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IMPLEMENTATION OF PLATE LINE SYSTEM IN UKRAINE

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Abstract. *The article is devoted to the analysis of possible Plate Line implementation in Ukraine. Problems which might occur during the installation of given system in Boryspil International airport are defined. Advantages and disadvantages of Plate Line on the example of Boryspil International airport are considered*
Keywords: construction of airfield; safety; separation; wake turbulence.

1. Introduction

Wake vortices from the wingtips and their influence on safety are well known for airports. The vortex of air masses can be kept a few minutes after the flight of aircraft. The effect of the wake is especially noticeable when small and medium-sized aircraft follows the heavy – it entails the need to create a distance between aircrafts, which imposes a limit on the capacity of the airport. This factor often leads to delays of aircrafts.

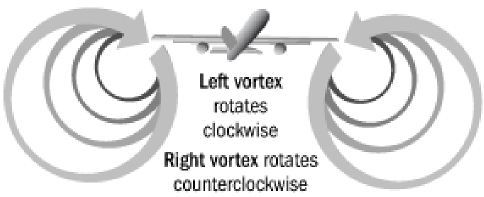

Fig. 1. Behavior of WV

As an unavoidable consequence of lift aircraft generates a pair of counter-rotating and long-lived wake vortices that may pose a potential risk to following aircraft (Fig. 2). The empirically motivated separation standards between consecutive aircraft which were introduced in the 1970s still apply at most airports. These aircraft separations limit the capacity of congested airports in a rapidly growing aeronautical environment. The highest risk to encounter wake vortices prevails in ground proximity where the vortices cannot descend below the glide path but tend to rebound due to the interaction with the ground surface [1].

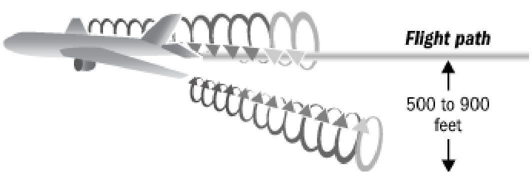

Fig. 2. Behavior of WV

2. Analysis of publications

After detailed analysis of publications we pointed the problems which are caused by wake vortex turbulence. It’s important to investigate such phenomena and find the way to faster eliminate of wake vortex turbulence near airports. In this article we will demonstrate possible installation which can help us to solve the problems and allow to reduce the intervals. Project manager Frank Holzäpfel from the DLR Institute of Atmospheric Physics says: "It’s important to dissipate vortices in front of the runway more quickly" [5].

3. Plate line importance

Weak crosswinds may compensate the self-induced lateral propagation of the upwind vortex such that it may hover over the runway directly in the flight path of the following aircraft. From large eddy simulation as well as from lidar field measurements it is known that wake vortices may live significantly longer than 2 min corresponding to the 5 NM separation between a leading heavy weight class aircraft and a medium follower. Consequently, most encounters are reported at flight altitudes below 300 ft. At such low flight altitudes the possibilities of the pilot to recover from a vortex encounter are limited. The simulations and flight experiments conducted on 29 and 30 April 2013 at special airport Oberpfaffenhofen indicate that the patented plate lines appreciably accelerate wake vortex decay and interfere favorably with end effects. This way safety can be further increased during the final approach -the flight phase with most reported encounters.

A trick with plates is that the plates are placed in front of the runway helps to dissipate the wake vortex turbulence significantly faster [2].

4. Plate line concept

On 29 and 30 April 2013 the Wake OP field measurement campaign has been accomplished at special airport Oberpfaffenhofen with the research aircraft HALO, a modified Gulfstream G550, in order to demonstrate the functionality of the plate line to significantly accelerate vortex decay in ground proximity. During the 72 overflights of HALO at an altitude of 22 m above ground the weather impact on vortex behavior was minimized by folding away the plates alternatingly. During the experiment using plate line consisting in total of 6 wooden plates mounted perpendicular to the flight direction. The field experiments have successfully demonstrated the efficiency of this way to provoke premature vortex decay in the most critical flight phase prior to touch down. Already the smoke and fog visualizations documented by video and photo indicated that with the plate line the formed vortex structures are less coherent. The lidar measurements corroborate quantitatively that with the plate line vortex decay progresses faster than above flat ground at all relevant vortex ages. Further, lidar measurements in a plane with an offset of 4.5 initial vortex separations to the plate line in flight direction reveal that the disturbances travel quickly along the vortices [3].

5. WV evolution with and without Plate Line

Consider the behavior of wake vortices (WV) under some conditions:

– Without barrier (Fig. 3);
– With solid barrier (Fig. 4);
– With plate line (Fig. 5).

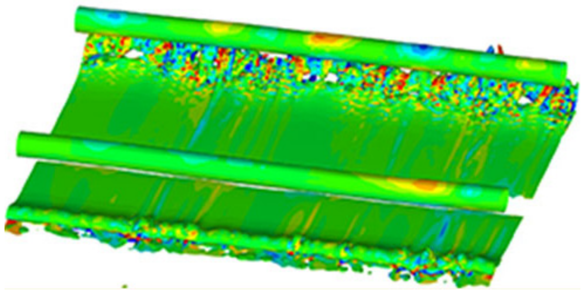

Fig. 3. Wake vortex evolution in ground proximity without barrier

Fig. 3 shows the interaction of the wake vortices with the turbulent structures at the ground surface generated by a crosswind blowing from left below. At a vortex age of 32 sec the vorticity sheet generated by the lee (rear) vortex detaches from the ground and starts rotating around the primary vortex. Triggered by crosswind streaks the secondary vorticity sheet transforms into so-called omega loops wrapping around the primary vortices and initiating vortex decay. Under unfavorable crosswind conditions the rebounding upwind (front) vortex may hover over the runway directly in the flight corridor of a landing aircraft.

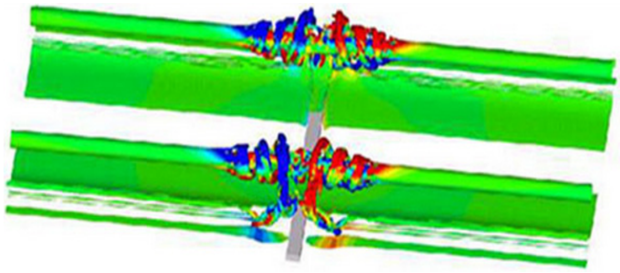

Fig. 4. Wake vortex evolution in ground proximity with solid barrier

The introduction of a barrier at the ground surface may substantially accelerate vortex decay in the critical area close to the threshold where most vortex encounters occur (Fig. 4). Such a setup specifically exploits properties of vortex dynamics to accelerate wake vortex decay in ground proximity with the following characteristics: (i) early detachment of strong omega-shaped secondary vortices, (ii) omega shape causes self-induced fast approach to the primary vortex , (iii) after the secondary vortex has looped around the primary vortex, it separates and travels both ways along the primary vortex, again driven by self induction, (iv) the artificially generated secondary vortex connects to the regular ground effect vortex and thus obtains continued supply of energy, (v) the highly intense interaction of primary and secondary vortices leads to rapid wake vortex decay independent from natural external disturbances [4].

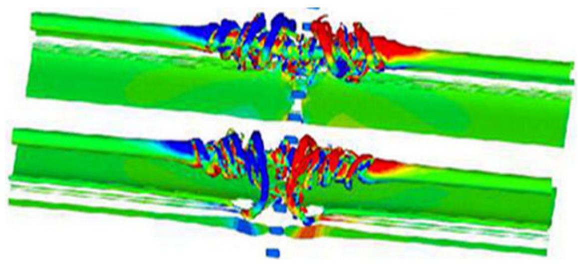

Fig. 5. Wake vortex evolution in ground proximity with plate line

Fig. 5 demonstrates that the solid barrier can be replaced by a less costly and objectionable plate line that turns out to produce similar effects. A closer look at Fig. 5 reveals that the secondary vortices are even slightly stronger and the propagation speed of the helical structures is even slightly higher with the plate line.

6. Implementation in Ukraine

Experiments show that the use of any barrier in front of runway helps to dissipate the wake vortex turbulence faster. As shown above, the use of plate line is more efficient than using a solid barrier. This is confirmed by many tests.

Despite the fact that Ukrainian airports don't have high workload, we may consider possibility of implementation of plate line as an example for the most loaded airport in the country – Boryspil International airport. It has four peaks of high level load per day:

– arrivals of domestic and other flights (8 AM – 9 AM);

– arrivals of flights from EU and others (5:30 PM – 6:30 PM);

– departures to the EU, Asia and domestic flights (9:40 AM – 10:40 AM);

– departures to the EU, Asia and domestic flights (7 PM – 8 PM).

During these four peaks airport needs to accelerate the take offs and landings, but because of the wake vortex turbulence we need impose the intervals between aircrafts. Possible solution of this issue is the installation of the plate line system. Let's see how it looks like in the scheme of airport.

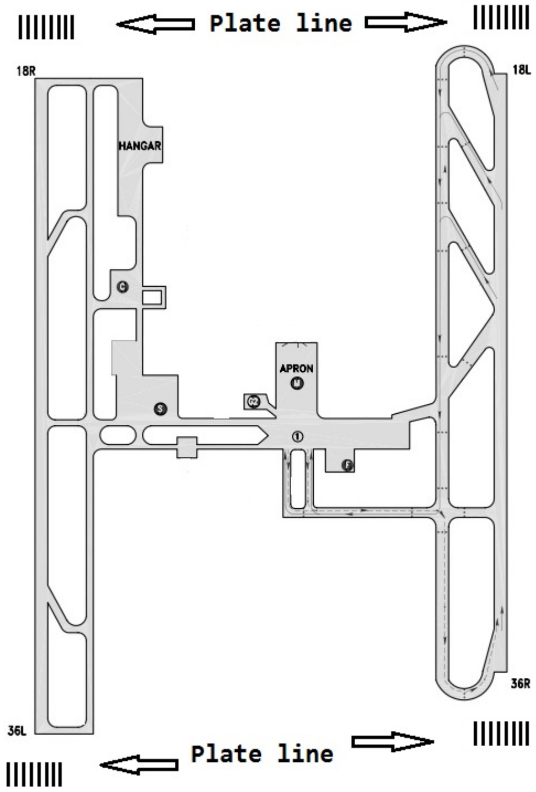

Fig. 6. Plate line on the scheme of airport

Plate line consisting in total of 6-8 plates mounted perpendicular to the flight direction (Fig. 6). Plate line should be located in a zone of glide path. Approximately in a zone where the wake vortex turbulence touches the Earth surface.

The procedure is the next: aircraft fly by the plate line during take off or landing (Fig. 7).

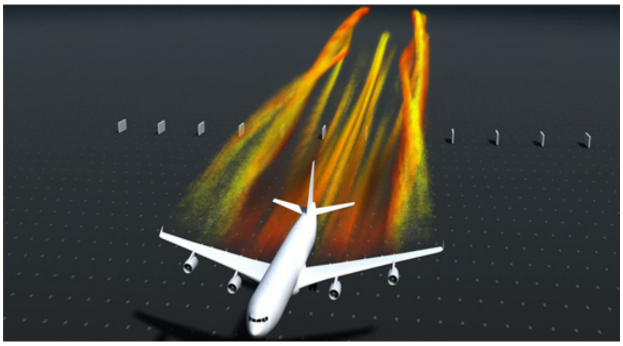

Fig. 7. Fly by of the plate line

After the overfly vortices are remain. These vortices descend and touch ground.

A simulation of behavior of wake vortices after the overfly the plate line by aircraft (Fig. 8).

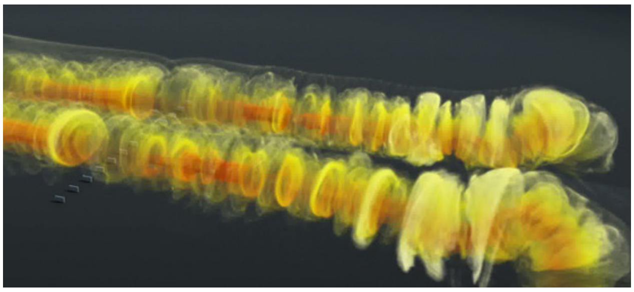

Fig. 8. Wake vortex evolution

Simulation gives us at least approximate distribution of wake vortices' velocities. High velocities are red and low velocities are white.

And after the period, approximately 20 sec, vortices are fading (Fig. 9).

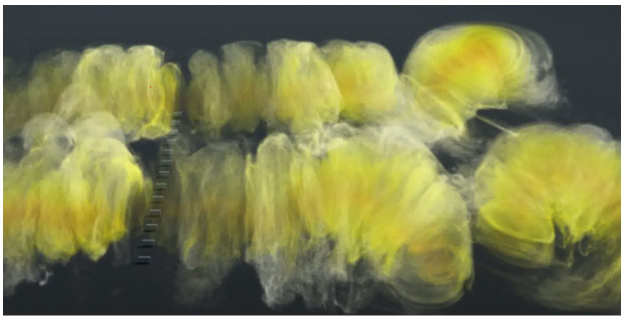

Fig. 9. Wake vortex evolution (20 seconds after the fly by)

After the analysis we can make a conclusion that vortices are fading and time interval between aircrafts, for take-off and landing procedures, may be reduced.

7. Advantages and disadvantages of system

This is only a theoretical analysis. Thus we only may predict some advantages and disadvantages.

Advantages:

– given system lead to a reduction of intervals between aircrafts during landing or take off;

– the problem of capacity of airport can be solved without building of new RWY;

– dissipate vortices in front of the runway more quickly;

– lead to increase of airport capacity.

Disadvantages:

– all issues that considering component materials of plate lines;

– again, depending on a component materials, plates can reflect any kinds of light. So issues considering influence of reflected light into recognition process must be solved;

– The same for all kinds of radio waves activity in this area. The process of radio waves extension and possible interferences must be investigated;

– Human factor (plates can influence on the RWY and elements recognition process).

During the installation of plates it is necessary to pay attention to the component materials of plates, their coverage and conduct an experiment of the pilot perception of given construction. The plates should be covered with the material which does not reflect light. Lots of investigations must be taken to find the best solution for.

8. Conclusions

The development and installation of these systems may lead to a reduction in intervals of arriving and departing aircraft and correspondingly significantly increase the airport's capacity. According to preliminary data capacity may increase to 50 %. The next stage of investigation it is a installation of system in civil airport. New systems in the future will be allow to dissipate vortices that makes creating intervals between approaches and taking off of aircraft. It is can provide sharp increase airport capacity without building new runways.

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Досліджено природу виникнення та існування супутнього сліду. Визначено потенційно небезпечні зони розповсюдження супутнього сліду. Проаналізовано наявну систему лінії плит, проблеми, які можуть виникнути під час впровадження системи в міжнародному аеропорті Бориспіль. Наведено переваги та недоліки системи лінії плит на прикладі міжнародного аеропорту Бориспіль.

Ключові слова: безпека польотів; ешелонування; конструкція аеродрому; супутній слід.

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Исследована природа возникновения и существования сопутствующего следа. Определены потенциальные опасные зоны распространенного сопутствующего следа. Выполнен анализ существующей системы линии плит. Рассмотрены проблемы, которые могут возникнуть при внедрении системы в международном аэропорту Борисполь. Приведены преимущества и недостатки системы линии плит на примере международного аэропорта Борисполь.

Ключевые слова: безопасность полетов; конструкция аэродрома; сопутствующий след; эшелонирование.

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