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In this issue

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Editorial

Smoke, Fire or Fumes (SFF) is an unwelcome guest onboard a flight and has to be handled immediately before it snowballs into a serious situation. In spite of various precautions, SFF incidents occur in commercial aviation operations.

SFF incidents are not uncommon in commercial aviation. In this issue, we look into some of these incidents and the crew guidance developed by Boeing for handling SFF.

To ease airport congestion and to improve runway turnaround time, Airbus has developed a smart automatic braking system. This system called the Brake-to-vacate (BTV) system is discussed in some detail.

As always, we look forward to your feedback, suggestions and contributions which can be sent to our office address given in this page. Happy reading and many more safe landings.

In-flight Smoke, Fire or fumes (SFF)

Dr.M.S.Rajamurthy

On April 28, 2009, Emirates Airlines flight EK87 from Dubai to Zurich, a Boeing 777-300ER(A6-EBQ) returned to Dubai shortly after takeoff, as the forward cargo hold smoke detector triggered. The airplane landed safely, emergency services found no trace of fire, heat or smoke. A replacement Boeing 777-300ER reached Zurich with a delay of 6.5 hours.

On July 29, 2008, an Emirates Airlines flight from London Heathrow to Dubai, a Boeing 777-300ER, was diverted to Budapest, Hungary after the crew received an alert from a smoke detector. The landing was safe and the alert ceased after landing. A replacement aircraft was dispatched to Budapest, which departed with a delay of 16 hours. The alert was attributed to a short circuit.

On Aug.06, 2008, an Emirates flight from Kuwait to Dubai, a Boeing 777-200 about to take off from Kuwait was halted after smoke was seen coming from its rear. Emirates is the world's largest operator of Boeing 777 with a fleet of nearly 80 aircraft.

On Feb. 26, 2007 at 1000 hrs UTC, United Airlines flight 955 from London (LHR) to San Francisco, California, a Boeing 777-222 experienced an electrical failure during taxi for takeoff. The aircraft was taxied to a nearby stand, and the passengers deplaned via steps. There were no injuries to the 20 crew and 185 passengers.

After pushback from the stand, during the engine start, after the right generator came online, flight deck instrument displays flickered, the crew heard an abnormal noise and an EICAS message, indicated that the right main bus had failed. About 40 seconds after the engines stabilized at ground idle, the smoke detector in the Main Equipment Center (MEC), located below the flight deck and forward vestibule, detected smoke. About two and a half minutes after the electrical failure, the crew felt faint smell of electrical burning on the flight deck, following which the right engine was shut down. The crew were alerted

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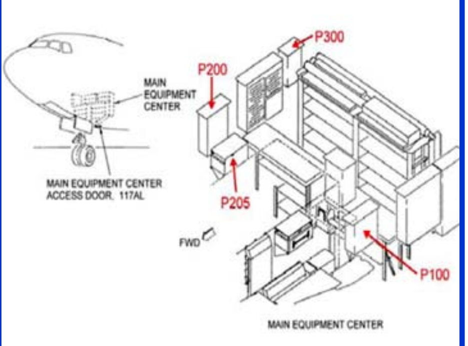


Figure 1. Location of P200 power panel and nearby panels in the MEC

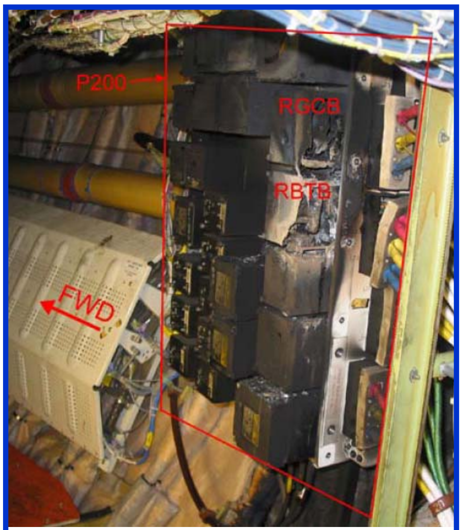


Figure 2. Fire damage to P200 power panel (cover removed), showing burnt-out RGCB and RBTB contactors (viewed looking forward and to the right)

Figure 3. Burnt aircraft structure & insulation blankets located directly below P200 power panel (viewed looking down & aft; the floor panel has been removed)

by the ground handling crew that smoke was coming from MEC vent, and couple of minutes later, ATC advised that smoke was seen coming from the aircraft.

Aircraft Accident Investigation Board (AAIB) of UK investigated the accident.

It found that the electrical failure of right main bus resulted in severe internal arcing and short circuits inside the two main power contactors of the right main bus. The heat generated due to this compromised the contactor casings, causing molten metal droplets to fall down onto the insulation blankets below. The insulation blankets ignited and a fire spread underneath a floor panel to the opposite electrical panel, causing heat and fire damage to structure, cooling ducts and wiring. The figures above show the severity of the damage caused by this failure.

AAIB in its final report of April 2009, made five safety recommendations. Three of these addressed design modifications. The fourth recommendation wanted FAA in conjunction with EASA to mandate that all Boeing 777 aircraft be equipped, at the earliest opportunity, with a software update that will generate a caution message to alert flight crew of the presence of smoke in MEC.

The fifth recommendation wanted the FAA in conjunction with the EASA to mandate that all Boeing 777 aircraft be equipped, at the earliest opportunity, with a containment tray below the open base of the P100, P200 and P300 power panels, to prevent any hot debris from a failed contactor from falling on to insulation blankets or other components and causing heat and fire damage.

SFF events can occur suddenly in commercial operations, but the information about the source of the event may be vague, incomplete, inaccurate, or contradictory. Additionally, there is a wide range of possible sources and situations.

Historically, airlines have provided flight crews with checklists to help them identify and deal with SFF. Until recently, manufacturer and airline checklists varied in format and content. In response to this situation, Boeing worked together with airlines, pilots, and other manufacturers to develop a philosophy and a checklist template to standardize and optimize flight crew responses to non-alerted SFF events (i.e., events not annunciated to the flight crew by onboard detection systems).

These efforts have produced a set of new, industry standard procedures that:

*Define a common approach for manufacturers and airlines to take when developing checklists.

*Define a common set of actions for pilots to expect across multiple models.

*Create an SFF checklist template that addresses key issues that were widely divergent in the industry.

The objective of the checklist template is to provide the best possible crew guidance for managing in-flight SFF events while acknowledging that every SFF situation is different.

As a result, flight crews worldwide now have a single integrated checklist that can be used across all non-alerted SFF events (*see table in the next page*).

The guidance provided by the new template addresses:

* SFF source identification.
* Actions to perform regardless of source.
* Crew communication.
* Timing for diversion & landing initiation.
* Smoke or fumes removal.
* Additional actions to perform if smoke persists.
* Loss of capability and operational consequences.

The Flight Safety Foundation (FSF) sponsored this international industry initiative to improve checklist procedures for airline pilots confronting smoke, fire, or fumes. It also published the *Smoke/Fire/Fumes Philosophy and Definitions*, which was used to construct the SFF checklist template. Here are the key components of this philosophy.

<u>General</u>

* The entire crew must be part of the solution.
* For any smoke event, time is critical.
* The SFF checklist template:
  - Does not replace alerted checklists (e.g., cargo smoke) or address multiple events.
  - Includes considerations to support decisions for immediate landing (e.g., overweight landing, tailwind landing, ditching, forced off-airport landing).
  - Systematically identifies and eliminates an unknown SFF source.
* At the beginning of an SFF event, the crew should consider all the following:
  - Protecting themselves (e.g., oxygen masks, smoke goggles).
  - Communication (e.g., crew, ATC)

SFF CHECKLIST TEMPLATE

STEP	ACTION	RESPONSE
1	Diversion may be required.	
2	Oxygen masks (if required)	On, 100%
3	Smoke goggles (if required)	On
4	Crew and cabin communications	Establish
5	Manufacturer's initial steps	Accomplish
	Anytime smoke or fumes become the greatest threat, accomplish separate ***Smoke or Fumes Removal Checklist.***	
6	Source is immediately obvious and can be extinguished quickly: If **yes** go to Step 7. If **no** go to Step 9.	
7	Extinguish the source. If possible, remove power from affected equipment by switch or circuit breaker on the flight deck or in the cabin.	
8	Source is visually confirmed to be extinguished: If **yes** consider reversing manufacturer's initial steps. Go to Step 17. If **no** go to Step 9.	
9	Remaining minimal essential manufacturer's action steps [These are steps that do not meet the "initial steps" criteria but are probable sources.	Accomplish
10	Initiate a diversion to the nearest suitable airport while continuing the checklist.	
	Warning: If the smoke / fire / fumes situation becomes unmanageable, consider an immediate landing.	
11	Landing is imminent: If **yes** go to Step 16. If **no** go to Step 12.	
12	"X" system actions [These are further actions to control / extinguish source.] If dissipating, go to Step 16.	Accomplish
13	"Y" system actions [These are further actions to control / extinguish source.] If dissipating, go to Step 16.	Accomplish
14	"Z" system actions [These are further actions to control / extinguish source.] If dissipating, go to Step 16.	Accomplish
15	SFF continues after all system-related steps are accomplished: Consider landing immediately. Go to Step 16.	
16	Review Operational Considerations.	
17	Accomplish ***Smoke or Fumes Removal Checklist***, if required.	
18	Checklist complete.	

- Diversion.
- Assessing the SFF situation and available resources.

Source elimination

* It should be assumed pilots may not always be able to accurately identify the smoke source due to ambiguous cues.

* It should be assumed alerted-smoke event checklists have been accomplished but the smoke's source may not have been eliminated.

* Rapid extinguishing or elimination of the source is the key to preventing escalation of the event.

* Manufacturer's initial steps that remove the most probable smoke or fume sources and reduce risk must be immediately available to the crew. These steps are developed by the manufacturer and typically have the pilot turn off components or systems having the highest probability of addressing a smoke/fire/fume source. These steps should be determined by model-specific historical data or analysis.

* Initial steps for source elimination:

– Should be quick, simple, and reversible.

– Will not make the situation worse or inhibit further assessment of the situation.

– Do not require analysis by the crew.

Timing for diversion/landing

* Crews should anticipate diversion as soon as an SFF event occurs and should be reminded in the checklist to consider a diversion.

* After the initial steps, the checklist should direct diversion unless the SFF source is positively identified, confirmed to be extinguished, and smoke or fumes are dissipating.

* The crew should consider an immediate landing anytime the situation cannot be controlled.

Smoke or fumes removal

* The decision to remove smoke or fumes must be made based on the threat presented to the passengers or crew.

* Crews should accomplish procedures in the *Smoke or Fumes Removal Checklist* only after the fire has been extinguished or if the smoke or fumes present the greatest threat.

* The crew should be directed to return to the *SFF Checklist* after smoke/fumes removal if the *SFF Checklist* was not completed.

Additional steps for source elimination

* Additional steps aimed at source identification and elimination:

- Are subsequent to the manufacturer's initial steps and the diversion decision.
- Are accomplished as time and conditions permit, and should not delay landing.
- Are based on model-specific historical data or analysis.

Boeing used this new template to develop a combined checklist addressing electrical smoke, air-conditioning smoke, cabin smoke, and fumes. In 2007, Boeing published new AFM & QRH checklists for all its passenger models.

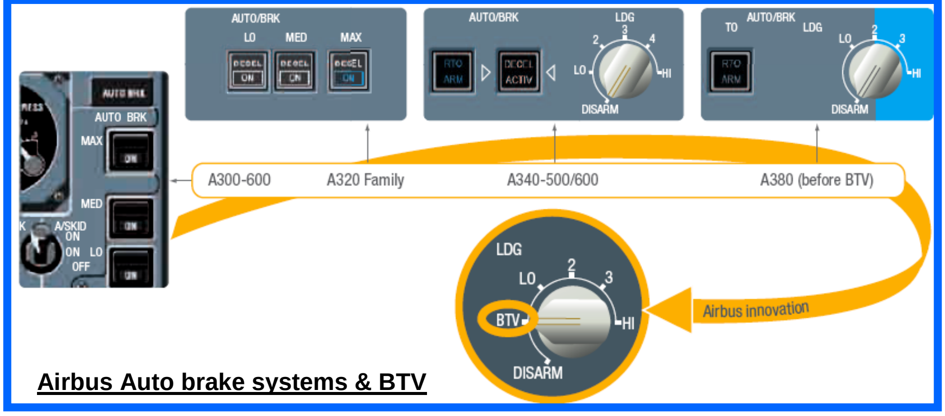
Finally, by working through a logical checklist, flight crew can better isolate the cause of SFF events and take appropriate action.

References:

1. William A. McKenzie., "Flight Crew response to in-flight Smoke, Fire, or Fumes (SFF)", Boeing Aero magazine qtr-01/09.

2. Report on the accident to Boeing 777-222, registration N786U at London Heathrow Airport on 26 February 2007, AAIB Report No.2/2009, April 2009.

Airbus Brake-to-vacate (BTV) System



Airbus Auto brake systems & BTV

The Brake-To-Vacate (BTV) system is an Airbus innovation to aid pilot in easing airport congestion and improve runway turn around time (TAT). It helps reducing taxiing time at busy airports by optimizing the runway occupancy time and lowering braking energy while maximizing passenger comfort. The BTV system, will be available on the A380(2009) and A320 Family (2012/2013).

Designed by a multidisciplinary team, BTV system allows pilots to select an appropriate runway exit during descent or approach preparation. This Airbus-patented innovative system uses the GPS, Airport Navigation, Auto-Flight and Auto-Brake Systems to regulate deceleration, enabling the aircraft to reach any chosen exit at the correct speed in optimum conditions. Through the minimization of the runway occupancy time, BTV helps also to reduce significantly the exposure time to a runway incursion risk.

Though started in 1998 as a research work, the industry product development began on A380 in October 2006 with a first test flight in May 2008. The final product on A380 was demonstrated on May27, 2009 at Toulouse along with two other innovations.

As BTV evolved from the automatic braking system developed earlier by Airbus, let us first understand features functionality and limitations of Automatic brake system.

Automatic braking system, also called auto-brake system, is designed to control aircraft longitudinal deceleration during rollout and down to full stop. The automatic deceleration control roughly starts at the nose landing gear impact with an onset transition ramp for comfort.

As Auto-brake system was to provide freedom for the pilot to perform other tasks, its use is recommended when the pilot's workload is high. This is part of Airbus recommended SOP at landing.

In A300-600, auto-brake is selectable for landing using either LO or MED, which provide low and medium fixed deceleration control. To have more operational flexibility, in A340-500/600 models, auto-brake system has five fixed deceleration modes through a new rotary switch: LO, 2, 3, 4 and HI. The A380 is fitted with a four-modes auto-brake system (LO, 2, 3 and HI). This is schematically shown in the figure above.

Analysis has shown that the auto-brake system cannot be adapted to each landing situation, which has specific touchdown position and speed with respect to the desirable exit taxiway foreseen by the crew.

Some of the drawbacks of the auto brake system are

• Onset nose high on some models more than the pilot's anticipation,

• Brake pedals override adds discomfort, as the pilot has to brake frequently, causing frequent asymmetric braking. In A380 models, this is overcome by auto-brake system disconnection through the Auto-Thrust Instinctive Disconnection button located on the thrust levers,

• In crosswind operations, it may induce asymmetric braking on some models, which helps lateral control, but has a negative impact TAT. With increased braking energy on the more loaded wheels, those brakes attain higher temperatures and need more time to cool down before the next departure,

• Frequent brake pedal applications during landing roll increases carbon brake wear.

• To reach the desired exit speed at the desired exit, pilot has to override the auto-brake system. The override decision criterion depends on the pilot's feel, view and experience. In low/poor visibility conditions, the pilot cannot compensate the classic auto-brake system. In such a case, auto-brake MED deceleration level is mostly used, bringing the aircraft at low speed in the middle of nowhere and then, the pilot taxies on the runway until an exit literally appears!

As the auto-brake system is a closed-loop control on deceleration, more reverse thrust results in less braking, but without shortening landing distance. This situation increases the risk of runway end overrun in case of long flare on short runways; even if the pilot selects, as committed, the maximum reverse thrust.

In terms of Human Machine Interface, the pilot, through the DECEL light extinction does a simplistic auto-brake system monitoring when current deceleration is 20% below the target deceleration.

The DECEL light might be extinguished at high speed on slippery runways while auto-brake system is operating normally. This is partially overcome on A340-500/600 by adding an ACTIV light in order to confirm the correct operation of the auto-brake system. Nevertheless, it will not help the pilot in achieving an intended exit or in preventing a possible runway overrun.

Congestion is already a serious issue at some airports, and these airports are already operating at their maximum capacity for sustained periods of time. SESAR (Single European Sky for Air Traffic Management Research) project focuses on making best use of airport airside capacity based on the available infrastructure, as new constructions are in many instances strictly limited by political and environmental constraints.

The airport's airside system capacity is significantly influenced by the runway capacity. Among the wide spectrum of runway capacity elements, reducing the time spent by aircraft on the runway is one of the most important issues.

Runway Occupancy Time (ROT) is inextricably linked to issues such as wake vortex separation minima and minimum separation standards for both arrival and departure. Minimizing the separation between arriving and departing traffic is equally crucial in reducing ROTs. Even environmental aspects, such as use of preferential runways, etc., may also have an impact on occupancy time.

Studies have shown that depending on the traffic mix (various aircraft types), runway capacity can be increased between 5% (in the case of single-runway airports) and 15% (multiple-runway airports) by reducing ROTs.

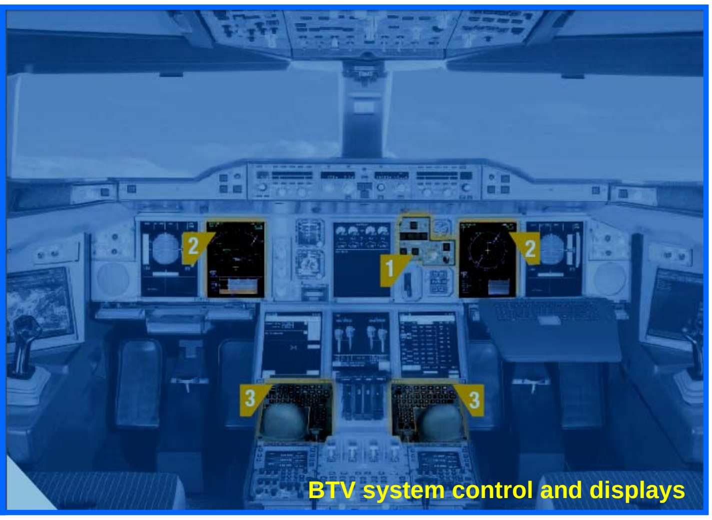
Increasing runway capacity by minimizing runway occupancy is a matter of seconds per operation. Indeed, aircraft that unnecessarily occupy the runway for additional seconds potentially provoke delays of at least one order of magnitude greater, (i.e. close to the minute or worse). If this develops into a domino effect, then overall system capacity will be reduced, causing losses of slots. On the other hand, the saving of a few seconds per movement can represent an important capacity increase. Enhancing runway capacity is not necessarily a matter of seeking absolute minimum occupancy time but rather one of achieving consistent performance, thereby building up the confidence of pilots and controllers, which is necessary to optimize runway capacity.

In case of low visibility, the runway capacity is drastically reduced due to lack of the operational guarantee between the pilot and the controller, inducing an important increase of safety margins added to everyday separation between two consecutive aircraft.

The Brake-to-Vacate function

An enhancement of the auto-brake system at landing which aims at reaching optimally a desired exit, by adding a new auto-brake mode (with the same activation/disconnection principles) is an answer to the issues discussed.

1. Control using auto-brake existing selector. BTV instinctive dis-connection using A/THR existing disconnection button
2. Independent display on existing navigation display
3. Selection using existing Key Board Control and Cursor unit (KCCU)



BTV system control and displays

Brake-to-Vacate system design objectives are:

- Ensure the best possible braking management at landing from main landing gear impact to runway exit vacation,
- Develop a crew intuitive selection, monitoring and termination of the BTV system,
- Propose a seamless and natural integration with: In-flight landing distances assessment during descent/ approach preparation and execution, Runway Overrun Prevention and Warning Systems (ROP and ROW) below 500ft until aircraft runway vacation, Airport Navigation during taxi,
- Ensure a safety improvement by increased crew situation awareness achieved with the in-flight landing distance computation continued on final approach and ground roll, even with low visibility operations,
- Ensure a safety improvement with the implementation of a brand new runway overrun prevention device covering most frequent cases on non-contaminated runways; feature which is also generalized to all other classical auto-brake modes.

BTV system is optimized considering both the aircraft and ATC. To attain "the best possible braking management at landing", BTV system, considers a robust and simple system which guarantees to vacate at the assigned exit, optimizes the brake energy considering current operational constraints, minimizes the runway occupancy time and improves the passenger comfort.

In an operation, the optimum exit selection depends on multiple criteria and constraints that can only be known in their full complexity by the pilot and the air traffic controller (ATC):

- Optimum braking energy (complex function of taxi, requested Turn Around Time (TAT), noise abatement procedures preventing maximal reverse thrust usage out of safety needs),
- Minimum number of brake applications,
- Minimum runway occupancy time,
- Best exit for taxi duration.

A short exit selection can obviously produce lower runway occupancy time than a far exit, but with higher brake energy and TAT.

For an exit selected by the pilot, the BTV system guarantees that simultaneously the lowest brake energy and ROT time are attained. This is achieved by delaying braking as much as possible, and applying maximum possible braking at the latest possible time while reaching the exit at suitable speed.

The design also considers passengers' comfort which constraints the maximum level of deceleration and variation of deceleration over time, during the landing roll. Special attention is paid to the BTV deceleration profile computation considering the visual perception of the pilot associated with late braking in the case of a selected exit close to the runway end.

To help the exit selection chosen by the pilot, the BTV system proposes a dedicated interface providing intuitive information to assist the selection of an optimum exit and to monitor BTV operation. This dedicated interface provides also a predicted and guaranteed ROT and an estimated TAT in a sense of brake cooling time (assuming thrust idle or maximum reversers' usage as per

SOPs).

However, the selection of the 'optimum' exit remains the pilot's responsibility. These indications then help the crew on the optimal thrust reversers' usage strategy during the landing roll on dry runway.

BTV also provides benefits on the ATM side: The main principle is to use efficiently the ROT reduction allowed by BTV fitted aircraft in the whole traffic converging on the considered airport; particularly, it takes benefit from the knowledge of the effective and guaranteed runway occupancy of the BTV-fitted aircraft using the 'runway resource'.

Following is the scenario with BTV fitted aircraft (which is still under study with the ATM community):

• Since the 'approach' controller manages the BTV-fitted aircraft, the pilot and the controller agree on the in-service landing runway and exit taxiway, which depends on several points: the airport layout configuration, aircraft landing performances, airline operational procedures and all other current landing conditions,

• The pilot communicates the predictive ROT, which will be guaranteed.

• The 'approach' controller manages arrivals considering separations to be respected and the forecasted arrival time on the landing runway threshold.

The results of this sequencing task is the location of all aircraft in final approach in order to optimize the arrival flow with respect to the ROT, but also allowable minimal separations (radar and wake vortex). Also, it results in managing forecasted separation in time on a given future position on the approach trajectory (runway threshold),

• Once the aircraft is established in final segment, the 'tower' controller monitors approaches so that the forecasted timing is respected

• The 'tower' controller gives the landing clearance with respect to its own conviction that the runway will be vacated on time.

The operational management of mixed traffic (BTV-fitted and non-BTV-fitted aircraft) is obviously much more complex. Nevertheless, it remains consistent. In this case, conservative forecasted ROT would overestimate known mean values with a sufficient margin to take into account uncertainties (like it is practiced today). For non-specialized runways (used simultaneously for take-off and landing), the arrival timing has to be also optimized; a takeoff can immediately follow the vacation of the previous just-landed aircraft and then take benefit of the time saved.

In addition to the operational and safety gains foreseen above, the immediate consequence is the minimization of strong constraints, which allow the improvement of admissible cadences. The induced ATM operational gain is based on the increase of runway technical capacity. This gain is particularly remarkable in case of low visibility conditions because standard separation can be reached thanks to BTV system (within the limits of sensitive radio electric protection zone constraints). The ROT can be the same as in case of good visibility operations as low speed evolution on the runway is reduced to its minimum. Also, as the ROT of the previous aircraft is known and respected, a certain number of go-around maneuvers will be avoided.

The reduction in the time spent on the runway while negligible for isolated aircraft can be tangible for a fleet. The most visible gains will be obtained on the delays reduction occurring during airport saturation periods. Eventually, the airport manager will benefit from a declared improved operational capacity without doing expensive investments (additional and/or exit runway building, etc.).

The benefits of BTV system are

• Reducing brake wear and temperature,
• Using less and even removing brake fans,
• Relieving maximum thrust reversers' usage on dry runways,
• Reducing noise level on ground, fuel consumption and gas emission,
•Controlling TAT before landing (guarantee for the next departure slot),
• Improving passengers' comfort during landing roll,
• Avoiding missed exit situations,
• And, minimizing ROT

<u>Reference:</u>

1. Fabrice Villaume., "Brake-to-vacate System", Airbus Tech. mag. FAST No.44, July 2009, pp17-25.

PHOTO OF THE MONTH

Emergency landing

On October 17, 2002, an Air France Boeing 777-228/ER had a cockpit fire due to windshield de-ice short and made an emergency landing in Churchill (YYQ/CYYQ), Manitoba, Canada.

As there were no stairs big enough to reach the doors of the 777 in Churchill they had to use the emergency slide to evacuate the people onboard.

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