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IDENTIFICATION AND PREVENTION OF SAFETY HAZARDS DURING TOWING OF LARGE AIRPLANES

Identyfikacja i przeciwdziałanie zagrożeniom bezpieczeństwa zaistniałym podczas holowania dużych samolotów

Abstract: *The introductory part of the article discusses briefly the basic principles and methods of towing large aircrafts. Then, events that occurred while different large passenger planes were towed are analyzed. Based on the analysis, the main causes of plane damages during towing are indicated. The percentage distribution of individual identified risk factors is determined to show that the main cause is the broadly understood human factor, especially errors of service personnel and the crew. Finally, preventive recommendations were made based on the analysis; they can help avoid such events. The analysis stimulates further research in this field and highlights the necessity to continuously analyze the risk, which should minimize the number of towing-related incidents.*

Keywords: towing, pushback, tugging, tug, safety threat

Streszczenie: *W części wstępnej artykułu omawiane są krótko podstawowe zasady i metody holowania dużych samolotów. Następnie przeprowadzana jest analiza zaistniałych zdarzeń podczas holowania różnych dużych samolotów pasażerskich. Na tej podstawie wskazano główne przyczyny uszkodzeń samolotów zaistniałych podczas holowania. Na tej podstawie określono procentowy udział zidentyfikowanych czynników ryzyka, wskazując, że główną przyczynę stanowi szeroko rozumiany czynnik ludzki, a w szczególności błędy obsługi oraz załogi. Na końcu sformułowano na podstawie przeprowadzonej analizy zalecenia profilaktyczne możliwe do realizacji w celu uniknięcia podobnych zdarzeń. Przeprowadzona analiza stymuluje dalsze badania z tego zakresu i konieczność bieżącej analizy ryzyka, która powinna zminimalizować ilość zaistniałych zdarzeń podczas holowania.*

Słowa kluczowe: holowanie, wypychanie, przetaczanie, holownik, zagrożenie bezpieczeństwa

1. Introduction

Towing (pushback) is moving an aircraft with turned-off engines around the airport (landing area), and even beyond it when aircraft rolling (taxing) is not possible or justified. Towing of the most common aircrafts like airplanes and helicopters is performed in a different way. Also, within the same group of aircrafts, the manner of towing may differ depending on individual features of a given aircraft. The manner and method depend on a series of independent factors such as aircraft size, its design, the length of the path, properties of the towing area etc.

Depending on their type and size, aircrafts can be towed using the following, most common methods:

- manual towing or towing using a drawbar,
- on a towing line or a rigid towbar behind a vehicle,
- using a motorized airport tug with manual control,
- using directly a special towing vehicle (a Taxibot).

As indicated by practice, different methods of towing are inherent activities proceeding the flight of an aircraft, and hence transition between storage of the aircraft (parking, servicing) and utilization phase. After the end of flight, towing is also often performed. Only in a small percentage of situations, the aircrafts start taxing straight from the parking area. Usually taxing is started at specially designated places, after the aircraft is moved there by means of towing. Hence, towing operations should be considered important from the point of view of aircraft usage and the resulting hazards.

2. General principles of large aircraft towing

According to valid national regulations, the term “large aircraft” refers to [11] transportation aircraft with MTOM (maximum take off mass) exceeding 8618 kg. This group includes airplanes commonly used for air transportation of both, passengers and cargos.

The basic method of towing is using a towbar and a tug. The towbar is attached to the undercarriage of the aircraft and to the vehicle (at the front or rear side). The length of the towbar allows maintaining a safe distance between the tug and the plane to ensure absolute safety. The towbar is usually equipped with wheels that allow the towbar transport when it is not attached to an aircraft. In case of excessive loads, the towbar is equipped with shear safety pin that detaches the plane from the tug. Apart from appropriate strength, the tugs must have a proper mass and size to ensure proper distance between the towing assembly and the plane.

Alternatively, an aircraft can be tugged using a towbar-free tug with hydraulic cradle design. The tug moves to the wheels of the aircraft and then contacts them with cradle stoppers, first with the front ones, and then with stretching rear ones. After the plane wheels

are mounted in the cradle, the cradle is lifted up by about 15–30 cm using a hydraulic system. After this procedure is completed, the plane is ready to be towed or pushed back. Figure 1 presents an aircraft ready to be towed without a towbar.

Over the recent years, remotely controlled (with use of a control panel beyond the tug) electric tugs without a driver gain more and more popularity. Their great advantage is lack of exhaust fume emission, quiet operation and increased safety margin due to remote control by an operator located outside the vehicle. This allows controlling the vehicle from any place around the towing assembly, which significantly increases the safety of this operation. Such a tug is presented in fig. 2.



Fig. 1. A plane ready to be towed without a towbar; near the tug, people engaged in towing can be seen

Regardless of the towing method used, the following general rules apply:

- each member of personnel taking part in towing should be trained and should understand the task being performed,
- the personnel should be equipped with a reflective vest, and with individual lighting at night,
- visual contact between team members and ideally radio communication should be enabled,
- equipment used to perform the operation should be operational and properly chosen for the given type of an aircraft and a tug,
- the place (path) of towing should be checked for presence of foreign bodies and other obstacles,
- a competent person in the aircraft cabin should be designated,
- before the tug approaches the aircraft, it should make two so-called safety-stops, and approaching should be made at low speed,

- before towing is initiated, all locks and safety elements should be checked; it must be also checked if all doors and hatches are properly closed,
- the towbar should be attached to the aircraft, and only then to the tug,
- in case of towbar-free towing, the towing procedure can be initiated only after proper mounting of aircraft wheels in the tug cradle is confirmed,
- towbar detachment can be performed only after the plane has stopped (or after stoppers are placed under the aircraft wheels),
- appropriate speed and turning angle must be ensured during the towing process [1, 11].



Fig. 2. Remotely-controlled electric tug; the operator with a control panel (visible in the figure) can move freely anywhere [4]

3. Analysis of events that occurred during the towing

To assess risks related to towing, analysis of chosen events that occurred during such procedures was performed. The analysis included different events that occurred while the following planes were towed: Airbus A320, Airbus A340-300, Boeing B767-300, Boeing 777-300ER, B737-800, B747-200F, Avro RJ85, Avro RJ100, CRJ 700, CRJ 200, McDonnell Douglas MD82, McDonnell Douglas MD-11, MD82. In total, 13 different events were analyzed. Such a small number of events results from a couple of reasons, especially from episodic occurrence of such events and lack of reliable information about such events. Due to the nature of such events, they do not have to be reported to the national aviation authorities and the committee for aircraft accident investigations, as they are not an aviation

accidents. Both the carrier and the airports are not interested in disseminating the information about their occurrence. Hence, many of such events remain undisclosed.

It can be seen that the incidents involved different aircrafts used in air transportation. This indicated that a given type of aircraft is not a risk-related factor, and the probability of such events is related to different issues.

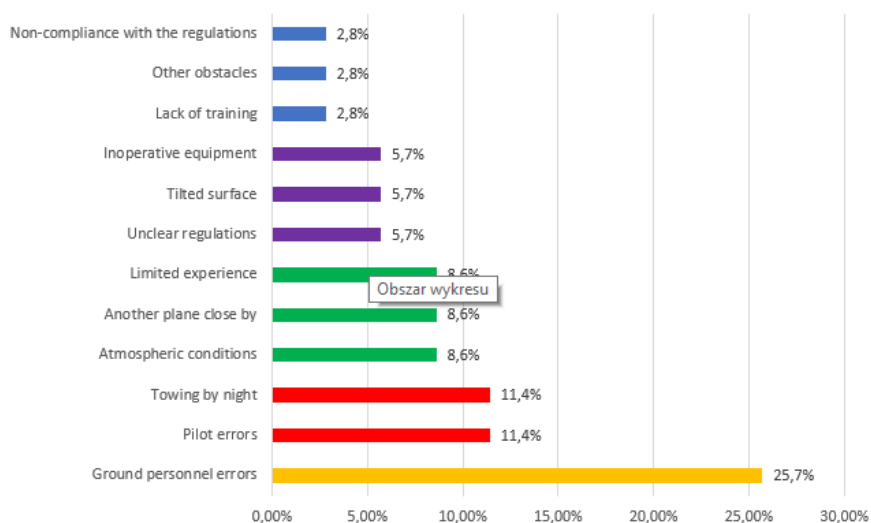


Fig. 3. Percentage of risk factors that affect the occurrence of an incident during aircraft towing [12]

Analysis of incidents that occurred upon aircraft towing proves that there is a number of recurring errors that contribute or lead to damage of aircrafts during towing procedures. The main errors include:

- using manual signals instead of more effective and universal radio communication,
- unclear or unequivocal radio communication,
- too few members of staff performing the towing operation,
- lack of appropriate communication between the vehicle driver and the operation supervisor,
- maintaining too small distances from other planes,
- lack of staff training,
- debris covering the surface markings.

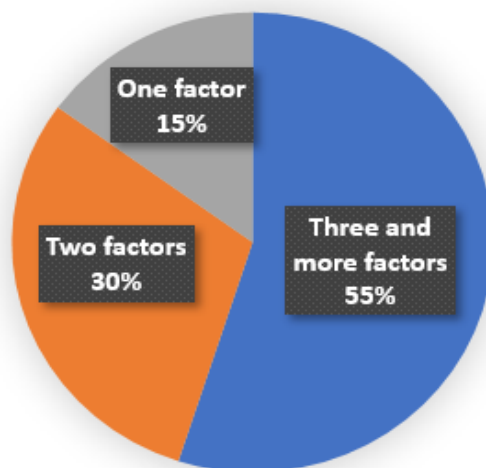


Fig. 4. Percentage of number of risk factors that affect the occurrence of a single incident during towing

To propose a proper preventive program, it is crucial to determine the percentage distribution of risk factor. Based on the performed analysis, percentage fraction of the identified risk factors was determined and presented in fig. 3.

It is worth noting that the biggest group covers the causes resulting from the broadly understood human factor. Here, it relates mainly to technical personnel, who always participate in towing operations and aviation personnel who usually (however, not always) take part. Another significant factor was found to be towing by night. Decreasing visibility, limited lighting and tiredness of personnel resulting from the night time can become a factor that increases the risk of undesirable events.

The mechanism of risk occurrence during towing is so complex that it can include more than one risk factor. Based on the chosen towing incident database, a graph was prepared to show percentage of number of risk factors that contribute to the accident; the graph is shown in fig. 4.

The graph indicates that the majority of incidents during aircraft towing, 55%, had three or more risk factors. Significantly less, 30% of cases, were influenced by two factors, and only in 15% of cases there was only one risk factor. Based on this data, it may be concluded that majority of the incidents had several causes. This leads to a conclusion that in order to decrease the probability of an adverse event, it is important to address more than one destructive factor at the same time.

4. Identification of risks and prevention

To illustrate the full scope of risks and potential preventive measures for individual risks based on the performed analysis, a table was prepared. The proposed preventive measures, if applied, may result in reduced probability of occurrence of an adverse event upon towing.

Table 1

A list of risks during aircraft towing, with appropriate corrective measures

Risks	Proposed preventive measures
No observers of the wings and the tail	<ul style="list-style-type: none"> – Updating instructions to include mandatory presence of observers on the wings and tail – Updating instructions to include information about ban of towing without full team of personnel – Updating the instruction to indicate the person responsible for engaging the full team of personnel – Providing the observers with means of communication or any other effective form of signaling.
Incorrect organization of the ground personnel	<ul style="list-style-type: none"> – Updating the towing instruction to include clear and full description of tasks for each member of the personnel – Updating the instruction to include information about the manner of designating and the tasks of the person responsible for towing supervision – Updating the instruction to include information about the obligation to immediately signal hazard by each member of the personnel
Tug driver error	<ul style="list-style-type: none"> – Introduction of periodical trainings on the principles of driving a tug – Introduction of speed limiters for the tugs – Updating the instruction to include information about the manner of communication between the tug driver and other members of the personnel
No communication between the pilots and the ground personnel	<ul style="list-style-type: none"> – Updating the instruction to include information about mandatory radio communication between the aircraft crew and the towing supervisor – Updating the instruction to include information that rolling can be initiated only after a radio information about completion of towing is obtained – Updating the instruction to include the obligation to signal hazards and the necessity to stop the plane by the crew
Start-up of engines during towing	<ul style="list-style-type: none"> – Updating the instruction to include information about the pilot obligation to acknowledge the principles of engine start-up during towing operations

	<ul style="list-style-type: none"> – Performing start-up according to the regulations
Too high torque of the engine	<ul style="list-style-type: none"> – Updating the instruction to include information about obligation to set the torque at minimum value – Updating the instruction to include information about the obligation to confirm this value by both pilots and to communicate it to the towing supervisor
Towing at night and with limited visibility	<ul style="list-style-type: none"> – Introduction of a principle to designate the most experienced personnel to perform the towing operation – Updating the instruction to set the minimum number of light sources during night towing – Updating the instruction to include information about speed limit for night towing – Painting information about limited speed upon towing in special conditions on the tug – Holding periodical trainings on night towing and towing in difficult conditions – Introduction of an aircraft towing simulator with ability to change atmospheric conditions and time of day
Another plane or obstacle	<ul style="list-style-type: none"> – Providing personnel training on maneuvers on a small area with obstacles and on towing aircrafts of different sizes – Performing training sessions on an area with non-invasive obstacles – Introduction of an aircraft towing simulator with ability to change the parameters of obstacles, other planes and the towed aircraft
Limited personnel experience	<ul style="list-style-type: none"> – Introduction of mandatory verification of authorization for performing towing-related tasks – Introduction of verification of operation level of difficulty with respect to the personnel experience – Introduction of training in a form of doubling people performing a specific function, with indication of minimum number of tows before independent activity can be undertaken. – Avoiding putting unexperienced personnel to additional risk factors
Lack of clear regulations and instructions	<ul style="list-style-type: none"> – Phrasing the regulations in a clear and easy to understand manner – Correcting errors and unclear phrases in the valid regulations – Continuous analysis of the applicable regulations and their periodical review – Periodical exchange of experiences with other companies – Option for the personnel to raise concerns about understandability of principles or about lacking documentation, without consequences
Tilted surface	<ul style="list-style-type: none"> – Updating the instruction to include information about speed limit depending on the tilt

	<ul style="list-style-type: none"> – Introduction of absolute obligation to use the parking brake after both, the tug and plane stop – Assigning experienced personnel to perform towing operations on tilted surfaces – Introduction of mandatory marking of tilted surfaces
Inoperative equipment	<ul style="list-style-type: none"> – Introduction of an obligation to maintain accurate and timely usage documentation for all towing equipment – Updating the instruction to include information about obligatory control of the equipment before and after the towing operation – Periodical controls of equipment and documentation without prior notice – Holding periodical mandatory training for the personnel on the use of equipment

The table presented above provides an open catalog of the identified hazards. In order to minimize the risks, it is necessary not only to apply the measures described in the table, but to continuously analyze potential hazards and introduce the necessary preventive actions. Its nature is universal, which results from the performed analysis of the number of individual events. Analysis of a larger number of events may lead to identification of other risk sources and slight changes in the risk factor distribution. It may also require adjusting to specific requirements of a given company and the equipment it is using.

5. Summary

Towing-related incidents are not very rare. Yet, they cause significant financial and reputational problems. They are also a cause of actual aviation hazards while still on the ground. Hence, the carriers should and do undertake broad measures to avoid them, although they still try not to disclose the occurrence of such events.

The performed analysis allowed determination of risk factors occurring during aircraft towing and their classification based on frequency, number of risk factors per incident, as well as detailed division of complex risk factors. The most complex and most common factor are human errors, especially those made by the ground personnel. This factors should gain the most attention in terms of prevention.

Based on the risk factor analysis, a prevention base was created that aims at increasing safety of aircraft towing operations. The proposed preventive measures determine the recommended actions aimed at minimization of the accident risk in a clear and easy to understand manner by introduction of new types of information, obligations and imperatives into the instructions. Other proposed preventive actions are focused on increasing ground personnel skills by various types of trainings and more detailed description of duties, as well as by increasing discipline and work safety during aircraft towing. Constant monitoring of risks within the scope of SMSs (safety management system)

already in place in aviation companies is an important element of the broadly understood prevention.

The presented analysis, despite relatively small number of events, shows unequivocally the general tendency within the scope of risk occurrence during aircraft towing. At the same time, it shows that the measures undertaken to minimize the risk of a towing-related incident are necessary and required because of the effects of damages and possible hazards. Constant increase in aviation transport is inherently connected with increased risk factors that threaten the safety and confirms the significance and relevance of this subject.

It also seems justified to continue studies on this subject matter using a greater number of events, which would allow a more detailed evaluation of the range of hazards and identification of new risk areas.

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