

SERVICE LIFE ASSESSMENT PROGRAM OF PZL-130 ORLIK TCII STRUCTURE

Andrzej Leski

*Air Force Institute of Technology,
Warsaw, Poland*

Abstract

The following paper concerns the structural integrity program (SEWST) for the PZL-130 Orlik TCII trainer aircraft. The origin of the program is defined as well as the most important tasks necessary to fulfill the assumed goal.

keywords: SEWST, Full Scale Fatigue Test, flight loads, teardown inspection

1. Genesis of SEWST program

The PZL-130 Orlik was designed by PZL Warszawa-Okecie as a trainer aircraft for the Polish Air Force. In 1994 it was introduced to service in the Polish Air Force (version TCI). It is a single-engine, two-seater aircraft for initial pilot training. The main disadvantage of the TCI version is the necessity of frequent overhauls (every 1000 flight hours), and frequent periodic maintenance performed by technicians. This maintenance scheme was a result of suspension of the Full Scale Fatigue Test and other equivalent programs which could verify the durability of the structure. Experience gained over 15 years of operation has demonstrated that this maintenance system is not optimal and there is no need to perform overhaul at every 1000 flight hours. Additionally, a sizable part of the fleet is not available as it has been sent to depot. An upgraded version of TCI is the TCII version. Major differences as compared to TCI are:

- changes in the wing shape and rudder leading to improvement in maneuverability
- change of the engine and the propeller (PT6-25C Pratt & Whitney, Hartzell)
- brand new wings
- new digital avionics (GPS/VOR/ILS).

The manufacturer provided the opportunity to upgrade the aircraft from the TCI version to TCII. Two aircraft operated by the Polish Air Force have been upgraded to the version TCII in the early twenty-first century. Positive experiences - particularly a significant improvement in maneuverability of the airplane – have resulted in a new contract for the Polish Air Force. In 2009 the Polish Air Force ordered a further 14 aircraft upgrade to the version TCII. In the meantime, the aircraft manufacturer PZL Warszawa-Okecie became part of EADS.

Alongside the modernization of the aircraft, the Polish Air Force commissioned developing a new maintenance system for PZL-130 Orlik. The main requirements of the new system are:

- Developing and applying Aircraft Structural Integrity Program – ASIP) according to MIL-STD -1530C
- Cancellation of overhauls
- Confirmation of total service life of the structure during Full Scale Fatigue Test – minimum 6000fth (with safety factor)

The realization of these objectives is the subject of the research program SEWST (abbreviation denoting the Polish language system for operating the aircraft based on their actual health). The SEWST program has been carried out by EADS PZL Okecie and the Air Force Institute of Technology.

The anticipated benefits of SEWST are:

- Huge savings from reducing maintenance costs (ok. 200 mln. PLN = 70mln USD);
- Increased operational availability by eliminating downtime during overhauls (about 25% of the fleet would have to be constantly in the depot);
- Extension of total service life over 8000 fth.

2. Service Life Assessment program as the main part of SEWST

The whole SEWST program covers many different topics. The most important part of the work should confirm the total aircraft flying hours without the need for overhaul. The main component of the SEWST program is the Full Scale Fatigue Test.

As stated above, the Polish Air Force has contracted the upgrade to the TCII version for the aircraft previously operated as TCI. During its modernization, the aircraft is fitted with a completely new wing and the fin is slightly enlarged while the fuselage remains without significant changes. It was therefore decided that the FSFT will be performed for the equivalent structure. For the purposes of FSFT, EADS PZL Okecie has prepared a partial upgrade (from version TCI to version TCII) of the aircraft. The selected aircraft (TCI) was withdrawn from service and its structure was upgraded to TCII version. Of course, it was not equipped with a new engine or modern avionics.

The key components of service life assessment program are:

- Preparation of load spectrum
- Full Scale Fatigue Tests
- Teardown Inspections
- Numerical analyses
- Corrosion Prevention & Control Program (CPCP)
- Non Destructive Inspections (NDI) and System for Health Monitoring (SHM)

The preparation of load spectrum was a task of the Air Force Institute of Technology (AFIT). The Air Force Institute of Technology is a research institute subordinated to the Polish Ministry of Defense, executing aviation works for the Polish Armed Forces. One of the tasks performed by the AFIT is monitoring the operational loads of airplanes and helicopters. The data from the previous operation of such aircraft as TCI were used to prepare the load spectrum for the TCII.

The analysis of the operational profile consisted of:

- analysis of mission types
- analysis of current and future training programs
- statistics for collected operational data

Based on the analyses mentioned above, a combination of mission types was developed which can be considered as a typical one for turbo trainers operated by the Polish Air Force. The average number of landings is 2.3 landings per one flight hour. The average number of spins is 0.16 per one flight hour.

Test flights represent an important component of SEWST. An aircraft operated by the Polish Air Force was instrumented with strain gages and a multi-channel recorder KAM-500. The strain gages were mounted onto the structure to measure internal forces in the aircraft during flight and on the ground.

After the instrumentation, the calibration procedure has to be carried out. During calibration, the structure is subjected to controlled loads while the signals from strain gages are recorded. Based on the calibration results, the mathematical relation between strain gage signals and internal loads can be calculated.



Fig. 1. Calibration of the wing and fin

Test flights were performed according to a special flight program. The flight program was developed to cover all maneuvers and mission types indicated after the analysis of the operational profile.

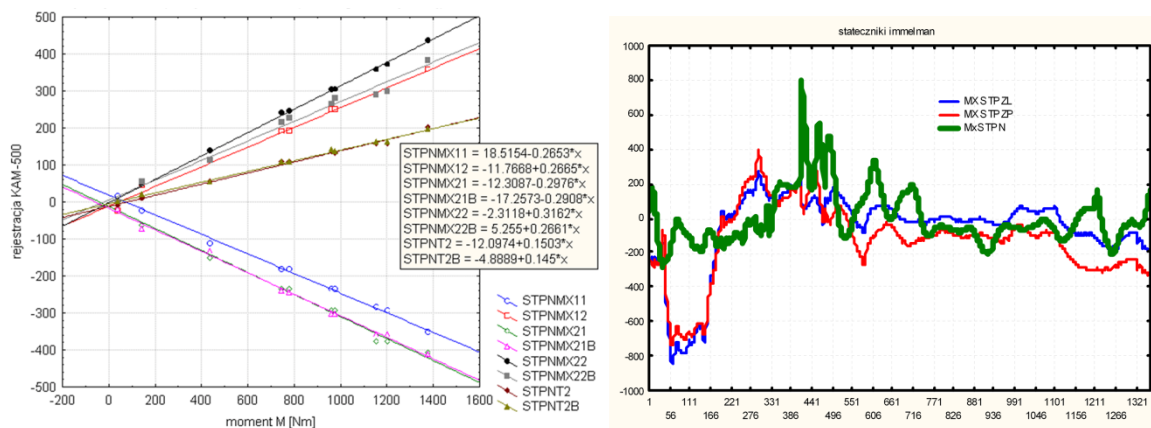


Fig. 2. Example results. Strain vs load from the calibration and finally obtained flight loads

Based on the obtained test flight results, the load history for FSFT can be developed.

This stage of work consists of:

- peak and valley searching,
- offset correction,
- filtration,
- editing of ground forces,
- marker bounds definition,
- load block definition.

The contractor for FSFT is VZLU Praha (Czech Republic). During the test the structure is periodically checked by the NDT personnel. The inspection plan is prepared by the AFIT. The inspections will be performed by both the VZLU and AFIT technicians.

After the FSFT has been completed the structure will be checked during the Teardown Inspection. TI is a destructive examination of the structure. The structure is cut into small parts suitable for inspections in the lab facility.

3 Recent progress in SEWST and conclusion

The SEWST program started at the end of 2009. The instrumentation of the aircraft was carried through in the spring 2010. Simultaneously, the flight test program was developed. The calibration and flight test were completed in the early autumn 2010. The test article was produced by EADS PZL-Okecie and delivered to VZLU at the end of 2010. The FSFT starts in the spring 2011.

According to the authors knowledge SEWST is the biggest and the most comprehensive program that has ever been carried out in Poland. Other programs used load sequences which were developed based on the literature data. A successful completion of the program will lead to the establishment of a new maintenance scheme for the PZL-130 Orlik TCII and is expected to result in considerable savings as well as in an increase in the safety and reliability of the aircraft.

REFERENCES

- [1] Anderson, I.A. & Parker, R.G. (1999). Full Scale Fatigue Test of the Pilatus PC9/A trainer aircraft. In 20th ICAF Symposium: Structural Integrity for the next Millennium, 14-16 July 1999. Bellevue, Washington, USA.
- [2] Molent, L., Barter, S.A., White, P., Dixon, B. (2008). Damage tolerance demonstration testing for the Australian F/A-18. *International Journal of Fatigue*. Vol. 31(2009), 1031-1038.
- [3] Rutledge, R.S., Backman D.S. & Hiscocks, R.J. Evaluation, Modification And Damage Tolerance of an In-Service Aircraft Critical Area, In 25th ICAF Symposium: Bridging the Gap Between Theory and Operational Practice, 27-29 May 2009. Rotterdam, The Netherlands.
- [4] Klimaszewski, S., Leski, A. & Zurek, J. The Role of AFIT in the Polish Aging Military Aircraft Programs. Proceedings of 7th Joint FAA/DoD/NASA Conference on Aging Aircraft, 9-11 September 2003. New Orleans.
- [5] Klimaszewski, S., Leski, A., Dragan, K. & Kurdelski, M. Aircraft Structural Integrity Program of Polish Su-22 Fitter. Proceedings from the ASIP Conference, 30.11-06.12.2006. San Antonio, USA.
- [6] Klimaszewski, S., Kurdelski, M. & Leski, A. Program zapewnienia integralności struktury samolotu jako praktyczne zastosowanie mechaniki pękania. Materiały konferencyjne CD z XI Krajowej Konferencji Naukowo-Szkoleniowej Mechaniki Pękania, 9-12 wrzesień 2007. Kielce/Cedzyna.
- [7] Leski, A., Klimaszewski, S. & Kurdelski, M. The Assessment of Fatigue-Life Resources of the PZL-130 Orlik's Structure. Proceedings from Sixth DSTO International Conference of Health & Usage Monitoring, 6-9 March 2009. Melbourne, Australia.
- [8] Klimaszewski, S., Leski, A., Dragan, K., Kurdelski, M. & Wrona, M. (2009). Helicopter Structural Integrity Program of Polish Mi-24 Helicopters. In 25th ICAF Symposium: Bridging the Gap Between Theory and Operational Practice, 27-29 May 2009, Rotterdam, The Netherlands. Part 4, 263-277.
- [9] Leski, A., Klimaszewski, S. & Kurdelski, M. (2009). The Fatigue Life Assessment of PZL-130 Orlik Structures Based on Historical Usage Data. In Antoni Niepokólczycki (Editor), *Fatigue of aircraft Structures* (pp. 131-139). Warsaw, Poland: Institute of Aviation Scientific Publications.
- [10] Leski, A. An Algorithm of Selecting a Representative Load Sequence for a Trainer. In 2nd International Conference on Engineering Optimization. 6-9 September 2010. Lisbon, Portugal.
- [11] Leski, A., Obrycki, L. (2010). Representative Load Sequence for the PZL-130 ORLIK. In Antoni Niepokólczycki (Editor), *Fatigue of aircraft Structures* (pp. 69-77). Warsaw, Poland: Institute of Aviation Scientific Publications.