Safety of Runway Operations During Construction Works

Moderator:
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Airport Operations SME, CSSI Inc.

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Gael Le Bris, Airside Development Manager, Paris – Charles DeGaulle Airport

Learning Objectives

- Understanding Safety and Operational Challenges of Construction on an Active Runway Complex
  - Identifying Hazards
  - Proposing Mitigations
- Planning and Design of Safe and Efficient Construction Work Areas
- Refining and Improving Safety Risk Assessments and Risk Mitigation Plans (Lessons Learned)
- Applying Best Practices from Other Airports
- Sharing Innovations with the Industry

Presentations

- Ensuring Safe Operations During Airport Construction *(David Siewert)*
- Reconstruction of Runway 4L-22R at New York JFK *(David Siewert)*
- Safety of the Runway Operations with a Temporary Displaced Threshold *(Gael Le Bris)*

Question and Answer Period

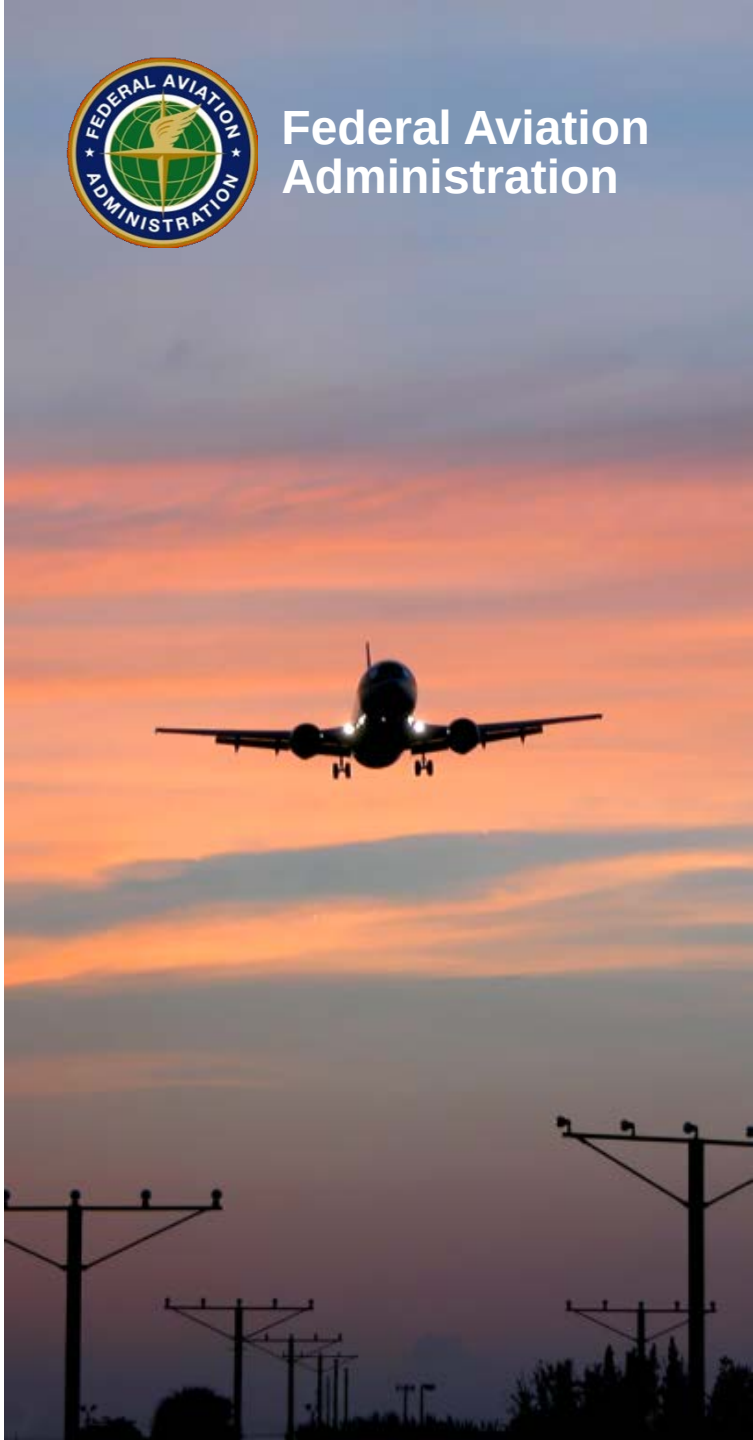
Runway and Taxiway Construction Safety

FAA Airport Construction Advisory Council (ACAC)

Presented to: TRB Webinar

By: David Siewert

Date: October 27, 2015



“Field Managers working with Field Managers”

Runway and Taxiway Construction Initiatives

FAA Airport Construction Advisory Council

Federal Aviation Administration

NBAA
ACI-NA
Airline Dispatchers Federation
Airports Division
Airlines For America
ALPA
ATO Safety
Flight Safety Foundation
Flight Standards
ICAO
NATCA
Runway Safety
AAAE

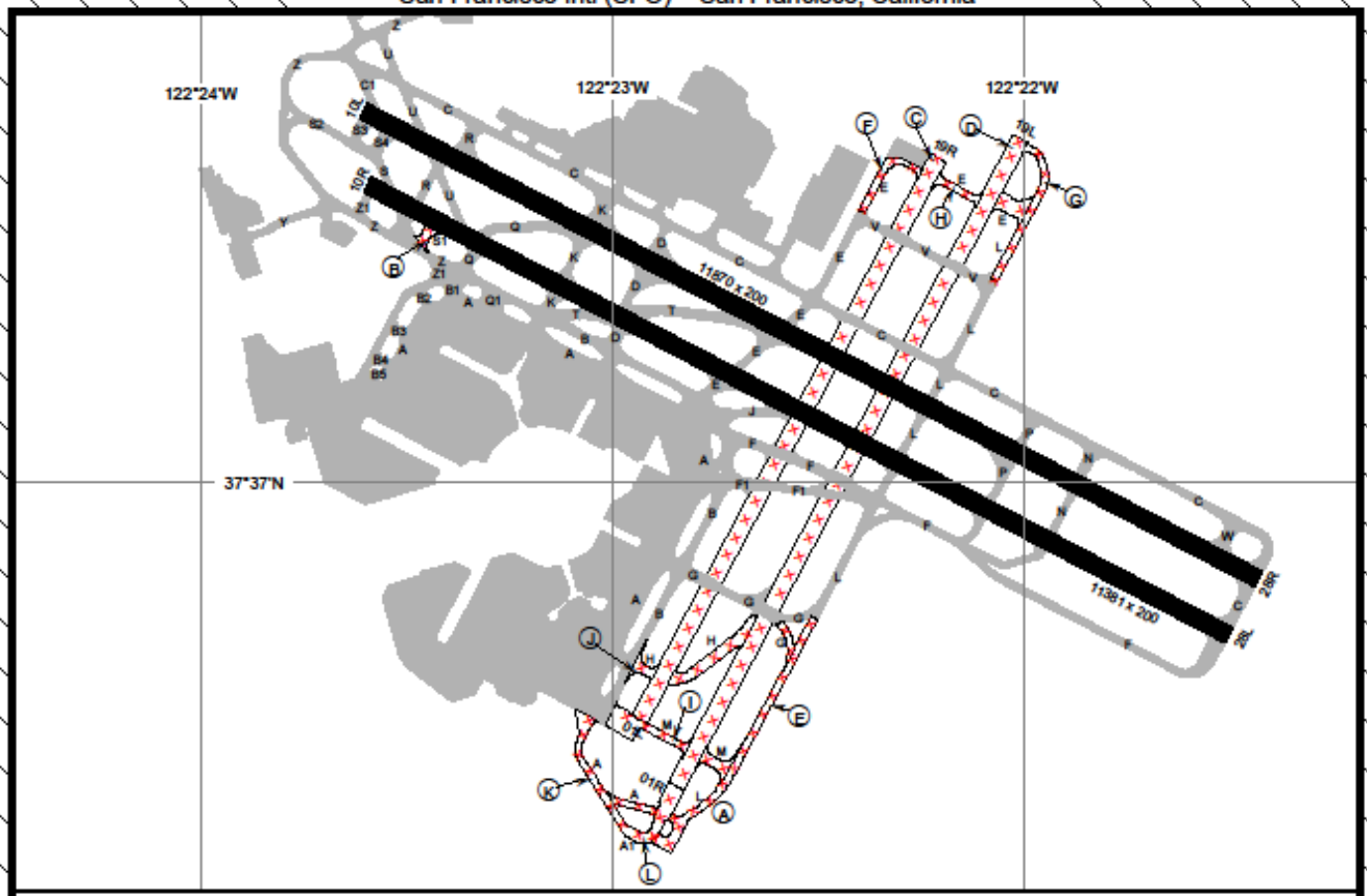
Linking symptoms and initiatives

1. Incomplete/ineffective ATIS broadcasts
2. "Full length" confusion
3. Missed NOTAMs
4. Airport Diagrams
5. Visual Cues

1. New ATIS requirements
2. "Full length" prohibited
3. New takeoff and landing clearances
4. Construction Notice Diagrams
5. Orange Signs

CONSTRUCTION NOTICE

San Francisco Intl (SFO) San Francisco, California



NOTAM		START DATE	FINISH DATE
A 03/007	TWY L BTN TWY M AND TWY A1 CLSD	MAR 3, 2014	SEP 8, 2014
B 04/086	TWY S1 CLSD	APR 17, 2014	JAN 1, 2017
C 05/087	RWY 1L/19R CLSD	MAY 17, 2014	SEP 7, 2014
D 05/088	RWY 1R/19L CLSD	MAY 17, 2014	SEP 7, 2014
E 05/104	TWY L BTN TWY G AND RWY 1R/19L CLSD	MAY 17, 2014	SEP 10, 2014
F 05/105	TWY E BTN TWY V AND AER 19R CLSD	MAY 17, 2014	SEP 10, 2014
G 05/108	TWY L BTN TWY V AND AER 19L CLSD	MAY 17, 2014	SEP 10, 2014

NOTAM		START DATE	FINISH DATE
H 05/112	TWY E BTN TWY L AND TWY V CLSD	MAY 17, 2014	SEP 10, 2014
I 05/114	TWY M BTN REPORTING POINT 1 AND TWY L CLSD	MAY 17, 2014	SEP 10, 2014
J 05/116	TWY H BTN RWY 1R/19L AND TWY B CLSD	MAY 17, 2014	SEP 10, 2014
K 05/117	TWY A BTN TAXILANE M AND TWY L CLSD	MAY 17, 2014	SEP 10, 2014
L 05/118	TWY A1 CLSD	MAY 17, 2014	SEP 10, 2014

NOTE: This diagram is intended to display published NOTAMs and is checked and updated daily (Mon. - Fri. only; no holidays); temporary closures/openings of less than 24 hours are not depicted; runway length shown is maximum length (shortened distances are not depicted); diagrams containing new runway surfaces will be deleted after (FAA) revised airport diagrams are published. Always CHECK CURRENT NOTAMs

Consult NOTAMS for Latest Information

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https://nfdc.faa.gov/xwiki/bin/view/NFDC/WebHome

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Federal Aviation Administration

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National Flight Data Center (NFDC)

Welcome to the NFDC web portal. This site is intended to service the aviation community providing the ability to browse for aeronautical data, submit data to the FAA for airport or chart updates, or communicate with FAA specialists. Learn more.

Alert: this site was recently updated. Login to My NFDC to get to FADDS. See release notes.

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- Construction Notices
- more ...

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Applications

- Airports GIS (AGIS)
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- Third Party Survey System (TPSS)
- more...

References and Links

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- Department of Transportation (DOT) Home
- AeroNav Products
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https://nfdc.faa.gov

We have conducted evaluation of orange construction warning signs at 5 airports

RWY 4L TAKEOFF RUN AVAILABLE 9,780 FT

CONSTRUCTION AHEAD

ISP

ORD

PDX

PVD

SFB

JFK

New signage for shortened runways

New signage to alert pilots about airport construction

New signage when illuminated by aircraft/vehicle lights at night

Air Traffic Management :

1. Notify ACAC
   - ConstructionCouncil@faa.gov
2. Train controllers prior to construction
3. Onsite Support for Managers by ACAC Managers
4. Use ACAC tools (Best Practices, Checklist)

Best Practices

No.	Best Practice / Lesson Learned	Loc.
8	Refine operating concept, and break projects down into phases. Integrating projects into single plan ensures that the cumulative effect of projects is considered, rather than projects being evaluated as stand alone. Matrix/Timelines provide a good visual reference of project overlap and/or influence on other projects. Identify critical stages needing completion prior to next phase: i.e. a taxi route needed for completion of one phase might be eliminated by the next phase; always look into each construction phase carefully to identify critical events that could ripple into the next phase(s)	ORD JFK
9	Once the phases and timeline have been broken down, involve Sys Ops. Start to develop impact statement.	ORD
10	Airlines and airport operator work together on publicity campaign; start of the communications campaign is driven by the ability to get the information out to the aircraft operators; typically, information is published about 1 month prior to actual work; make sure to involve air carrier Certificate Management Offices (CMO); Begin outreach with customers at least one year in advance, sooner if possible. They also have a tremendous amount of planning to do, especially if they are planning to adjust schedules and marketing plans for the construction period. This involves major airlines, dispatchers, chief pilots, scheduling, marketing, and user groups such as ALPA, NBAA and AOPA.	ORD MSP

Runway Construction checklist

e fill out the following form. You cannot save data typed into this form.
e print your completed form if you would like a copy for your records.

Highlight Existing F

Partial Runway Construction Closure Checklist

Partial Runway Closure (Relocated Threshold) **Start date:** _____

		Required	Status	Date Complete	Reason Not Accomplished
	As Early as Possible:				
1	Review best practices/lessons learned	X	0%		
2	Notify local Technical Operations System Support Center (SSC) of proposed start and end dates to begin NAVAIDs evaluation for impact and to begin the Strategic Event Coordination (SEC) for NAVAID shutdown during construction	X	0%		
3	Review airport Master Plan (long-range) with airport authority Review specific imminent phases (revisit as funding changes); request daily updates be posted on airport authority webpage	X	0%		
4	Notify the Airport Construction Advisory Council via email to the following address: **9-AJA-ConstructionCouncil@faa.gov**	X	0%		
5	Coordinate with sponsor to effect closure coincidental to publication/charting date	Best Practice	0%		
6	Conduct and complete SMS activities (SRMD, SRMDM, etc.)	X	0%		
7	Model the construction in the simulator	X	0%		
8	Advise/coordinate project with regional Runway Safety Office - accomplish local-regional RSAT focused on construction impact	X	0%		
9	Tailor communication strategy to this project	X	0%		
10	Coordinate with Traffic Management - develop impact statement	X	0%		
11	Confirm effect to instrument procedures, critical areas, protected surfaces; check with AFS	X	0%		
12	Review necessary LOA changes related to local operators	X	0%		
13	Evaluate whether construction may generate need for new/different runway hot spot(s)	X	0%		
14	Review ARFF routes/staging and suspicious materials holding areas with airport authority	X	0%		
15	Confirm location of RSA(s) for each proposed and existing runway affected	X	0%		
16	Determine extent of surface surveillance (ASDE-X and/or AMASS) map changes needed and coordinate as necessary	X	0%		
17	Determine whether video map set change is needed and coordinate as necessary	X	0%		

Reachout

ICAO

CDG Interaction

AAAE Workshops/Webinars

NBAA Workshops/Exhibits

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ConstructionCouncil@faa.gov

ALL POINTS/SAFETY

everyone. everywhere. everyday.

Safety of the Runway Operations during Construction Works

Gaël LE BRIS, Airside Development Manager

TRB Webinar
November 2015

AÉROPORTS DE PARIS

The speaker

Gaël LE BRIS

Airside Development Manager, Paris-CDG

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Member of AV070 Aircraft/Airport Compatibility

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Contents

1.

Introduction

1. Introduction

1.1 Runway constructions are not an option

- **Runways are strategic and "living" assets. They must be properly maintained and rehabilitated.**
- **Different solutions exist to perform long duration works on a runway:**
  - **Closures only on successive nights,**
  - **H24 closure on an extended week-end or a longer period,**
  - **Shortened runway with or without a temporary displaced threshold (DTHR).**
- **Not all of them are adapted to the various types of construction projects and local characteristics:**
  - **Type of works: RSA upgrade, taxiway or runway construction, rehabilitation, reconstruction, ….**
  - **Pavement management policy: thin or thick overlay, reconstruction in asphalt or cement concrete, …**
  - **Traffic profile: non-hub, daily program with various peak hours ("hub waves"), …**
  - **Fleet mix: required runway lengths vs reduction of the declared distances, …**
  - **Runway system: configuration (single, secant, parallel RWYs), noise mitigation procedures …**
  - **Multi-airport system: options for relocating operations during maintenance (e.g. DUB to DXB, 2014).**

Runway constructions must carefully balance the safety issues and the throughput, but also the airport technical policy and the needs of the construction project.

1. Introduction

1.2 Keeping runway operations safe

- **Runway construction projects are the most critical for the aviation safety since they imply modifying the operating conditions and involving non-aviation staffs and machines in the close vicinity of runway operations.**

- **Records show that accidents and incidents have occurred on runway construction projects, including during H24 closures or temporary DTHR fully compliant with the standards.**

- **If deadly accidents are extremely remote (TPE, 2000), most of the incidents are premises of catastrophic events (ABV, 2013).**

- **However, it appears that most of the related risks could be significantly mitigated by simple and inexpensive solutions.**

Paris-CDG, 2012


Abuja, 2013

1. Introduction

1.3 Motivations and goals

- **This research project on runway construction works was motivated by:**
  - **Continuing a research initiative launched in 2012 for ensuring a safe temporary DTHR at Paris-CDG,**
  - **Providing elements of Safety Risk Management for runway construction works,**
  - **Promoting the best practices in risk mitigation and operational safety.**

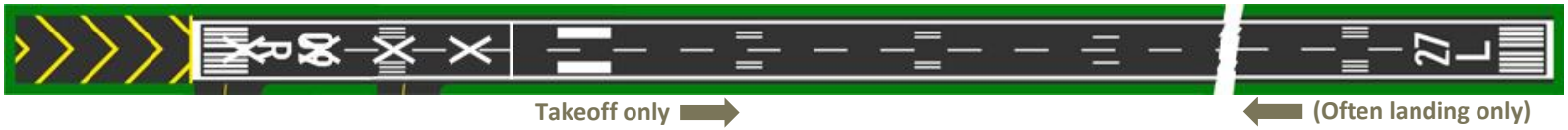
- **The main goals of the projects were:**
  - **Finding generic hazards on runway construction works and assessing their risks,**
  - **Identifying the best mitigation actions.**

- **Data collection and analysis were focused on:**
  - **Hazards on and from aviation operations**
  - **The 1997-2015 period (20-year range, same standards, information still available, rise of the SMS),**
  - **U.S. primary commercial airports (NPIAS) with runways longer than 1,500 m (about 5,000 ft),**
  - **Non U.S. airports are primary commercial and have runways of ICAO number of code 4 (or longer than 1,500 m),**
  - **Construction works and safety occurrences on non-commercial airports are documented in the database.**

1. Introduction

1.4 Definitions

- **Shortened runway without a temporary displaced threshold (DTHR)**



- **Shortened runway with a temporary displaced threshold (DTHR)**

- **Closed runway**

2.

The research project

2. The research project

2.1 A three-phase project

- **Phase I (2011-2012)**

  Objective: support the Safety Risk Management (SRM) of a temporary DTHR at CDG (April-June 2012)

  Data collection: 10 accidents/incidents, 10 shortened RWY

  Shared with the FAA's Airport Construction Advisory Council (ACAC) in Nov. 2012

- **Phase II (2012-2013)**

  Objective: apply the SRM methodology to a selection of temporary DTHR

  Data collection: 36 accidents/incidents, 17 shortened RWY

  Presented during the 93rd TRB Annual Meeting in January 2014

- **Phase III (2014-2015)**

  Objective: extend the dataset of runways and accidents/incidents, and include runway closures

  Data collection: 46 accidents/incidents, 143 shortened RWY, 44 closed RWY

  Presented during the TRB Webinar "Safety of the RWY Operations during Construction WKS" in Nov. 2015

2. The research project

2.2 Methodology

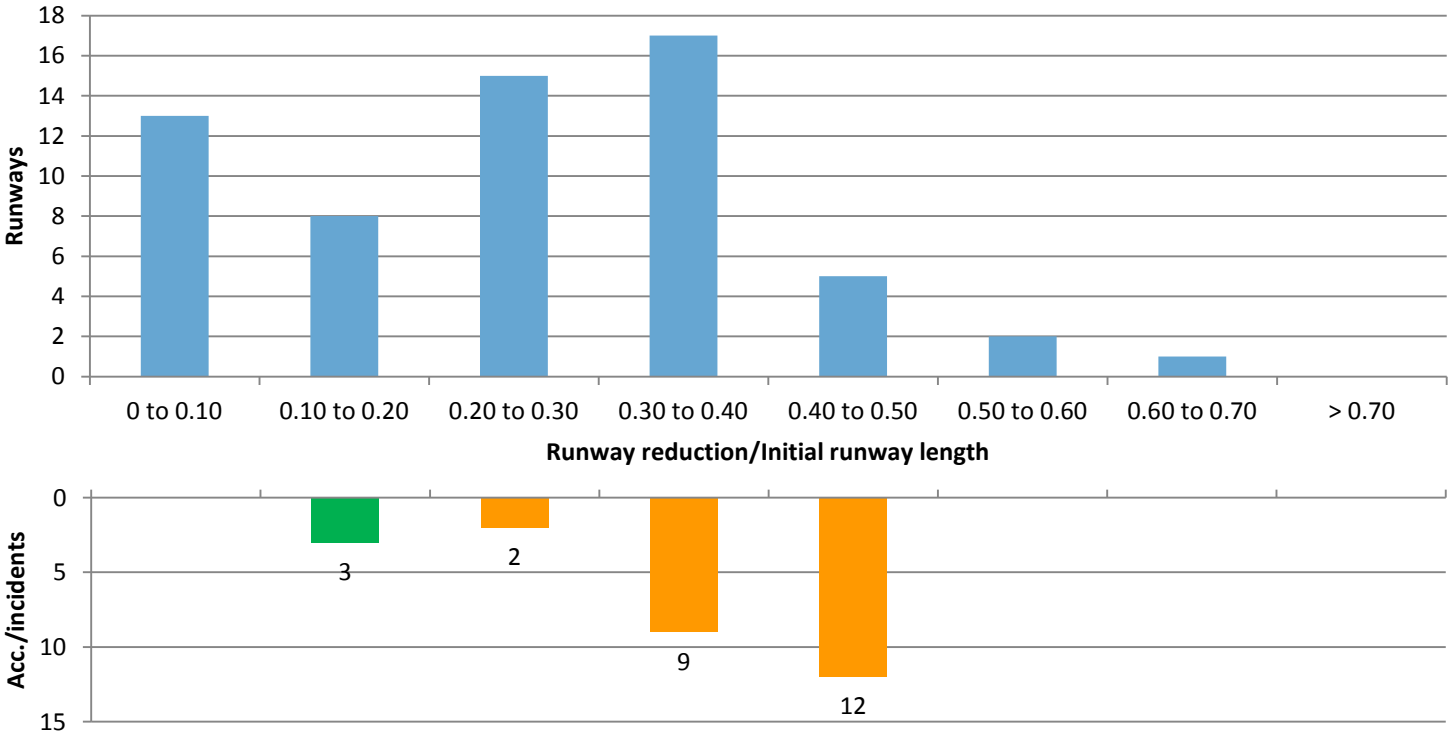
1. Collect construction works on shortened and closed runways
2. Collect accidents/incidents during runway construction works
3. Build a database
4. Analyze data and produce statistics
5. Identify hazards and assess the risks (SRA)
6. Identify the best practices and develop recommendations in risk mitigation
7. Share the results with the industry and the air transportation community

3.

Safety risks on shortened runways

3. Safety risks on shortened runways

3.1 Reduction of the runway length



Most of the shortened runways have their length cut by less than 1/10 or by 1/4 to 1/3.
Higher reductions seem correlated to more accidents and incidents (to be completed).

3. Safety risks on shortened runways

3.2 Hazards identification

01	Landing short before the temporary DTHR
02	Landing below the approach path to the DTHR
03	Takeoff long toward the constructions
04	Runway excursion toward the construction site
05	Runway excursion back to the construction site

3. Safety risks on shortened runways

3.3 Safety risk analysis

01 **Landing short before the temporary DTHR**

Airport (IATA)	Date	Description
Vienna (VIE)	1997	Nine landings short before the temporary DTHR.
Porto (OPO)	May 1997	Landing short of a S340 substantially damaged after crossing a trench.
Auckland (AKL)	Nov. 2004	Landing short of a B777 before the displaced threshold on a construction area.
Yerevan (EVN)	May 2005	Landing short of an A300-600 before the temporary DTHR.
Perth (PER)	Apr. 2005	Landing short of an A340-200 before the temporary DTHR.
Perth (PER)	May 2008	Two interrupted approaches of a B737 over the initial THR before landing on the DTHR.
Chicago (ORD)	May 2009	Touchdown of a MD80 before the temporary DTHR and Go Around.
Mumbai Intl. (BOM)	Nov. 2009	Two interrupted approaches of an A320 over the initial THR before landing on the DTHR.

3. Safety risks on shortened runways

3.3 Safety risk analysis

01	Landing short before the temporary DTHR

- **In the undershoots of Porto (1997), Perth (2005 and 2008) and Mumbai (2009), the initial threshold markings were not removed. Investigations on Porto and Perth identified these dual threshold markings as one of the causes of the incidents.**

- **The temporary markings in Perth and Mumbai were not compliant with the international standards. In addition, in Perth, the contractor closed the unserviceable section of the runway with crosses of 6 m (20 in) instead of 36 m (120 in).**

- **After the undershoot of Chicago (2009), discussions with the stakeholders concluded the displacement was not sufficiently highlighted despite fully compliant markings. Also, the removal of the existing paintings left confusing marks.**

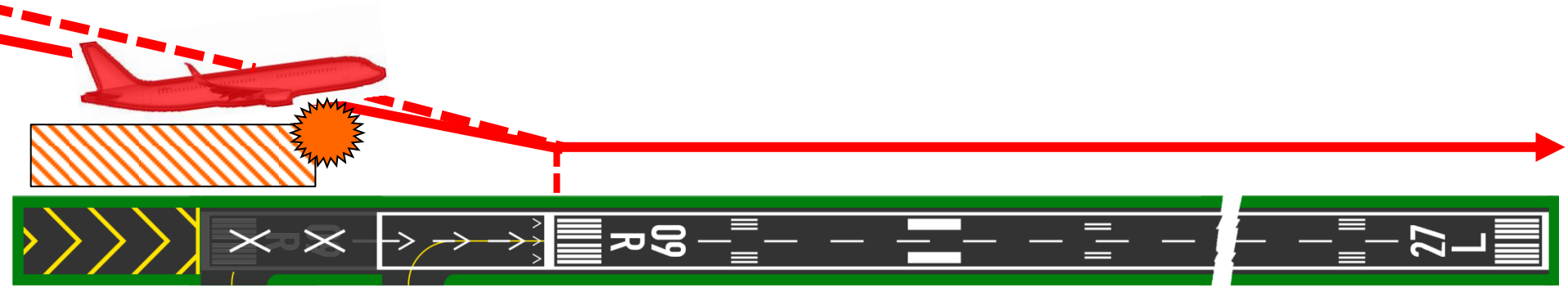

Mumbai, 2012


Perth, 2008

3. Safety risks on shortened runways

3.3 Safety risk analysis

02	Landing below the approach path to the DTHR



Airport (IATA)	Date	Description
Vnukovo (VKO)	June 2011	Premature loss of height during the landing on a DTHR. The A330 snagged a wire fence.

3. Safety risks on shortened runways

3.3 Safety risk analysis

02	Landing below the approach path to the DTHR

- **In the undershoot of Vnukovo (2011), an A330 hit the perimeter of the construction works on the crossing runway with the section of the other runway still active.**

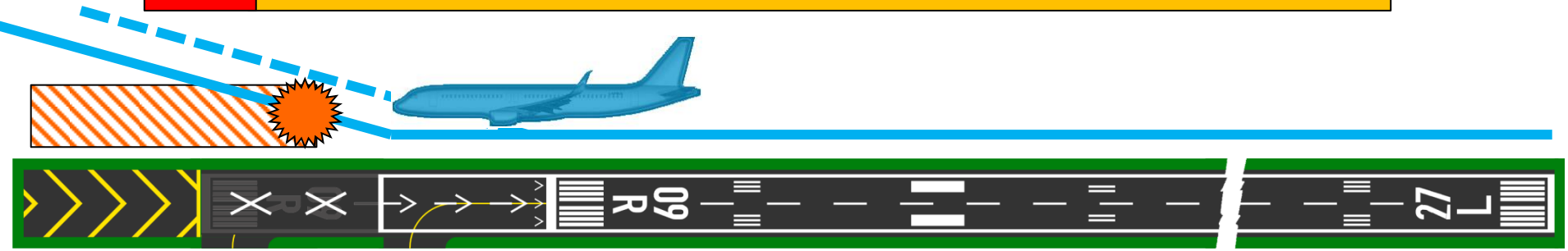
- **Fortunately, the fencing was not made of blast fences but of wire fence. The aircraft sustained minor damages to the main gear and the fuselage.**

- **NAVAIDS and procedures: Landing on the DTHR only during daylight. No temporary PAPI. The DME was only available for confirming the GP Interception Point. LOC and NDB available.**

3. Safety risks on shortened runways

3.3 Safety risk analysis

03 **Takeoff long toward the constructions**



Airport (IATA)	Date	Description
Vienna (VIE)	1997	Too long takeoff based on full RWY lengths. Blast fences cleared by 5 m (16 ft).
Manchester (MAN)	July 2003	Too long takeoff of a 737 based on full RWY lengths. 14 ft-high machine cleared by 17 m (56 ft).
Auckland (ACK)	Mar. 2007	Too long takeoff of a 777 based on full RWY lengths. Work vehicles cleared by 28 m (92 ft).
Paris (CDG)	Aug. 2008	Too long takeoff of a 737 based on full RWY lengths. Blast fences cleared by a short margin.
Chicago (ORD)	Sept. 2009	Too long takeoff of a MD10 based on full RWY lengths. Construction cleared by a short margin.
Chicago (ORD)	Sept. 2009	Too long takeoff of a 747 based on full RWY lengths. Construction cleared by a short margin.
Paris (CDG)	2012	3 ACFT cleared to T/O only by the TWY providing the longest TORA, entered by intermediary TWY.
Prague (PRG)	July 2012	Too long takeoff of an A319 based on full RWY lengths. Construction cleared by a short margin.

3. Safety risks on shortened runways

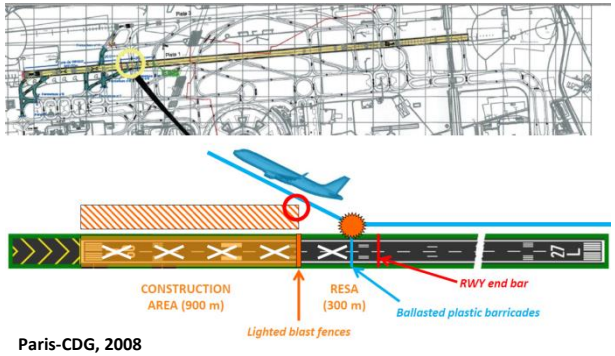
3.3 Safety risk analysis

03	Takeoff long toward the constructions

- **Before all the listed events, an Annex 15 compliant aeronautical information was published (NOTAM, AIP or AIP SUP). At ORD (2009) and CDG (2012), stakeholders were briefed on the modifications of the runway operating conditions. However, the information did not reach all the cockpits.**

- **At ACK (2007), CDG (2008) and ORD (2009), pilots misunderstood or missed the meaning of the ATC messages. At ORD, the instruction "taxi to RWY10 full length" (for the longest but reduced TORA available) contributed to performance calculations based on the usual lengths. At CDG (2008), the reduced distances were reminded by the ATC to the crew.**

- **In all the 7 takeoffs, the pilot in function succeeded in clearing the construction site by reacting after identifying the works.**



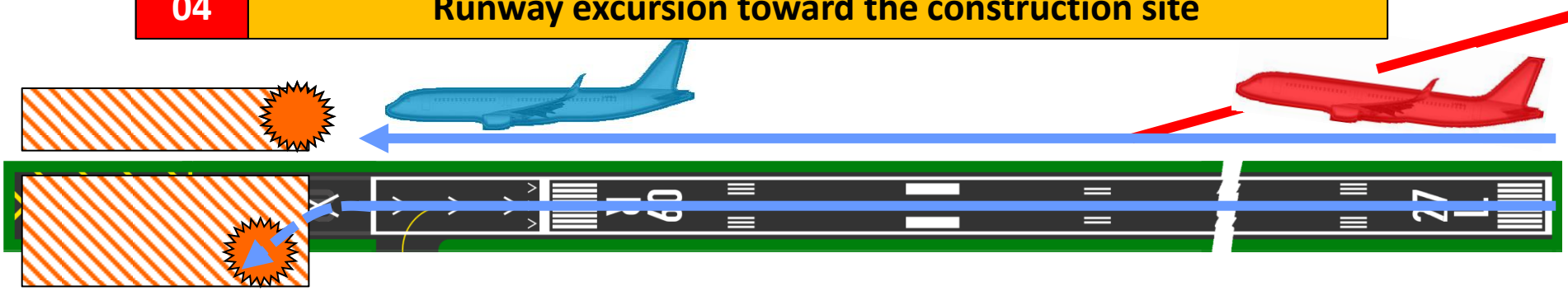
Paris-CDG, 2008


O'Hare, 2009

3. Safety risks on shortened runways

3.3 Safety risk analysis

04 **Runway excursion toward the construction site**



Airport (IATA)	Date	Description
Chicago (ORD)	May 2009	A CRJ ended its landing after the temporary end of the runway and stopped on the pavement.
Abuja (ABV)	Dec. 2013	A 747 overran the RWY and collided with machines, trucks and a construction cabin. No injuries.
Tamale (TML)	Oct. 2015	A BAe 146 received substantial damages in ending its landing in the works of a runway extension.
Non-construction related accidents and incidents		
Paris (CDG)	Oct. 2000	Veer-off with dissymmetric thrust. The ACFT stopped beyond the CAT I protections.
Paris (CDG)	Nov. 2000	Rejected takeoff after V1. Overrun of the end of the runway.
Toronto (YYZ)	Aug. 2005	Long overrun of a 777 on a contaminated runway after a late touchdown.
Brussels (BRU)	May 2008	Rejected takeoff after V1. Overrun of the end of the runway.

3. Safety risks on shortened runways

3.3 Safety risk analysis

04	Runway excursion toward the construction site

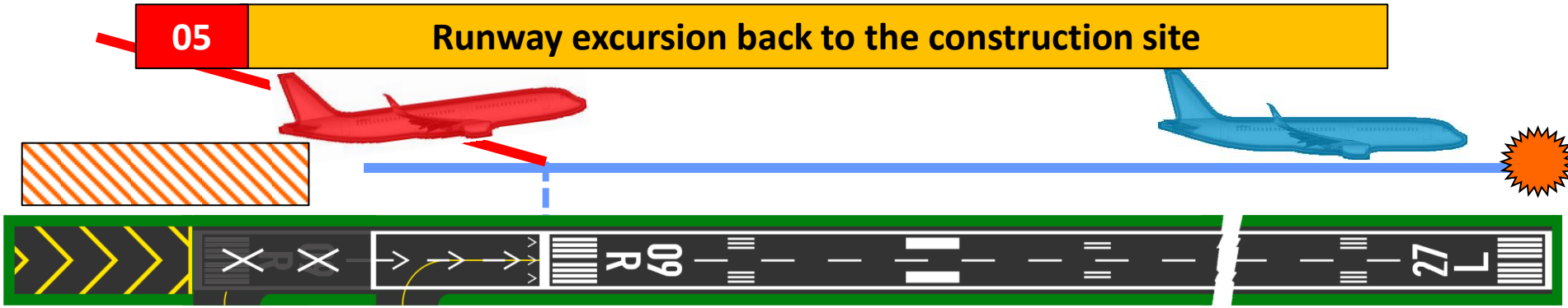
- **When landing toward the construction works, performing it based on non-reduced Landing Distance Available (LDA) is a hazard.**

- **When a runway is shortened, the likelihood of a runway excursion based on up-to-date reduced lengths is higher due to shorter available distances. The criticality is also increased (incursion into the construction site). Excursions occur during landings and takeoffs, including rejected takeoffs (RTO) after V1.**

- **Exceptional takeoff overruns (BRU, 2008), landing overruns (YYZ, 2005) and landing veer-offs (CDG, 2000) show trajectories ending far beyond the limits of the runway.**

3. Safety risks on shortened runways

3.3 Safety risk analysis



Airport (IATA)	Date	Description
Mumbai (BOM)	Oct. 2009	Landing overrun of an ATR72 on a wet and shortened runway.
Vnukovo (VKO)	May 2011	Landing overrun of a Yak 42.
Oslo (OSL)	May 2015	A 737 ended its landing on the paved surface of the RESA.
Non-construction related accidents and incidents		
Paris (CDG)	Oct. 2000	Veer-off with dissymmetric thrust. The ACFT stopped beyond the CAT I protections.
Paris (CDG)	Nov. 2000	Rejected takeoff after V1. Overrun of the end of the runway.
Toronto (YYZ)	Aug. 2005	Long overrun of a 777 on a contaminated runway after a late touchdown.
Brussels (BRU)	May 2008	Rejected takeoff after V1. Overrun of the end of the runway.

4.

Safety risks on closed runways

4. Safety risks on closed runways

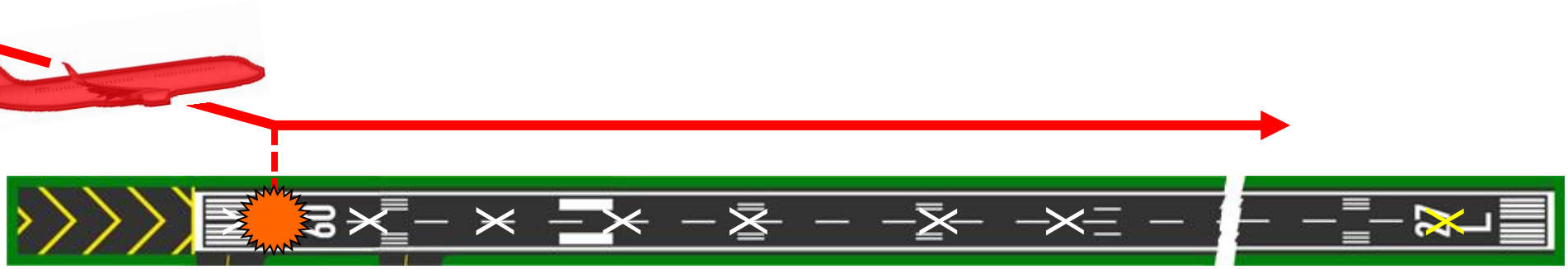
4.1 Hazards identification

A	Landing on a closed runway
B	Takeoff from a closed runway
C	Increase of likelihood in certain risks on the remaining runways

4. Safety risks on closed runways

4.2 Safety risk analysis

A **Landing on a closed runway**



Airport (IATA)	Date	Description
Menorca (MAH)	Apr. 2011	LD on a runway closed by ICAO white crosses. Agents and a vehicle on the RWY. No injuries.
Katowice (KTW)	July 2014	LD of a CRJ on a RWY in construction. Closed by two white crosses on a black square. No injuries.
El Paso (ELP)	Apr. 2015	733 cleared to land on a closed runway. Workers evacuated when seeing the ACFT. No injuries.
Krasnodar (KRR)	Aug. 2015	LD of a BAe 146 on a runway closed for rehabilitation. No injuries.

4. Safety risks on closed runways

4.2 Safety risk analysis

A **Landing on a closed runway**

- **The runways at MAH, KTW and KRR were closed for a long period. At ELP, the runway was closed for the day only. All the airports published NOTAM or AIP SUP on these closures.**

- **At MAH and KTW, the runways were closed by long white crosses. At KTW and KRR, the runways were rehabilitated. The bearing pavements were complete. At MAH and ELP, workers and vehicles were on the runway.**

- **These runways were closely-spaced and parallel with an active runway, except at ELP (convergent and staggered). At MAH and KTW, the crews landed on the other runway despite a correct clearance. At ELP, the aircraft was cleared to land on the wrong runway.**

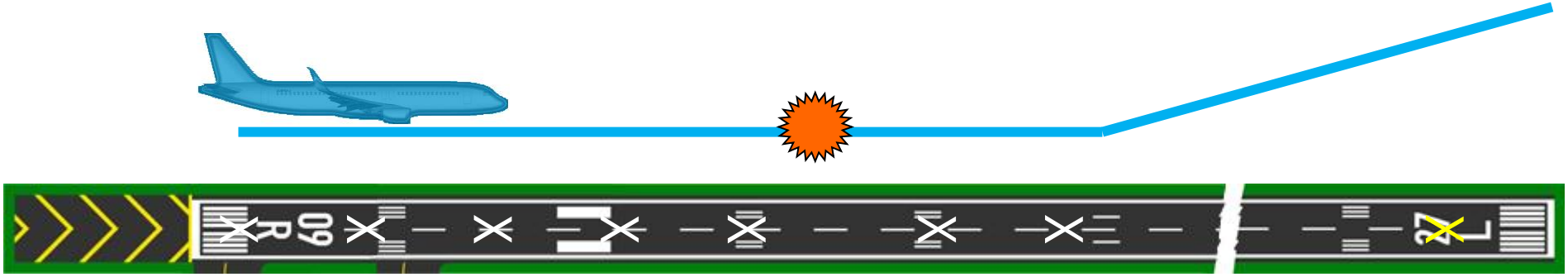

Menorca, 2011


Katowice, 2014

4. Safety risks on closed runways

4.2 Safety risk analysis

B **Takeoff from a closed runway**



Airport (IATA)	Date	Description
Taipei (TPE)	Oct. 2000	Takeoff of a 747 from the wrong closely-spaced and parallel runway. Crash into the construction.
Non-construction related accidents and incidents		
Lexington (LEX)	Aug. 2008	Takeoff of a CRJ from the wrong runway (shorter). Overrun with multiple fatalities.

4. Safety risks on closed runways

4.2 Safety risk analysis

B **Takeoff from a closed runway**

- **The accidents at Taipei (TPE) and Lexington (LEX) demonstrate that takeoffs from a wrong runway are possible on closely-spaced parallel runways (TPE) as crossing runways (LEX).**

- **At TPE, the parallel runway was closed for construction works. It was not physically closed from the threshold as partly used as a taxiway. Due to low visibility conditions, the crew of the 747 confused the runway they were cleared with the one in maintenance.**

- **At LEX, the crew was distracted and confused by two close thresholds of crossing runways with very different length.**

4. Safety risks on closed runways

4.2 Safety risk analysis

C **Increase of likelihood of certain risks on the remaining runways**

Airport (IATA)	Date	Description
New Orleans (MSY)	Apr. 2011	A 320 came back to the airport due to smoke in the cockpit. After performing an emergency landing, the aircraft overrun the end of the runway. The main and longer runway was in maintenance, and it was not evacuated on time for allowing the aircraft to land on it.

5.

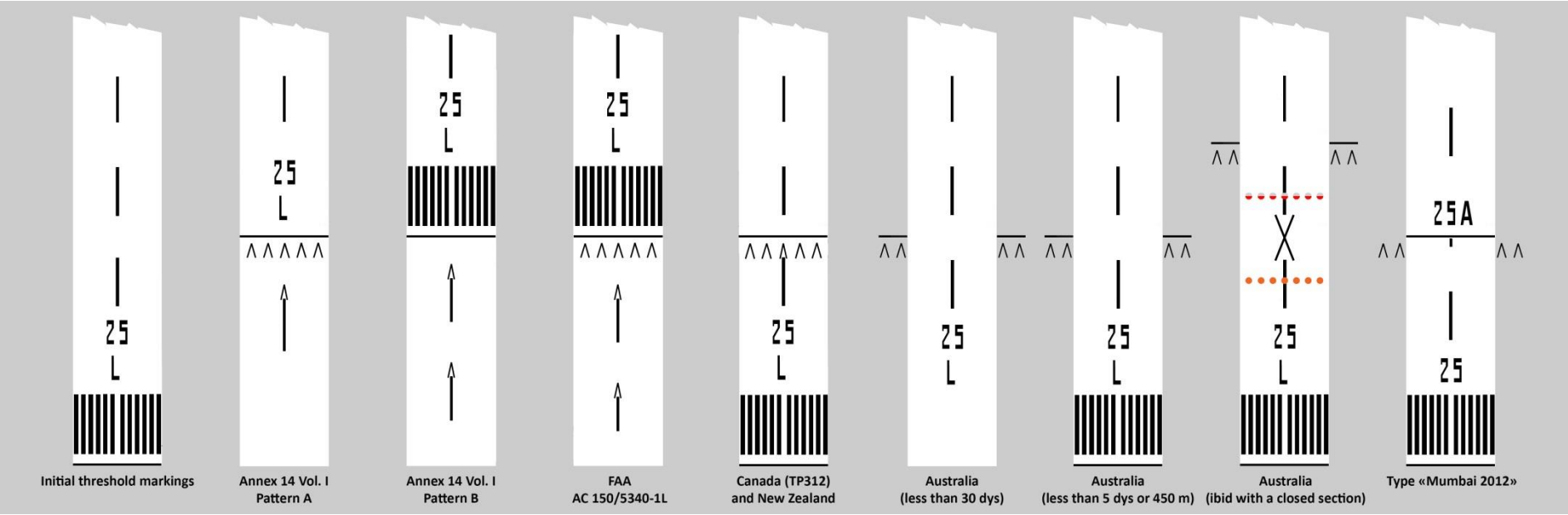
Best practices and recommendations

5. Best practices and recommendations

5.1 Markings and lighting

01 03 04 05

From a region to another, the visual experience changes when landing on a temporarily displaced threshold. Local rules and practices vary from the international standards. They sometimes include provisions for “simplified” markings. These can be confusing, especially for foreign pilots. Also, keeping the initial markings has been clearly identified as a cause of undershoot.



5. Best practices and recommendations

5.1 Markings and lighting

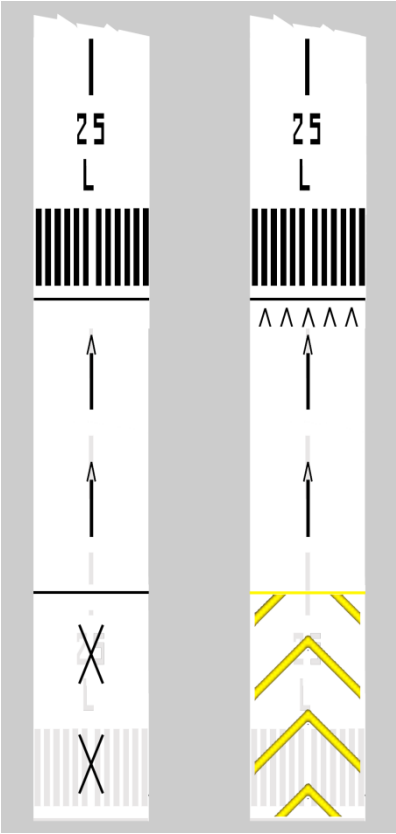
01 03 04 05

The most comprehensive and recognized standard patterns provide clear and univocal markings. Initial markings should be carefully removed or occulted. All the markings of the initial threshold should be relocated (no simplification even if the runway is downgraded to non-precision or visual).

The relocation should be highlighted by “wing bars” (threshold and runway end light bars on the sides of the runway). They are necessary if night operations are conducted. The eventual closed section should be clearly marked as unserviceable.

A temporary PAPI visually confirms the displacement of the landing slope and of the touchdown zone.

The markings and lighting are the first safety net when landing. Let’s be simple and comprehensive!



5. Best practices and recommendations

5.2 Runway closed markings

01 A

Observations of long H24 closures show that:

- **The crosses are not all always on the runway (69%),**
- **They are not always compliant (wrong size, dissymmetry, etc.) (69% deviations with An. 14 and 31% with Part 139).**

For the rehabilitation of RWY08R/26L in 2014, Paris-CDG used mobile crosses made in fabric. The fabric was strongly clipped on a wood frame equipped with wheels. Only four workers were necessary to move it by hand without effort. During the works on the pavement, they were relocated on the shoulders or the immediate vicinity of the runway strip.

All along the constructions, all the mandatory crosses were in place for protecting the runway against incursions.

Mobile crosses are a cheap and safe alternative to paintings.

Paris-CDG, 2014

5. Best practices and recommendations

5.2 Runway closed markings

01 A

Paintings (not mobile)	Geotextiles	Heavy plates	Wood and fabric
✓ Do not need ballast ✓ Trucks can drive on it × Removed by pavement demolition/construction × Leave post-removal scarrings and marks × Visibility can be degraded by vehicles passes (dirt) × Require painting operations × Require painting removal	✓ Can be kept on or aside the runway all the time ✓ Do not leave post-removal scarrings and marks ✓ Easy to install ✓ Easy to remove/relocate × Geometry needs to be checked on the field × Require constant care (perforated ballast, etc.) × Wind sensitive × Need ballasts. They can compromize the visibility. × Trucks cannot drive on it	✓ Can be kept on or aside the runway all the time ✓ Do not leave post-removal scarrings and marks ✓ Stable under the wind ✓ Do not need ballast ✓ Do not need constant care × Installation and removal are not easy × Geometry needs to be checked on the field	✓ Can be kept on or aside the runway all the time ✓ Do not leave post-removal scarrings and marks ✓ Stable under the wind ✓ Easy to install ✓ Easy to remove ✓ Do not need ballast ✓ Do not need constant care × Contacts with vehicles damage the cross

5. Best practices and recommendations

5.3 Color and contrast of the crosses

01 A

Past incidents involved aircraft landing on runways closed by ICAO compliant white crosses. At Katowice (2014), they were even highlighted by a black background.

Is white really the most relevant color, since it is used for operative runway markings?

The FAA requires yellow crosses. At Narita (2009), yellow and white crosses were used resp. on cement concrete (clear) and asphalt concrete (dark). In Tianjin (2009), Katowice (2014) after the incident, and Berlin (BER), red/orange crosses were applied on clear concrete. During the construction of a new independent runway, BER used black crosses on the clear (white) area of construction.

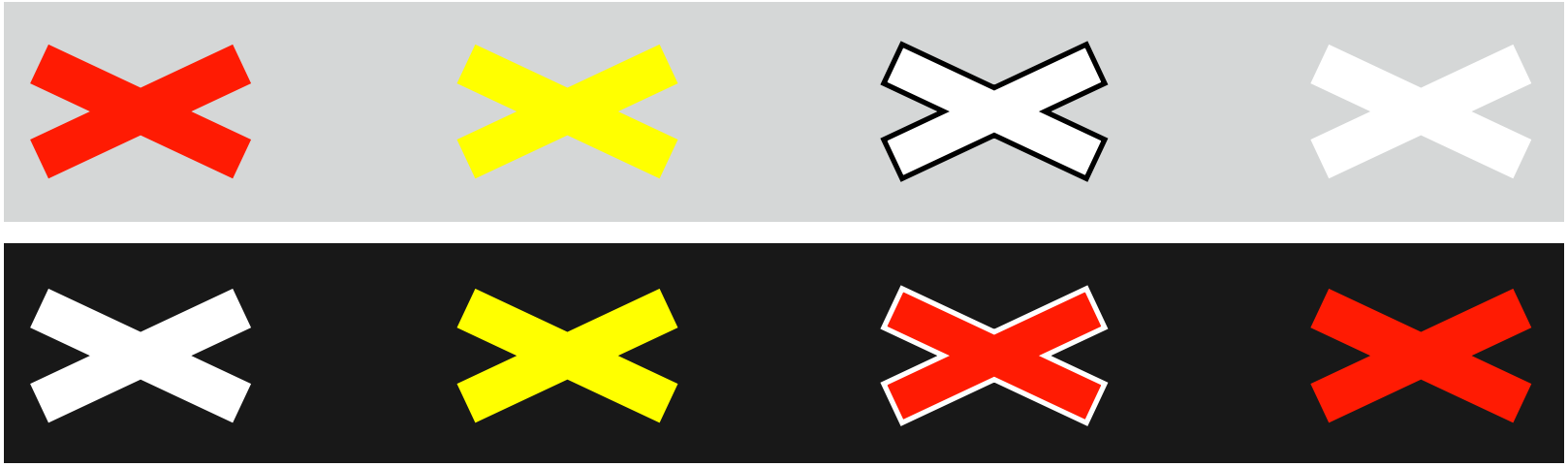
Crosses should contrast with the pavement and alert the pilots on the runway status.

5. Best practices and recommendations

5.3 Color and contrast of the crosses

01 A

Paris-CDG has been working of closure markings contrast and visibility since 2014. During the next runway rehabilitation in 2016 (RWY08L/26R), evaluations will be conducted with pilots. They will involve 36 m-long crosses of different colors on different types and colors of pavement.



5. Best practices and recommendations

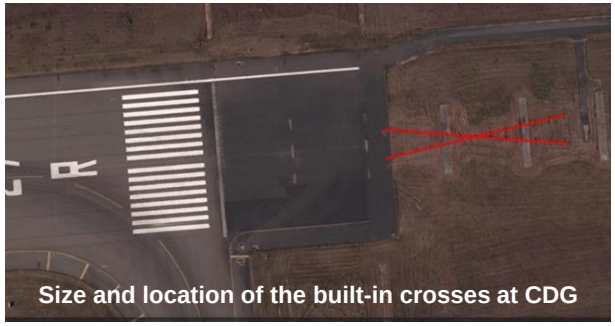
5.4 Lighted crosses

A

Portable vertical lighted "X" are now common devices. Located at the threshold, they provide a visual information to the crews during short (e.g. night maintenance) and long (e.g. H24 rehabilitation) runway closures, especially by night and low visibility conditions.

Paris-CDG has been developing built-in lighted crosses installed before the threshold. They are controlled from the tower. They can be activated for punctual closures e.g. FOD removal (not protected today).They should be evaluated on the field in 2016.

Lighted crosses are the only direct visual safety net for short periods of closure and night operations.



Size and location of the built-in crosses at CDG

5. Best practices and recommendations

5.5 Temporary information signage

03 04 05

Takeoffs based on initial “full” TORA show the need of a special signage during construction works, different than the usual “TORA” signs on the entrance taxiways.

The FAA evaluated Orange Construction Signs at various airports in the U.S. Paris-CDG conducted similar evaluations, and developed a set of short messages for the different airfield modifications. Oslo also used in 2015 an orange background for displaying reduced TORA, along the word “SHORTENED”.

Feedbacks from the field about these innovative signs are very positive. They increase the situational awareness.

The Orange Construction Sign is a cheap, simple and efficient mean for preventing takeoffs based on erroneous TORA.

CDG, 2015

OSL, 2015

5. Best practices and recommendations

5.6 Phraseology

01 02 03 04 05

- **The words "SHORTENED" and "DISPLACED" alert the pilots about the modification of the runway, as stating the temporary TORA and asking confirmation from the crew. Avoid "FULL LENGTH" for designating the maximum but reduced TORA available (confusing).**

- **Changing the name of the runway or access taxiways increases the situational awareness:**
  - **At CDG (2012), the access taxiway for taking off facing the constructions was designated TWY R1 "WORKS",**
  - **At BOM (2009), RWY 27 was re-designated 27A when relocated. At BLR (2012), RWY09 and RWY27 were labeled 09D and 27D. At STN (2015), the thresholds of the unique runway were RWY 04"C" and RWY 22"C".**
  - **At OSL (2015), the procedures were called with a suffix "X" or "Z" depending on the period of different threshold relocations. The operators were invited to use the same designators in their performance databases.**

Paris-CDG, 2012

To avoid miscalculation of ACFT performance, the performance databases should use the same designators for RWY options as the relevant RWY configuration, i.e. X in phase one and Z in phase two.

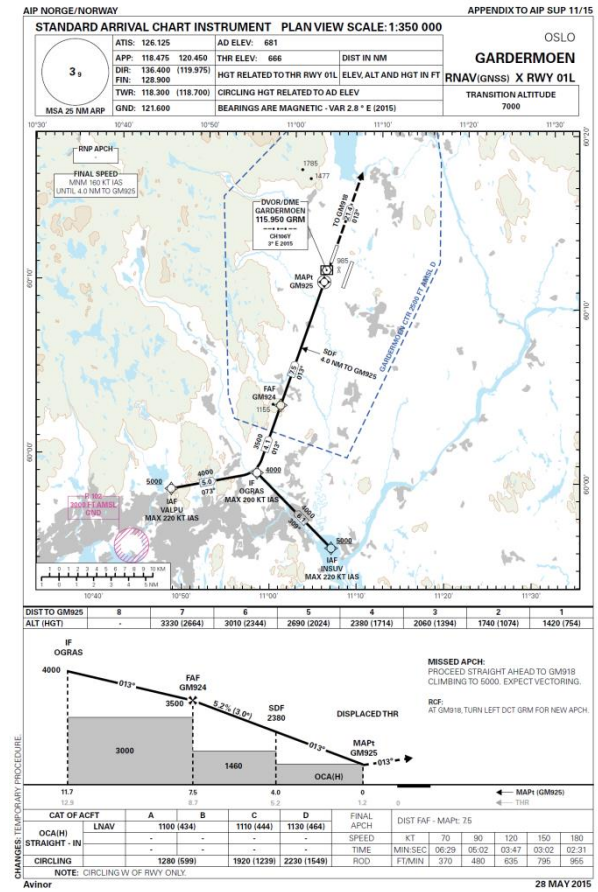
Oslo (AIP SUP), 2015

Phraseology is a powerful and real-time tool for informing the crew and preventing accidents.

5. Best practices and recommendations

5.7 Procedures

01 02 04 05



When a landing threshold is temporarily relocated, the Glide Path of the ILS is not valid. ILS precision approaches are not possible.

Alternate non-precision procedures include:

- **LOC-DME (alignment and distance measurement)**
- **VOR-NDB (radial position and distance measurement)**

Airports (JFK, OSL) start to propose temporary RNAV GNSS for the approaches to the temporary DTHR.

RNAV GNSS offers new opportunities of temporary approach procedures during construction works.

5. Best practices and recommendations

5.8 Aeronautical info.

01 02 03 04 05 A B

Aeronautical information is one of the biggest concern during construction works. The experience shows that the information does not always reach the cockpit and the pilots.

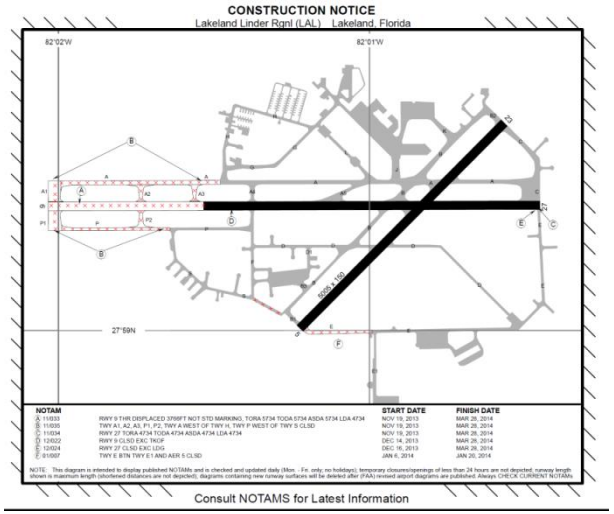
For maximizing the efficiency of the publications:

- **Publish procedures and charts on AIRAC cycles,**
- **Avoid non-AIRAC publications,**
- **Use Construction Notice (FAA) or AIP SUP (non-US) on top of NOTAMs.**

The best practices include:

- **Provide clear information on the ATIS,**
- **Email the information providers (LIDO, Jeppesen, etc.),**
- **Directly brief and email airlines and pilots' representatives.**

Information prior and during the modification is a key challenge. The "Annex 15 information" is necessary but not sufficient by itself.



LAL 11/035 LAL TWY A1, A2, A3, P1, P2, TWY A WEST OF TWY H, TWY P WEST OF TWY S CLSD 1311192028-1403282100
LAL 11/034 LAL RWY 27 DECLARED DISTANCES: TORA 4734 TODA 4734 ASDA 4734 LDA 4734. 1311192029-1403282100
LAL 11/033 LAL RWY 9 THR DISPLACED 3766FT NOT STD MARKING. DECLARED DISTANCES: TORA 5734 TODA 5734 ASDA 5734 LDA 4734. 1311192029-1403282100
LAL 11/021 LAL NAV ILS RWY 9 GP OUT OF SERVICE 1311181200-1403182359EST
LAL 11/020 LAL RWY 9 PAPI OUT OF SERVICE 1311181200-1403182359EST
LAL 11/019 LAL RWY 9 ALS OUT OF SERVICE 1311181200-1403182359
LAL 11/013 LAL RWY 27 ALL DISTANCE REMAINING SIGNS MISSING 1311082156-1403312200
LAL 11/012 LAL RWY 9 ALL DISTANCE REMAINING SIGNS MISSING 1311082154-1403312200

5. Best practices and recommendations

5.9 Avoiding takeoffs on closed runways

B

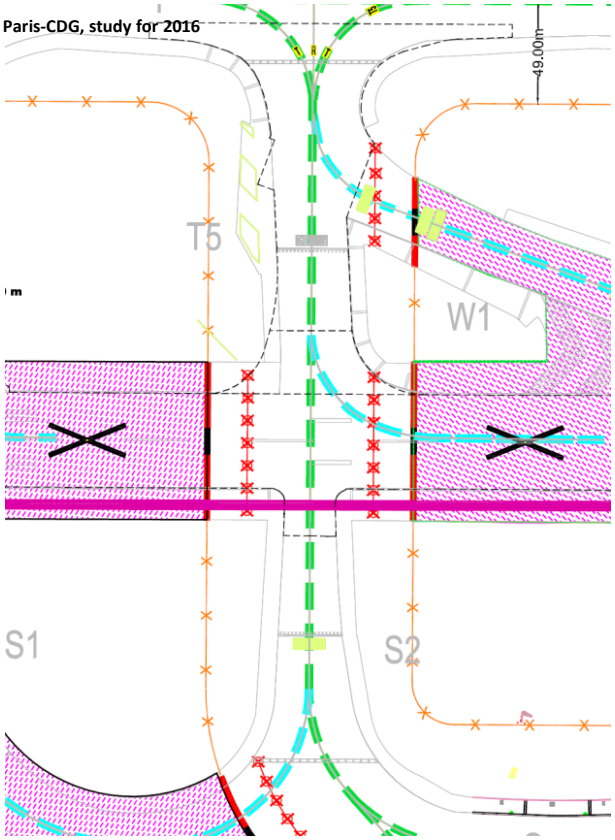
Observations on closed runways show that:

- **Aircraft used part of the runway to taxi (21%),**
- **Aircraft cross the closed runway (70%),**
- **Aircraft operate on a crossing active runway (32%).**

Consequently, a Taipei-like accident is possible if all the accesses to a closed runway are not clearly blocked. Indeed, pilots on the ground do not have visual aids for identifying a runway closures, especially in low visibility procedures.

At CDG, when aircraft have to cross the closed inner runway for operating from the closely-spaced outer runway, the paths across the closed runway are now protected by a continuous line of red and white concrete blocks and red edge lights.

It is better an aircraft hurts a concrete block at the taxi speed than construction machines at the takeoff speed.



5. Best practices and recommendations

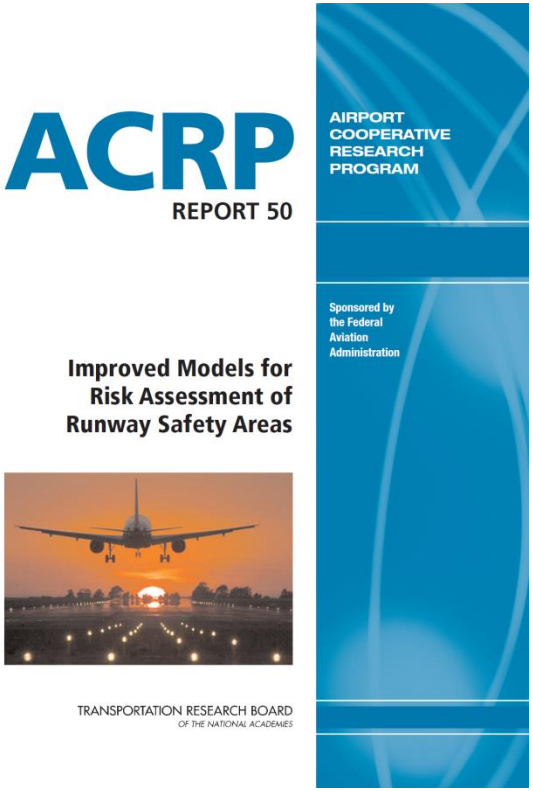
5.10 Runway excursion risk assessment

04 05

Reducing the runway, or closing a runway and diverting its traffic on a shorter runway, modify the likelihood of a runway excursion. The location of construction works also increase the criticality of an overrun or a veer-off.

The risk of runway excursion should be re-assessed when runway construction works are conducted. On top of performance calculations with your airlines, guidelines and tools are available on runway excursions (ACRP Reports, assessment matrix, etc.).

Runway constructions can modify the risk of runway excursion at the airport.



6.

Conclusion and perspectives

6. Conclusion and perspectives

- **Runway constructions are the most critical airside works possible.**
- **The markings and lighting are the first safety nets. Following the standards dramatically reduce the risks, especially at airports with multiple airlines and international traffic.**
- **Application of provisions for “simplified” markings on “short term” modification should be carefully considered.**
- **Pilots and the ATC are the last safety nets before the accident. The aeronautical information, the phraseology and the signage should be simple, useful for the pilots and straight-to-the-point.**
- **Safety assurance is a key issue. Daily self-inspections of the construction sites based on checklists are necessary. Initial and final inspections should involve controllers and pilots.**

6. Conclusion and perspectives

- **Being compliant to the standards is not sufficient. Standards do not address local specificities. Standards can also be “incomplete”. SMS fills the gaps…**

- **The failure of the “good old” certainties must be considered when assessing the risks of runway construction projects: NOTAMs can never reach a cockpit, clearances can be wrong or misinterpreted, markings can be not perceived.**

- **Cheap, simple and efficient means exist for mitigating these risks. A lot of them are best practices and innovations developed by the airside operations community: “from the field to the field”.**

- **Few airports have encountered catastrophic accidents or performed temporary DTHR, but we have all together an extensive collective experience of these operations.**

- **Experience sharing and collaborative innovation save life… but also time and money. Let’s be proactive all together!**

Appendix – Complements for Safety Risk Assessment

A1 – Safety risks on shortened runways

01	Landing short before the temporary DTHR

Risks:

- **"High energy" collision with an active construction works leading to the destruction of the aircraft,**
- **"High energy" collision with or jet blast on workers with consequent serious to catastrophic injuries,**
- **Landing on an unsuitable surface (open trenches, etc.) causing significant damages to the aircraft.**

Criticality: catastrophic (possible fatalities)

Causes:

- **Pilots do not have information available on the shortened runway,**
- **Pilots forgot/miss the information on the runway reduction,**
- **Confusion between the initial threshold and the temporary DTHR,**
- **The markings of the initial threshold are still visible,**
- **The markings of the temporary threshold are not or insufficiently visible,**
- **The markings of the temporary threshold are not recognized (if non standard).**

Appendix – Complements for Safety Risk Assessment

A1 – Safety risks on shortened runways

02	Landing below the approach path to the DTHR

Risks:

- **Collision with an active construction works and/or heavy vehicles leading to the destruction of the aircraft,**
- **Jet blast on workers with consequent serious injuries,**
- **Unstabilized approach conducting to a runway veer-off or overrun.**

Criticality: catastrophic

Causes:

- **Non compliant approach with a descent initiated too early (e.g. before the Final Approach Fix),**
- **Non compliant approach with a higher rate than expected,**
- **Unstabilized approach.**

Appendix – Complements for Safety Risk Assessment

A1 – Safety risks on shortened runways

03	Takeoff long toward the constructions

Risks:

- **High speed collision with an active construction works leading to the destruction of the aircraft.**

Criticality: catastrophic

Causes:

- **Pilots do not have information available on the shortened runway,**
- **Pilots forgot/miss the information on the runway reduction,**
- **Misunderstanding of the aeronautical information,**
- **Misunderstanding of the controller's messages and clearance,**
- **The shortened TORA is not displayed on the field,**
- **The shortened TORA is not clearly displayed on the field,**
- **The aeronautical information is not clear and simple.**

Appendix – Complements for Safety Risk Assessment

A1 – Safety risks on shortened runways

04	Runway excursion toward the construction site

Risks:
- Collision with an active construction works and/or heavy vehicles leading to the destruction of the aircraft,
- Collision with workers with consequent serious to catastrophic injuries,
- High speed taxiing on unsuitable surfaces causing damages to the aircraft.

Criticality: catastrophic

Causes:
- Pilots do not have information available on the shortened runway,
- Pilots forgot/miss the information on the runway reduction,
- The aeronautical information is not clear and simple,
- Usual external factors of runway excursions (weather conditions, wet runway, etc.),
- Usual human factors of runway excursions (unstabilized approach, atypical thrust applied, etc.).

Appendix – Complements for Safety Risk Assessment

A1 – Safety risks on shortened runways

05	Runway excursion back to the construction site

Risks:

- **High speed taxiing on non paved/unsuitable surfaces with damages to the undercarriage or the structure,**
- **Serious to catastrophic consequences if the trajectory ends beyond the end of the RSA/RESA.**

Criticality: minor to catastrophic (depending on the RSA/RESA and the risk of RWY excursion during the WKS)

Causes:

- **Pilots do not have information available on the shortened runway,**
- **Pilots forgot/miss the information on the runway reduction,**
- **The aeronautical information is not clear and simple,**
- **Typical external factors of runway excursions (weather conditions, wet runway, etc.),**
- **Typical human factors of runway excursions (unstabilized approach, atypical applied thrust, etc.).**

Appendix – Complements for Safety Risk Assessment

A2 – Safety risks on closed runways

A	Landing on a closed runway

Risks:
- Collision with an active construction works and/or heavy vehicles leading to the destruction of the aircraft,
- Collision with or jet blast on workers with consequent serious to catastrophic injuries,
- Landing on an unsuitable surface (works in progress, etc.) causing significant damages to the ACFT.

Criticality: catastrophic

Causes:
- Pilots do not have the aeronautical information available on the closed runway,
- Pilots forgot/miss the aeronautical information on the closed runway,
- Pilots do not see or perceive the crosses,
- Pilots see the first crosses and believe they just mark a short unserviceable area before the threshold,
- Pilots confuse two runways,
- Wrong or confused clearance from the ATC,
- The closure markings are missing or not clearly visible.

Appendix – Complements for Safety Risk Assessment

A2 – Safety risks on closed runways

B	Takeoff from a closed runway

Risks:
- Collision with an active construction works and/or heavy vehicles leading to the destruction of the aircraft,
- Collision with or jet blast on workers with consequent serious to catastrophic injuries,
- Landing on an unsuitable surface (pavement in construction, etc.) causing significant damages to the ACFT.

Criticality: catastrophic

Causes:
- Pilots do not have the available information on the closed runway,
- Pilots forgot/miss the aeronautical information on the closed runway,
- Confusion between two runways with close thresholds,
- Confusion with two runways when crossing first the closed runway to join the active runway,
- Wrong or confused clearance from the ATC,
- The runway is not clearly closed from its access taxiways.

Appendix – Complements for Safety Risk Assessment

A2 – Safety risks on closed runways

C	Increase of likelihood in certain risks on the remaining runways

Risks:

- **Risks related with runway excursion (the traffic is diverted on a shorter runway),**
- **Risks related with runway incursion (the traffic is diverted on a runway subjected to incursions),**
- **Etc.**

Criticality: variable (depend on the hazard leading to the risks with an increased likelihood).

Causes:

- **Variable.**

Appendix – Complements for Safety Risk Assessment

A3 – Other hazards during runway construction works

- **Incursion of a vehicle or a pedestrian on the shortened runway**
- **Incursion of a vehicle or a pedestrian on an adjacent runway (esp. on closely-spaced runways)**
- **Incursion of a vehicle or a pedestrian on a taxiway**

- **Disturbance of the NAVAIDS of the shortened runway (by the constructions)**
- **Disturbance of the NAVAIDS of a closely-spaced runway (by the constructions)**
- **Obstruction to the takeoffs and/or landings by a crane or another vehicle or machine**

- **The constructions block roads used for wildlife mitigation purpose**
- **The constructions compromise the ARFF/RFFS response time**

- **Etc.**

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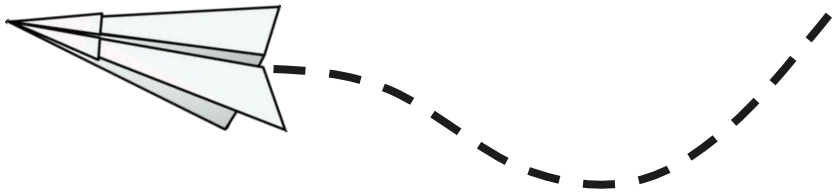

Fly Safe!