ORANGE IS THE NEW BLACK…
ENHANCED AIRFIELD SIGNAGE TO IMPROVE SITUATIONAL AWARENESS IN THE VICINITY OF AERODROME CONSTRUCTION WORKS

by Gaël Le Bris, David Siewert and Robert Berlucchi

Over the years, the aviation community has regularly faced accidents and incidents associated with infrastructure and procedures modified during airport construction works. Some of these safety events could have been prevented by better visual alerting. Paris-CDG and the FAA Airport Construction Advisory Council (ACAC) worked with the user community and evaluated in the field innovative signage to enhance situational awareness.

Airside construction works are always sensitive activities since they involve constraining the aviation operations and often create temporary new hazards. Accident and incident data show that standards alone are not sufficient[1]. Specific measures must be carefully developed through a comprehensive safety risk management process involving pilots and air traffic controllers. The risk assessment should incorporate lessons learned from past experience and include such experiences at other airports. The readers of HindSight may be familiar with these issues since they have been previously discussed in this magazine[2,3].

The key challenge for operational safety during construction works is situational awareness. Past occurrences demonstrate that the usual means of communication with the pilot community are not always sufficient. For instance, publishing an AIP Supplement even on an AIRAC cycle[4] is not the guarantee that this information will reach the flight deck. In 2008 an aircraft took off from a temporarily shortened runway at Paris-Charles de Gaulle (CDG), without being aware of the reduction. The aircraft performance was calculated by the pilots using the full runway length, despite reference to the reduction in a current AIP Supplement and verbal reminders from the controller[5]. Also, painting comprehensive and required markings when a runway threshold is temporarily relocated is not enough either. In 2009 at Chicago O'Hare, an aircraft undershoot a temporary displaced threshold (DTHR) despite the presence of the correct markings. After this incident and a field visit with pilots, these markings were reinforced beyond the standards so as to enhance their conspicuity[6]. Such events are not isolated and similar ones continue to occur all around the world.

1- Safety of the runway operations with a temporary displaced threshold during construction works, Gaël Le Bris, TRB/TRIS, 15 November 2013, http://docs.trb.org/prp/14-3126.pdf
2- Mind the gap… Keeping aircraft operations safe during runway construction works, Gaël Le Bris, Hindsight n°19, Summer 2014, pp. 58-61, http://www.skybrary.aero/bookshelf/books/2796.pdf
3- Tearing down barriers – building up relationships, Jim Krieger, Hindsight n°19, Summer 2014, pp. 31-33, http://www.skybrary.aero/bookshelf/books/2789.pdf
4- http://www.skybrary.aero/index.php/Aeronautical_Information_Publications_(AIPs)
5- http://www.skybrary.aero/index.php/B738,_Paris_CDG_France,_2008
6- What's on Your Runway? (Expanded Version), Lessons Learned During Runway 28 Threshold Relocation – Chicago O'Hare International Airport (ORD) in 2009, Wayne Rosenkrans, AeroSafety World, July 2012: http://flightsafety.org/aerosafety-world-magazine/july-2012/construction-council

Innovating together to improve safety

The best solutions for aviation safety issues involving human decisions are always the simplest ones. With this in mind, airports on each side of the Atlantic Ocean worked simultaneously on similar ways of preventing accidents by increasing pilot awareness during taxiing. At Chicago O'Hare in 2009 and at Paris-CDG between 2011 and 2014, yellow signs with special messages were introduced. However, in Singapore in 2009, two aircraft took off without taking into account a reduction in runway length despite a lighted sign advising of the SHORTENED RUNWAY[7]. This showed that a distinctive variation of standard signage should be considered for temporary and safety-critical information.

In 2012, Paris-CDG and the ACAC met together and shared their experience and researches on airfield signage. They agreed to continue their common efforts in order to maximise their contribution to the improvement of the airfield safety during construction works.

Designing a new signage for construction sites

Specifying a new signage system means identifying specific messages and then selecting an appropriate graphical presentation (colours, lettering size, etc.). Different designs and colours were considered and a set of slightly but visibly different variants of the usual standard was selected for further investigation.

We usually think about two colours when it comes to construction works and safety: yellow and orange. Since yellow is already used in airfield signage for communication of regular information such as direction signs and markings, the ACAC came up with the idea of using an orange background as it was already used for temporary roadway signage in the United States.

We verified that orange was one of the two approved colors for construction signs in the Convention of Vienna on Road Traffic[8]. Also, it is the standard in many other countries including Canada, Brazil, New Zealand and Ireland. For the lettering, two different colors were considered and evaluated in the field: black and white.

For the text, the ACAC designed and evaluated variants built around three different signs: CONSTRUCTION AHEAD, CONSTRUCTION ON RAMP and RWY 8L TAKEOFF RUN AVAILABLE 10,000 FT (or any other runway designation and length). Paris-CDG performed parallel and complementary research focused on the development of specific messages for each one of the major hazards that could require increased situational awareness during taxi and takeoff.

7- http://www.skybrary.aero/index.php/A343,_Changi_Singapore,_2007
8- Convention of Vienna on Road Traffic, section G §I.4, version of 28 February 2012

Figure 1 - Reduced TORA signs at Chicago O'Hare (2009) and Paris-CDG (2012)

Figure 2 - Roadway construction signs in different countries

These messages must be short, simple and straight-to-the-point.

The following is a list of the proposed messages:

- CONSTRUCTION AHEAD for situations where the risks are not precisely located and identifiable. For instance, this sign should be used when there is an increased risk of vehicle/pedestrian incursion from a construction site on operational taxiways. When the end of the section under construction is not clear, an END CONSTRUCTION sign should be added;
- MAX SPAN 65 m (or any other wingspan) is a text that has been used for years at Paris-CDG with very good results when the maximum allowable wingspan is reduced. This is a good, simple message;
- DEAD END is a message used for advising the crews that a taxiway temporarily terminates in a dead end. Previous messages included FROM X TO Y ONLY, with X and Y the names of the closest and farthest accessible stands. However, taxiway incursions occurred since this information did not specifically point out the problem as a dead end, it just implied that certain stands were not accessible;
- REDUCED 08L TAKEOFF RUN AVAILABLE 3000 m (or other runway length) is obviously the most important development in this project. It prevents the most critical accident possible for a departing aircraft -the collision at high speed with constructions.

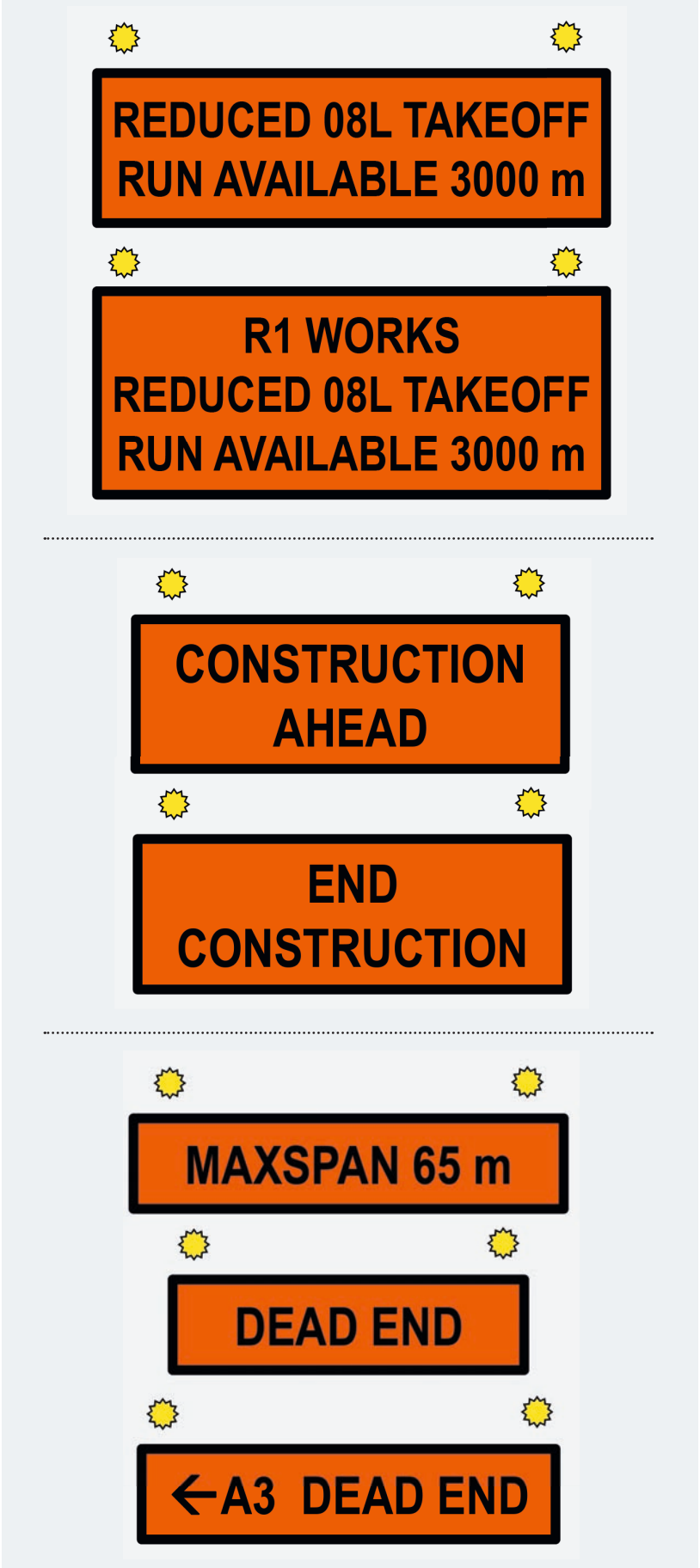

Figure 3 - Tempory information signs

The importance of field evaluation

The design process was performed by workgroups involving all the stakeholders in airside operations - pilots, air traffic controllers, towing service providers, airside drivers, etc. It was reviewed and validated by Local Runway Safety Teams (LRST)[9] also known as Runway Safety Teams (RSAT). However, whilst this approach to design can sound fine, it has little value if it is not trialed successfully in operation.

To validate the final sign prototypes, comprehensive field evaluations were conducted at a number of airports in 2013 and 2014 - Chicago O'Hare (ORD); Portland International (PDX); Theodore Francis Green (PVD); Long Island MacArthur (ISP); Orlando Sanford (SFB) and New York JFK.

Paris-CDG benefited from the FAA's trials and based on feedback from them, CDG designed a three-phase evaluation. Trials were conducted during actual taxiway construction works using operational ground routings. A questionnaire was prepared and sent to the airfield drivers and to pilots with the support and collaboration of their airlines - Air France, EasyJet, FedEx, SAS and Singapore Airlines. After passing orange signage, participants were invited to complete the questionnaire on paper or online.

The trial took place in three phases with each one taking account of the feedback from the previous one Phase 1 involved an orange background with a 300 mm-high lettering CONSTRUCTION AHEAD. Since the participants complained about the size of the letters and the conspicuity of the white lettering against the orange background, Phase 2 replaced the white lettering by a 400 mm-high black lettering and the same message. Phase 3 evaluated the marking variant with the text DEAD END.

The results of the evaluations

Overall, vehicle operators and pilots overwhelmingly agreed that the messages, character heights and colours of the black and orange signs were comprehensible, conspicuous and an effective way of providing alerts about construction activity.

At the six U.S. airports, 87% of 131 respondents (98 vehicle operators and 33 pilots), 'strongly agreed' or 'agreed' that the CONSTRUCTION AHEAD sign was conspicuous and 88% 'agreed' or 'strongly agreed' that the sign was readable from a sufficient distance. At Paris-CDG, 80% of the combined 116 respondents to Phases 1 and 2 (including 100% of the 17 respondents to Phase 2) understood the meaning of CONSTRUCTION AHEAD.

When evaluating the CONSTRUCTION ON RAMP sign, 92% of the combined total of 51 respondents in the U.S. campaign 'agreed' or 'strongly agreed' that the sign was conspicuous,88% 'agreed' or 'strongly agreed' that the sign was comprehensible at a sufficient distance and 94% 'strongly agreed' or 'agreed' that the sign adequately alerted them to temporary construction activity.

A total of 27 pilots and vehicle operators in the U.S. evaluated TORA signs providing available takeoff run information. Overall, 92% of them 'agreed' or 'strongly agreed' that these signs were conspicuous, 81% 'agreed' or 'strongly agreed' that the signs were comprehensible at a sufficient distance and 89% 'agreed' or 'strongly agreed' that the signs adequately alerted them to temporary construction activity.

At the six U.S. airports, 89% of the combined respondents 'agreed' or 'strongly agreed' that the CONSTRUCTION AHEAD sign provided an adequate alert of temporary construction activity. At CDG, 72% of the 110 respondents (including 100% of the respondents to Phase 2) agreed that the sign improved their situational awareness in the vicinity of construction.

9- http://www.skybrary.aero/index.php/Local_Runway_Safety_Teams_%28LRST%29

Figure 4 -Orange construction signs evaluated in the United States

Figure 5 - Orange construction signs evaluated at Paris-CDG

The final concept and operational deployment

At Paris-CDG, the set of orange signs was adopted as a best practice to be included in the safety risk assessments (SRA) of the airfield construction works. Each situation requiring enhanced visual information now has a specific orange sign, with variants adapting the concept to the local airside geometry including the alternative of a ground-marked version when there is no space for a vertical sign.

The ICAO (Annex 14) and the EASA CS ADR-DSN standards for the minimum height of the lettering is 30 cm for usual information signs. However, the feedback from the field trials clearly indicated that 40 cm high lettering is a minimum for all the aviation signs not just for runway signs.

The first operational deployment occurred in September 2015 with the CONSTRUCTION AHEAD sign. The goal was to increase the situation awareness on a modified ground routing where a possible confusion between a taxiway (non-runway entry) and a Rapid Exit Taxiway (RET) had been identified.

Following the publication of the final report of the U.S. study[10], the FAA has updated its standards. Advisory Circular 150/5370-2 Operational Safety on Airports During Construction has been modified to include safety orange construction signage as a visual aid to alert pilots and vehicle operators of existing airport construction. It is recommended that signs displaying CONSTRUCTION ON RAMP and CONSTRUCTION AHEAD are placed at locations leading to ramps and other areas with construction activity. When a runway is temporarily shortened due to construction, it is recommended that signs indicating the reduced takeoff run available (TORA) are placed at runway entrances.

Additionally, it is recommended that the overall size of the signs should be 76 cm (30 inches) high by 213 cm (84 inches) wide with the near side of the sign be placed perpendicular to and approximately 11 m (36 ft) from the taxiway pavement edge.

Both pilots and vehicle operators considered that either text TORA or the expanded text TAKEOFF RUN AVAILABLE acceptable for use on TORA signage. However, it was recommended that additional education be conducted to increase understanding of the TORA acronym to ensure pilots have adequate situational awareness in the case the runway is shortened.

Sharing best practice

This research project, "from the field to the field", developed a practical answer to a real and recurrent aviation safety issue. Of course, this is not a unique or magical solution, it must be used in association with other means of risk mitigation in order to help with the layered approach on which Reason's "cheese slices" for avoiding an accident are based[11].

Our efforts in collection, sharing and improvement of best practice go beyond the temporary information signage itself. In 2015, Paris-CDG and the ACAC participated in a webinar recorded by the Transportation Research Board (TRB) to sharing these practices with the community[12]. Also, the ACAC has, since 2011, maintained an inventory of best practices and lessons learned[13], while a coalition of airports within the Infrastructures Workgroup of Alfa-ACI[14] is preparing guides on how to conduct safe aerodrome works. These materials now include the orange signage among the recommended tools to ensuring safe airport operations during construction work.

10- Development and Evaluation of Safety Orange Airport Construction Signage, Robert Bassey, October 2015, http://www.tc.faa.gov/its/worldpac/techrpt/tc15-52.pdf
11- http://www.skybrary.aero/index.php/James_Reason_HF_Model
12- TRB Straight to Recording for All: Safety of Runway Operations during Construction Works, http://www.trb.org/Main/Blurbs/173568.aspx
13- Runway-Taxiway Construction Best Practices & Lessons Learned, Revision H, 7 April 2014, http://www.faa.gov/airports/runway_safety/runway_construction/media/Rwy_Const_Lsn_Lrnd_Bst_Prc.pdf
14- The Alfa-ACI is the association of the French-speaking airports members of the Airports Council International (ACI).

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