    The main causes of the crash were two explosions taking place just before landing.
    One of them impacted the left wing near its mid-point and caused an extensive damage, effectively breaking the wing in two. The other, inside the fuselage, caused an profound damage and dismemberment of the latter, as well as loosening the connection of the left wing and fuselage. The landing in a woody area, no matter how unfortunate and at what angle, was incapable of causing the documented fragmentation of the structure.