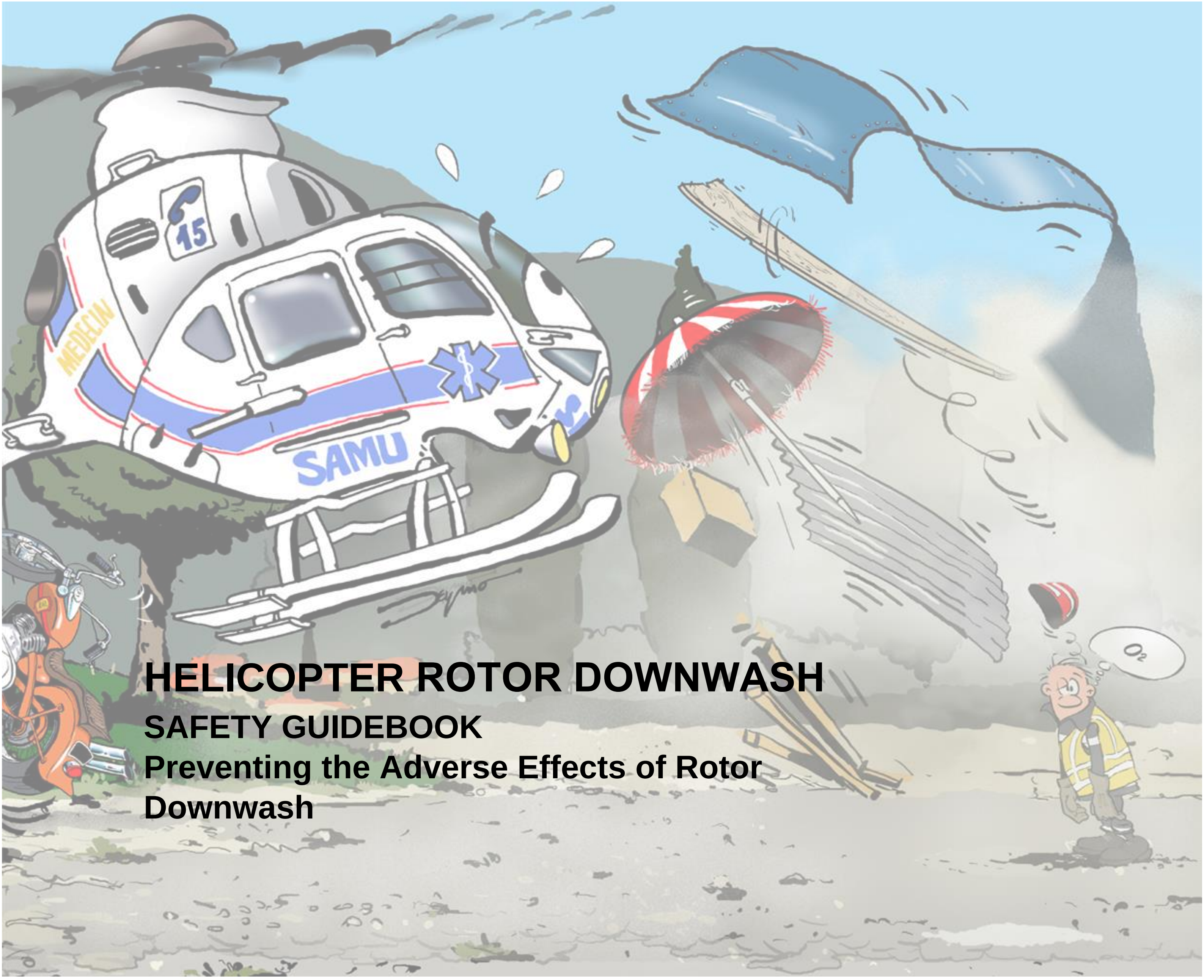
MINISTÈRE
CHARGÉ
DES TRANSPORTS
Liberté
Égalité
Fraternité

dgac direction générale de l'Aviation civile
DSAC



HELICOPTER ROTOR DOWNWASH

SAFETY GUIDEBOOK

Preventing the Adverse Effects of Rotor Downwash

Direction de la sécurité de l'aviation civile (DSAC) / Civil Aviation Safety Directorate
State Safety Program and Safety promotion Unit
Edition N° 1
Version N° 1
First published on November 05, 2022 (French Version)

UAF & FA UNION DES AÉROPORTS FRANÇAIS & FRANCOPHONES ASSOCIÉS
AIRBUS
babcock™
wsp

MINISTÈRE CHARGÉ DES TRANSPORTS
Liberté
Égalité
Fraternité

dgac direction générale de l'Aviation civile DSAC

Document approval sheet

Record of amendments

Edition & version	Date	Amendments	
Ed1v1			

Document approval

Names	Contribution	Date	Signature
André Vernay DSAC/MEAS HF expert	Initial draft	August 10 2023	
Stéphane Corcos, Head, DSAC/MEAS	Approval	August 31 2023	

For any suggestions regarding this guidebook, please report to DGAC at rex@aviation-civile.gouv.fr

The organizations hereafter, the STAC and DSAC services contributed to the creation of this guidebook by bringing their expertise. May they be thanked, as well as Cédric Michel, FOCA flight OPS inspector:

AIRBUS babcock™ wsp

UAF &FA UNION DES AÉROPORTS FRANÇAIS & FRANCOPHONES ASSOCIÉS

Summary

Foreword

This guidebook is the result of a collaborative effort coordinated by the French Aviation Safety Network (RSAF). The RSAF is a national, multidisciplinary group of experts, including industry members, helicopter operators, and experts from DGAC – the French National Aviation Authority – and The French-Speaking Airports (UAF&FA).

The guidebook targets primarily heliport and airport operators. However, it was written with all stakeholders and practitioners in mind, including non-aviation organizations operating heliports (e.g., local governments, hospitals, etc.), and each of them should find useful information that they can use to address safety issues in their field of operations as well as to learn about others' concerns. It provides a state of the art on the helicopter downwash related hazards, as well as best practices on their mitigation in the field.

Note: Per ICAO terminology (Annex 14 – Volume II, 5th Edition of July 2020), "heliport" refers to "an aerodrome or a defined area on a structure intended to be used wholly or in part for the arrival, departure and surface movement of helicopters". This is the generic term used throughout this guidebook, except when talking about heliport facilities in the French rules and regulations. In that specific case, the term "helistation" will be preferred in order to reflect the French usage. For most purposes, the two terms are equivalent. See the Code de l'Aviation Civile *(in French) for the official definition of* hélistation *in force in France.*

The document was developed based on a review of the literature available as of November 2022. Resources include documents from the aviation industry (manufacturers and operators) and institutions (e.g., ONERA, FAA, DSAC), as well as lessons learned from past accidents and incidents with safety reports and analyses from BEA, ECCAIRS, operators, and OEMs. It is important to remember that this guidebook is not an advisory circular or a guidance material for certification purpose, nor an alternative mean of compliance (AltMOC). It does not supersede the position of the Authority in charge of issuing required approvals, regarding operations or training.

Note: This document applies to the operations of helicopters, and in particular the rotorcraft with one main rotor axis (also known as single-rotor helicopters). To date, this guidebook does not account for the specificities of vertical takeoff and landing (VTOL) aircraft that do not fall under the definition of the helicopter. However, VTOL practitioners will find many discussions relevant to the operations of such aerial vehicles, in particular to emerging electric VTOL aircraft. This guidance is intended to be revised in the future in order to take into consideration the evolution of the regulations and of the technology, the state of the art, the progress of best practices, and the advancement of the expertise of the vertical flight community.

Green text boxes highlight best practices and requirements based on lessons learned that should be implemented.

Example:

☒ The surface of these areas should be **prepared against the effects of downwash** and **graded** to enable safe helicopter takeoff and landing operations (see Appendix II §1.1.3).

Disclaimers

This guidebook on rotor downwash does not supersede the national and regional rules and regulations in force. This document is not a safety risk assessment. The flight or heliport operator is responsible for ensuring regulatory compliance and the level of safety of the facilities and its operating conditions based on the standards and the regulation, as well as the provisions of local aeronautical studies and safety risk assessments following applicable standards and the principles of ICAO's Safety Management Manual (SMM). The accidents and incidents presented in this guidebook are provided as case examples only. They do not account for the entirety of the rotor downwash safety event typology.

This version in English was translated from the original November 2022 document in French. The intent of this English version is to facilitate the dissemination of the technical information, best practices, and case examples contained in the guidebook to the broader helicopter community worldwide. This version was developed with the goal of preserving the meaning of the original narrative, rather than providing a "word-for-word" translation. Comments on the specificities of the European and French regulatory frameworks were introduced to help practitioners apply the guidance in their own country or region. Differences between the ICAO, EASA, and French terminology are also explained through notes. Consequently, the reader might spot slight differences between the two versions.

Introduction

The particularity of helicopter flight operations is linked to the economic and social weight of this industry, and to the relatively light volume of activity of the sector compared to aviation as a whole. Approximately 500 helicopters are operated in France by companies, despite a fairly broad range of activities:

- On-demand passenger transport

- Aerial work in support of other industries (public works, imagery, cinema, media, load lifting, refueling of shelters and oil platforms)

- Public service and public service delegation contracts (public safety, health, firefighting, transportation and communication network surveillance)

- Helicopter training, testing and acceptance (most of these flights are due to the presence of Airbus Helicopters in France)

- Recreational flights

Helicopter flight operations are the daily routine of the general public during the summer months (aerial and sports events and media organization), but also during the rest of the year (medical or rescue operations, public safety operations, aerial works...).

The impact of helicopter blast effects has been identified by the State Safety Program (PSE, Horizon 2023 strategic plan). This 5-year safety roadmap for the DGAC France has identified, in its risk portfolio, the safety issues arising from helicopter rotor downwash, and in particular the safety around helipads.

It should be noted that the safety related to helicopter blast must be taken into account for all helipads (including those located at aerodromes), their approach or during low-level traffic.

The improvement of safety requires the sharing and analysis of feedback, i.e., the collection of events that affect safety and the lessons that can be learned from such events. This is what has been attempted in this guidebook, while also putting into perspective the technical and regulatory literature where appropriate.

Finally, in order to fully understand the matter, this guide also presents the helicopter downwash and its effects with the contribution of manufacturers data and calculation methods. This last chapter is important as there are no public documents presenting the characteristics of helicopter downwash as a function of rotor size and aircraft weight as of today.

I. Helicopter rotor blast characteristics

1. Rotor downwash and outwash effects and assessment methodology

The required lift to sustain the helicopter in flight is generated through the main rotor blades rotation. An airflow around the blades airfoils is created by this rotation, which results in aerodynamic forces on each blade. The total rotor lift is the sum of each individual blade lift.

As a result of the aerodynamic forces generation, the main rotor behaves like a fan, sucking in air from above it and blowing air below it. The airflow is thus accelerated through the rotor and pressure and speed change in the process.

Upstream, far from the rotor, air pressure equals the atmospheric one, named P_0. Airspeed relative to the rotor is in the opposite direction to the vertical movement of the helicopter, named V_0,

Given that air is accelerated into the rotor, immediately above its surface the air velocity V_1 is greater than V_0. As a consequence, P_1 at this same location is smaller than P_0: this underpressure contributes to lift generation.

Immediately below the rotor, the air velocity is still V_1 but the pressure P'_1 is increased by the blades rotation and is now greater than P_0: this overpressure contributes to lift generation.

Downstream of the rotor (at a distance between 1 and > 10 rotor diameters), the air velocity V_2 is at its maximum: $V_2>V_1$ and the pressure P_2.

Downstream further away from the rotor (more than 10 rotor diameters), the downwash can be considered dissipated, and velocity and pressure are once again V_0 and P_0 respectively.

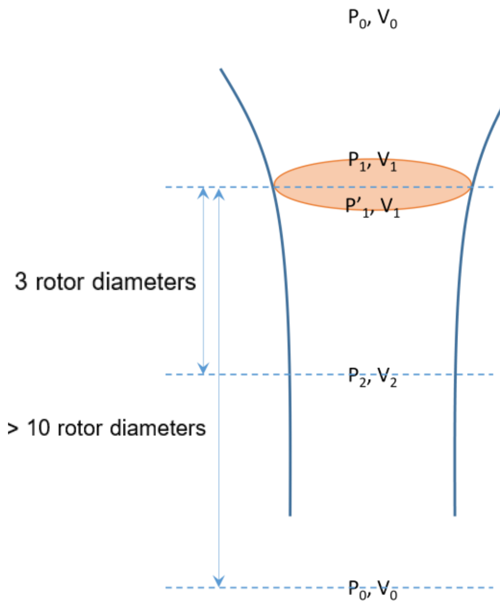


Fig 1 – Shape of the airflow upstream and downstream the rotor

Air velocity regularly increases from V_0 to V_2. As air is sucked in and blown out of the rotor, the velocity increase is constant throughout the disk in this simplified model. This velocity V_1 or V_i is known as induced velocity (or Froude velocity) and is the result of the airflow acceleration through the rotor. This airflow is illustrated in figure 2.

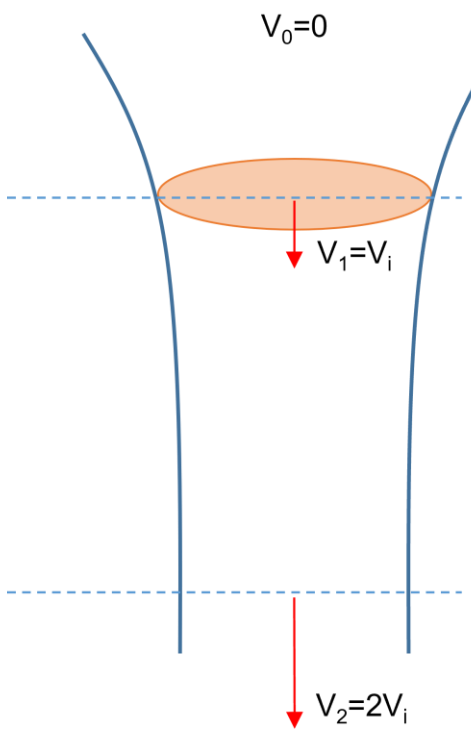


Fig 2a - V_i in hover

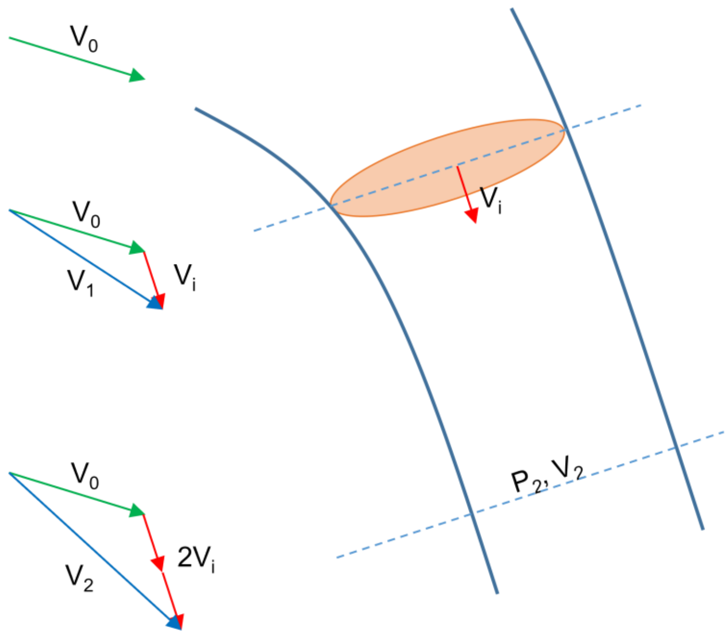


Fig 2b - V_i in helicopter displacement (forward, lateral, etc.)

The induced velocity (V_i) depends on the helicopter mass (in order to sustain it in air), on the rotor disk surface (or indirectly of its radius) and on the air density, through the following relation:

$$V_i = \sqrt{\frac{M\,g}{2\,\rho\,S}}$$

Aircraft Mass
Rotor Disc Surface

This is clearly an approximation of the real rotor downwash as several parameters contribute to modifying the airflow, such as the presence of the helicopter fuselage underneath (dark blue areas in figure 3). Additionally, the induced velocity distribution is not uniform along the blade span: the velocity is higher towards the blade tip. Finally, the airflow is not steady and is highly influenced by the blade tip vortices (such as the ones generated at an airplane wing tip).

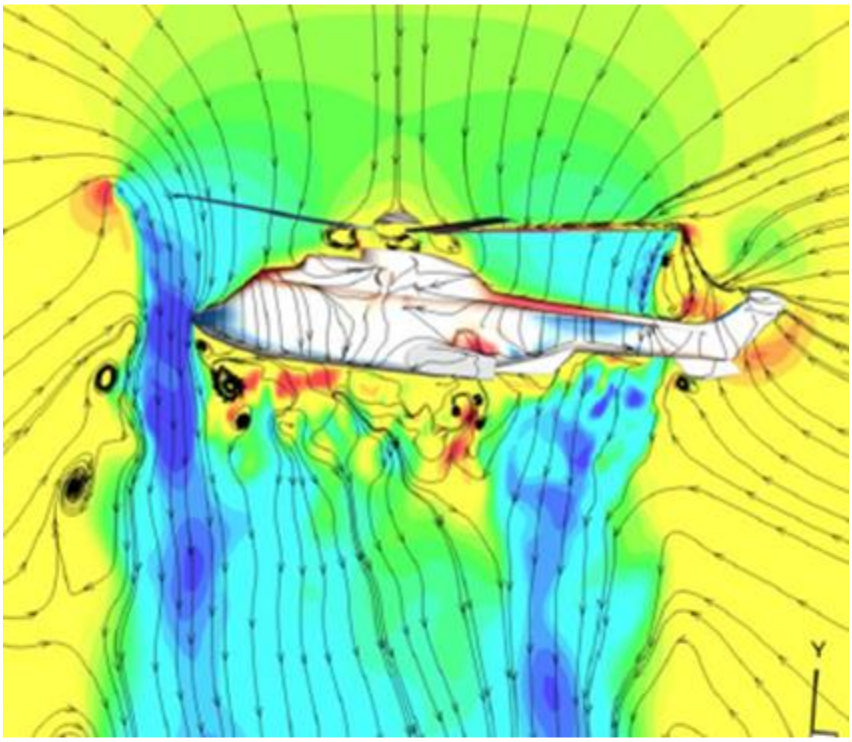


Fig 3 – Visualization of the rotor downwash through CFD simulation

When in hover in ground effect, the airflow generated by the rotor is obviously deviated horizontally in what can approximately be considered in a symmetrical way, compared to the rotor axis. This horizontal airflow generated by the rotor in hover in ground effect is known as *outwash (cf. Figure 4).*

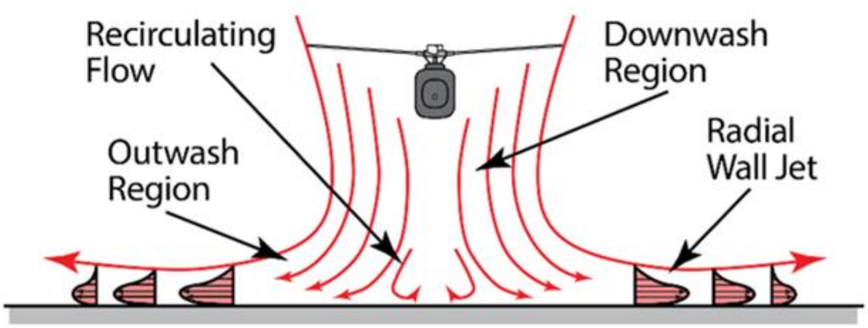


Fig 4 – Airflow downstream of the rotor in ground effect: outwash

The air velocity level in this horizontal flow depends on the distance to the rotor axis. The velocity distribution is not uniform and presents a maximum at a given height. This maximum value can be thus represented as a function of the distance to the rotor axis: figure 5 (right).

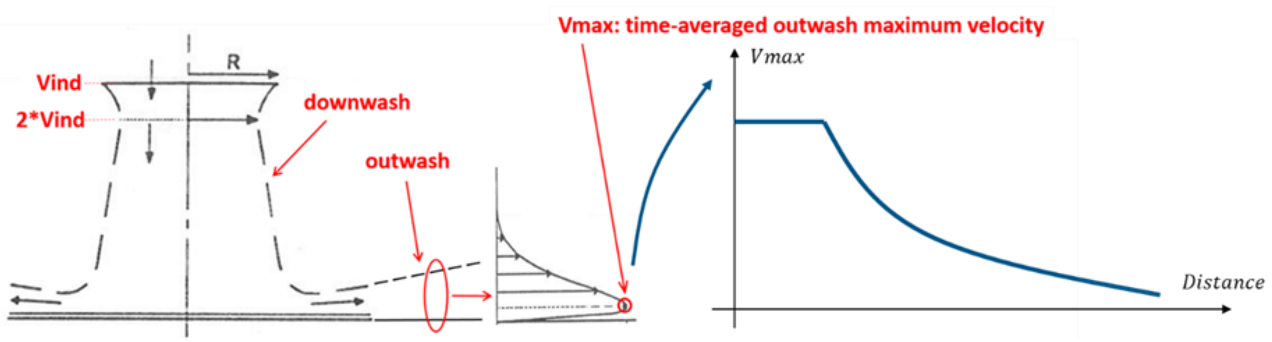


Fig 5 – Left: outwash variation as a function of the location compared to the ground. Right: outwash maximum velocity as function of the distance to the rotor axis.

In reality, it is not so simple. The rotor is never perfectly parallel to the ground and the outwash is expected to be modified as shown in figure 6.

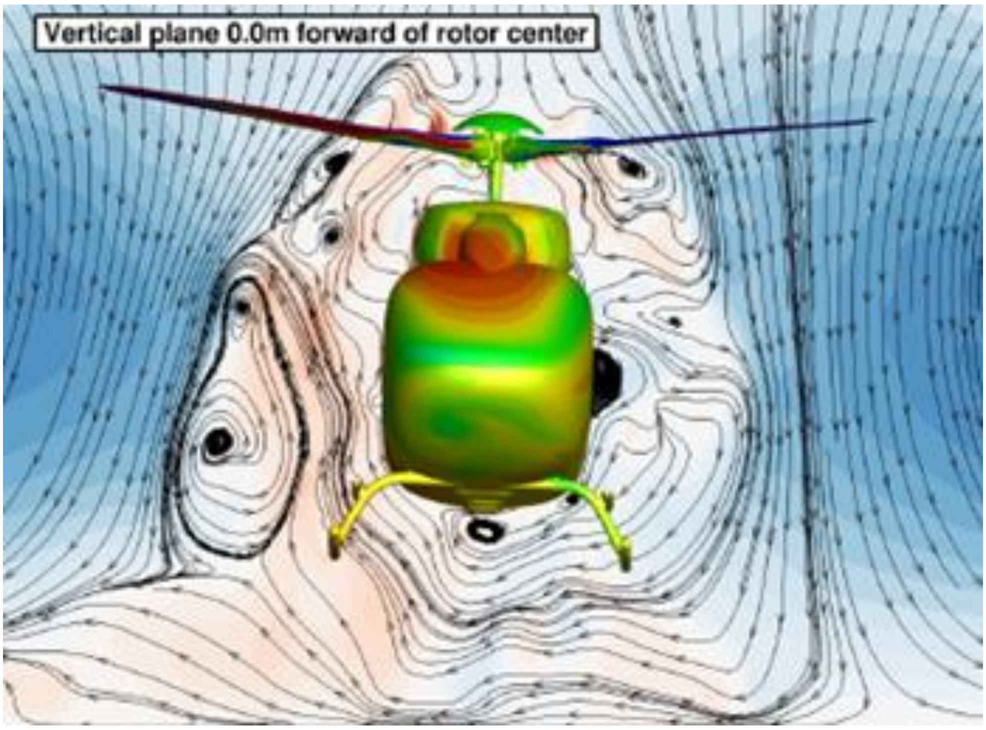


Fig 6 – CFD simulations reveal the asymmetrical nature of the helicopter blast

For these reasons it is virtually impossible to correctly predict or develop helicopter rotor outwash model.

The most suitable modelling of the rotor outwash currently available is the mathematical model proposed by Preston which provides an approximation of the maximum velocity in the rotor outwash as a function of the distance to the rotor axis for a helicopter in hover.

This model is valid for a helicopter in hover close to the ground, namely from 0 ft up to a height equivalent to 3 rotor diameters. As the air velocity in the rotor downwash decreases beyond 3 rotor diameters, the Preston model can be used to estimate the maximum rotor outwash in hover independently of the height compared to the ground.

It is important to point out that any forward flight of the helicopter will result in a reduction of the vertical component of the rotor induced velocity (see figure 2b). Consequently, the rotor downwash is reduced compared to pure hover of the same helicopter at equal height.

The maximum rotor outwash is given by the Preston model. At sea level in standard atmospheric conditions, the maximum outwash can be assessed through the following relation:

$$\textbf{Outwash velocity}[km/h] = 7.2 * K \sqrt{\left(\frac{gM}{2\rho\pi R^2}\right)}$$

In which:

R is the rotor radius [m]

K is a unitless coefficient computed as a function of the rotor radius (R) and the distance to the rotor axis (d):

- If d ≥ 2R, then K=2R/d
- If d ≤ 2R, then K=1

g is the gravitational acceleration [m/s^2]

M is the helicopter mass generating the outwash [kg]

ρ is the air density at zero altitude and a temperature of 15 °C [kg/m^3]

During transition phases such as starting to climb in a vertical take-off or decelerating a vertical descent the rotor induced velocity is higher than the induced velocity required for pure hover flight.

Moreover, the induced velocity depends on the air density.

Finally, wind gusts can locally increase the velocities as wind is added to the rotor outwash.

Therefore, it is necessary to apply a conservative factor to the rotor induced velocity estimated via the Preston model in order to assess the maximum possible outwash generated by a helicopter close to a landing area.

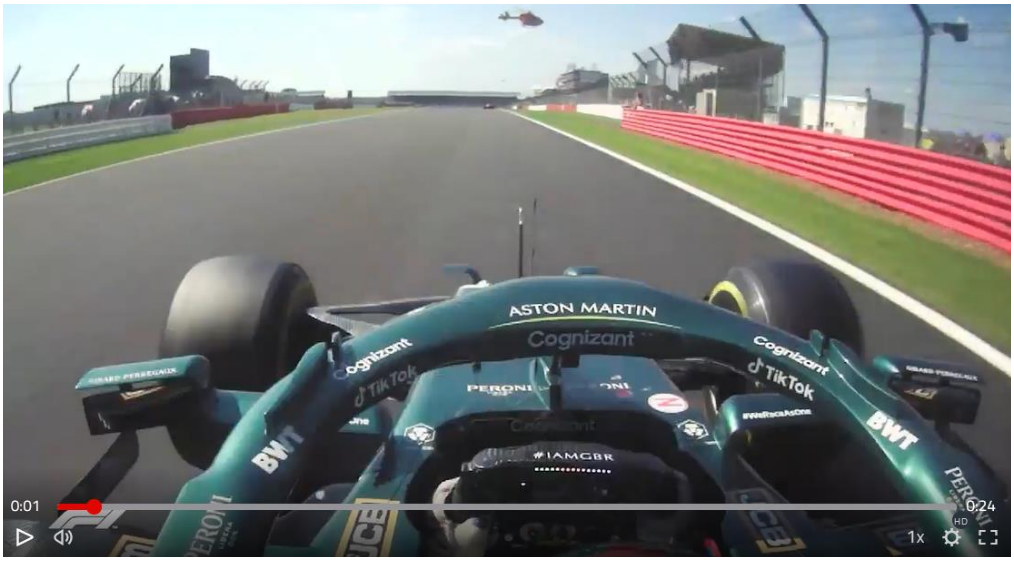
2. Events that created risks to the safety of people and property

Numerous blast-related events with important consequences have been notified by helicopter operators or infrastructure managers.

A selection of safety events has been chosen below to show the diversity of risks that can be induced by the blast effect of a rotary-wing aircraft. They are described and commented to illustrate example and education on the risks of helicopter blast on the ground. This collection of accidents and incidents is not exhaustive regarding the diversity of causes and consequences.

✓ Effect of vertical blast on the aerodynamics of A Formula 1 car

During the Formula 1 Grand Prix in England on July 19, 2021, a racing driver reports instability linked to the presence of a helicopter hovering at low height. This video (youtube link) shows the adverse effect of helicopter blast flying 30 m above the ground. That day, many pilots complained about instabilities created by the helicopter flying over the Formula 1 track.



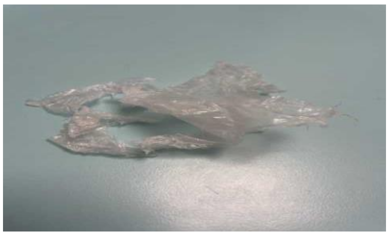
Helicopter is visible during the first second of the video (source https://www.formula1.com)

✓ The blast from the helicopter causes the ingestion of plastic material which damages it

A construction site is located in the vicinity of a hospital helipad. Plastic waste is present. The pilot describes the event:

« Back from a night mission on the hospital, after leaving the "H" for the parking pad, the helicopter starts to shake strongly for about 2 to 3 seconds. I land the helicopter gently, the mechanic reassures the medical team. The inspection of the helicopter shows traces of white plastic film on the fenestron. Many pieces of plastic are present around the DZ. After technical inspection by our mechanic, no damage is detected, and the helicopter is declared airworthy" (see pictures below).

Photographs : plastic on the fenestron and the nacelle, and an identified piece



The ingestion of plastic could have led to very serious damage to the helicopter, as in the video below. In this video, a plastic bag is also ingested into the fenestron.

Screenshot from a YouTube video

Damages are very important on the rear rotor:

Photographs: damage to the fenestron

✓ The blades of a stationary helicopter begin to flap and cause damage to its rear tail

In Switzerland, an EC135P1 helicopter took off from Grenchen Airport (LSZG) just after the arrival of another aircraft and flew over it. The main rotor blades of the helicopter on the ground were then set into oscillation by the blast of the other helicopter, striking the rear tail.

The lack of coordination between the first helicopter departure and the second helicopter arrival was identified in the investigation report as the cause of this serious incident. At the airfield, there were no clear procedures in place to ensure safe "parking" of the helicopters.

Remote monitoring image of the Grenchen airport (April 27, 2013, at 15:00)

✓ 3 children hurt at Rancho Cucamonga police event involving a sheriff's helicopter, bounce house.

In May 2022, during the landing of a San Bernardino County Sheriff's Department AS350 (California, USA) in Rancho Cucamonga, three children were injured in an event involving a blown away bounce house (video link). The 3 children were injured in their head and face.

Screenshot from the video (source ABC)

✓ **A Military ambulance driver gets hit by the door of his medical vehicle.**

This video on YouTube shows that the risk of blast exists even when the helicopter is on the ground.

The video shows an ambulance driver hit by the door of his vehicle when the helicopter lands.

The man is violently thrown on the ground.

Screenshot from the video (source: YouTube)

These few events show the diversity of the situations that may be encountered and highlight situations of risks linked to the helicopter blast for people and goods. This is why a first step was to integrate preventive measures into the regulations.

3. Helicopter outwash formula

For helicopter operations on landing zones, the formula given in §1 simply gives a sufficient estimate of the outwash produced by a hovering helicopter over the ground at a height of 3 rotor diameters, without wind.

$$\boldsymbol{Outwash\ velocity}[\boldsymbol{km/h}] = \mathbf{7.2} * \boldsymbol{K}\sqrt{\left(\frac{\boldsymbol{gM}}{\mathbf{2}\boldsymbol{\rho\pi R}^{2}}\right)}$$

At sea level, this formula can be simplified:

$$\boldsymbol{Outwash\ velocity}[\boldsymbol{km/h}] = \mathbf{8.13} * \frac{\boldsymbol{K}}{\boldsymbol{R}}\sqrt{\boldsymbol{M}}$$

As a reminder, in this formula:

R is the rotor radius [m]

K is a unitless damping coefficient depending on the rotor radius (R) and the distance to the rotor axis (d):

- While d ≥ 2R, then K=2R/d
- If d ≤ 2R, then K=1

M is the mass of the helicopter producing the outwash [kg]

Let's take 2 examples to show how to use the chart.

- **Case A: d=10 m, R=7.5 m, M= 8000 kg**

Start at mark 1: R=7,5 m and d=10 m.

The observer is in the area where K=1, namely the outwash measured between d=0 and d=15 m has the same value. Then join the uppermost part of the chart for the maximum d, here 15 m (mark 2). Then move vertically (mark 3) to the curve giving the mass of the helicopter: 8000 kg in this case (mark 4). From this intersection move horizontally to the left to read the outwash velocity on the vertical axis: 97 km/h (mark 5).

- Case B: d=50 m, R=6 m, M= 6000 kg

Start at mark 1: R=6 m and d=50 m. The observer is in the area where K=2R/d. Then join the uppermost part of the chart for the actual d, here 50m (mark 2). Then move vertically (mark 3) to the curve giving the mass of the helicopter: 6000 kg in this case (mark 4). From this intersection, move horizontally to the left to read the outwash velocity on the vertical axis: 25 km/h (mark 5).

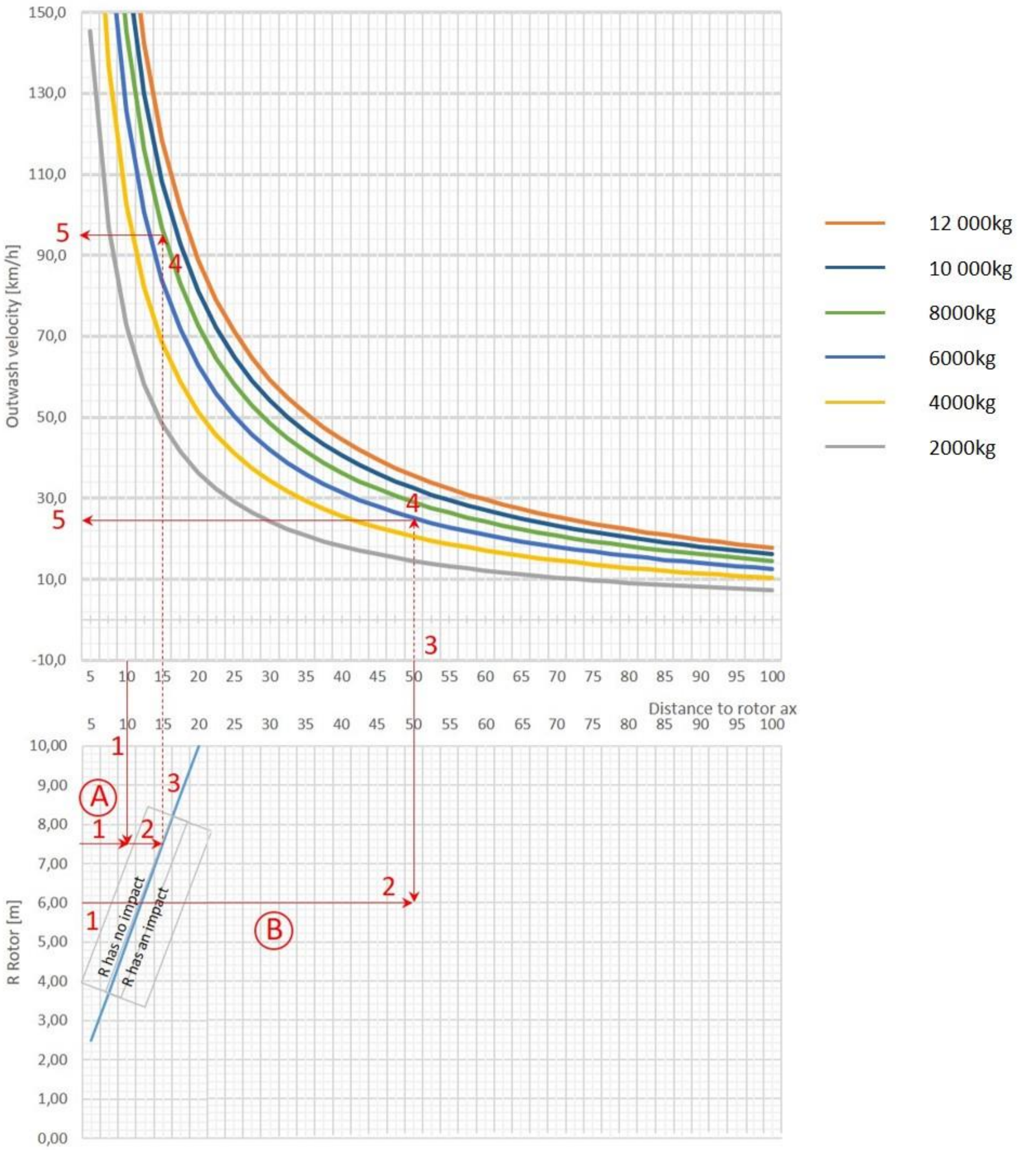


Fig 7: abacus for determining downwash velocity

The lowest part of the chart gives K, the uppermost part gives the outwash.

In the event of several different variants or models or possible optional pieces of equipment for one type of helicopter, the data (mass and radius) must come from the precise rotorcraft flight manual of the helicopter.

CAUTION

As written in §1, when the helicopter starts to move up vertically or stops its vertical descent, the outwash is temporarily greater than the outwash given by this chart. In the same idea, gusts of wind may temporarily modify the outwash of the helicopter. A safety correction factor should then be considered. Due to the lack of specific studies on this complex subject, and due to the great variability of the actual conditions on site, a minimum safety margin of 30% seems necessary.

Obstacles (buildings) could modify the outwash. The reader shall bear in mind that the outwash given by this chart is only the outwash produced by the helicopter. The reader must consider the environment to assess the risks related to the outwash in this precise environment.

As a comparison, onshore, the wind is assessed as dangerous when it blows up to 80 km/h in average or gusting to 100 km/h (available from local weather services such as Météo-France). Those values may also depend on regional and local conditions.

4. The particular case of wake turbulence

Helicopter wake turbulence is a very dangerous and little-known phenomenon, although its impact can be major. This phenomenon is still unknown by helicopter pilots due to the lack of general information available, but wake turbulence is often mistakenly confused with rotor blast.

When the helicopter is in a forward flight, wake turbulence dominates:

- The rotor structure can then be compared to an aircraft wing and generates wake turbulence similar to the latter.
- The wake turbulence develops as it descends behind the helicopter and persists for several minutes after its generation, which can correspond to several hundred meters behind the helicopter (and depending on the wind, over very large areas around the flight path).

The phenomenon of wake turbulence will not be discussed in this rotor downwash guide but it is important to know that it has an impact on safety.

More information on wake turbulence is available at this link.

II. Downwash in the heliports regulation

This section explains where and how the helicopter downwash effect has been taken into consideration by the regulatory framework applicable to facilities[1] intended to accommodate helicopters performing scheduled commercial air operations [2].

In EASA Member States, heliports intended for the exclusive use of helicopters performing instrument approaches, as well as VFR heliports at certified airports falling within the scope of the European Regulation 2018/1139, are only subject to the regulations, standards, and guidance materials of the European Aviation Safety Agency (EASA).

The national rules and regulations only apply to other helicopter facilities intended to accommodate public transport helicopter operations.

The identified infrastructure operator is responsible for maintaining the heliport, except for the private-use heliports. Facilities designated as private-use heliports that can be used only under certain conditions[3] are operated under the sole responsibility of the pilot in command (PIC).

Note: The EASA has published prototype technical design specifications (PTS) for vertiports accommodating operations of manned VTOL-capable aircraft (See EASA PTS-DSN-VPT of March 2022).

1. In France

The regulation of September 29, 2009, also known as « Arrêté TAC Hélistations »[4] defines the physical characteristics and the visual aids that are required for the design, construction, operation, and maintenance of aviation facilities at ground level that are used exclusively by helicopters with one main rotor axis with a MTOW greater than 450 kg (approximately 1,000 lbs). It also provides standards regarding obstacles to air navigation at and in the vicinity of such facilities.

This regulation presents the items to be taken into consideration for minimizing the rotor downwash hazards on the final approach and takeoff area (FATO), the safety area, and the helicopter routes on the ground, as well as the applicable obstacle clearance distances.

[1] There are four types of heliports in the French regulatory framework: « ministerial » helistation (most airport and hospital heliports fall under this category) intended for public transport, heliport with prefectural approval for on-demand public transport and for private transport, and helipad (operated under certain conditions) which requires the owner's agreement and information to the immigration control services against the employment of illegal immigrants (reference order of 6 May 1995 relating to aerodromes and other locations used by helicopters

[2] "Transport public régulier" in the French regulatory framework, for the purpose of this version in English, it can be understood as "public transport" in most countries. For the legal definition of this term in the French context, see the Code de l'Aviation Civile and other applicable lwas and regulations.

[3] Based on the French Circular of May 6, 1995 on helistations and helisurfaces, "the helisurface […] can be operated only under specific conditions:

- The helisurface is used occasionally;
- It shall be identified by the pilot prior to flying it;
- The pilot, the flight operator, or the user shall obtain prior authorization from the land or facility owner;
- They shall inform the authority in charge of immigration control and the prevention of illegal immigrant employment."

[4] Arrêté du 29 septembre 2009 relatif aux caractéristiques techniques de sécurité applicables à la conception, à l'aménagement, à l'exploitation et à l'entretien des infrastructures aéronautiques terrestres utilisées exclusivement par des hélicoptères à un seul axe rotor principal

(1) Surface-level Infrastructure

✓ **Final Approach and Take-off Area (FATO) area and Touch-down and Lift-off'(TLOF) in surface**

Aerial view of the Rodez helipad (France): Final Approach and Take-off Area (FATO)

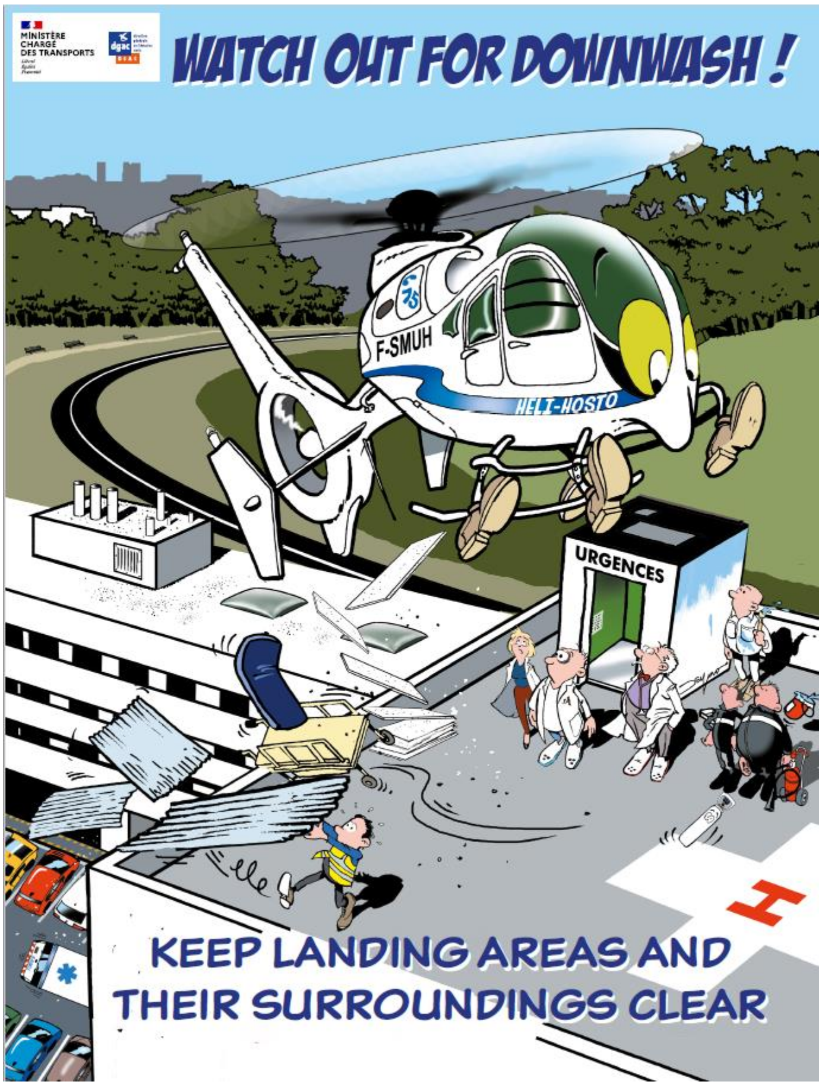
(STAC: © Photo from STAC / Christian BOUSQUET)

☒ Final Approach and Take-off Area Final is resistant to the effects of rotor downwash; and is free of irregularities that would adversely affect the touchdown or lift-off of helicopters

(Requirements from « Arrêté » TAC hélistations (France), annex II §1.1.3)

Resistant implies that effects from rotor downwash neither cause degradation of the surface nor result in flying object (ie FOD).

The surface of the FATO must not be subject to departures of materials. Note that the FATO, unlike the TLOF, is not necessarily paved and does not meet the same load bearing capacity criteria.



Poster to raise awareness of the effects of helicopter blast on hospital helipads (2017)

Management of the blast during the operation of a helicopter on a hospital helicopter platform was the subject of a France safety information leaflet in 2017.

Any object that **can be blown away, called FOD** (Foreign Object Debris), when subjected to the blast, becomes a missile projected with considerable force; this phenomenon is otherwise known as the "missile effect". The risk of serious or even fatal injury to anyone in the path of the object is significant.

The best way to limit the risk of flying debris is to inspect the entire helipad on a regular basis. Inspections should be carried out **at least once a day when a movement is scheduled,** by **trained personnel** and **according to an inspection program established by the facility operator**.

An additional inspection may also be carried out if work is being carried out in the vicinity of the helipad or in the event of particular weather conditions (strong wind, heavy rainfall, ...).

MINISTÈRE CHARGÉ DES TRANSPORTS
Liberté Égalité Fraternité

direction générale de l'Aviation civile DSAC

The objectives of these inspections will be to:

- detect objects (FOD) present on and around the helipad
- remove or secure these objects; and
- communicate relevant information to helicopter operators

After having carried out the inspections, it is recommended that the operator records the inspections in a logbook which includes the date, the name of the agent, his signature, his observations (e.g., presence of FOD) as well as any actions carried out (e.g., collection of FOD).

(Requirements from « Arrêté » dated 9 Jun 2021 on Aerodrome Movement Area Inspections - Heliports are **only affected by Chapter I General Provisions, and Chapter II Movement Area Inspection)**

Recommended actions for hospital technical services operating helipads (and helipad owners)

[…] Particular attention should be paid to objects that are not properly secured or are not secured on and around the infrastructure; increased vigilance should be exercised when working on or around the helipad.

To reduce the risks associated with helicopter operations, the following measures may be implemented:

☒ Installation of ground-mounted signs in the vicinity of the helipad for the attention of pedestrians and drivers of vehicles bearing, for example, a pictogram of a helicopter with the words "Caution of rotor blast";

☒ Installation of barriers or signs (secured to the ground) informing pedestrians of the risk of blast and protecting access to the helipad

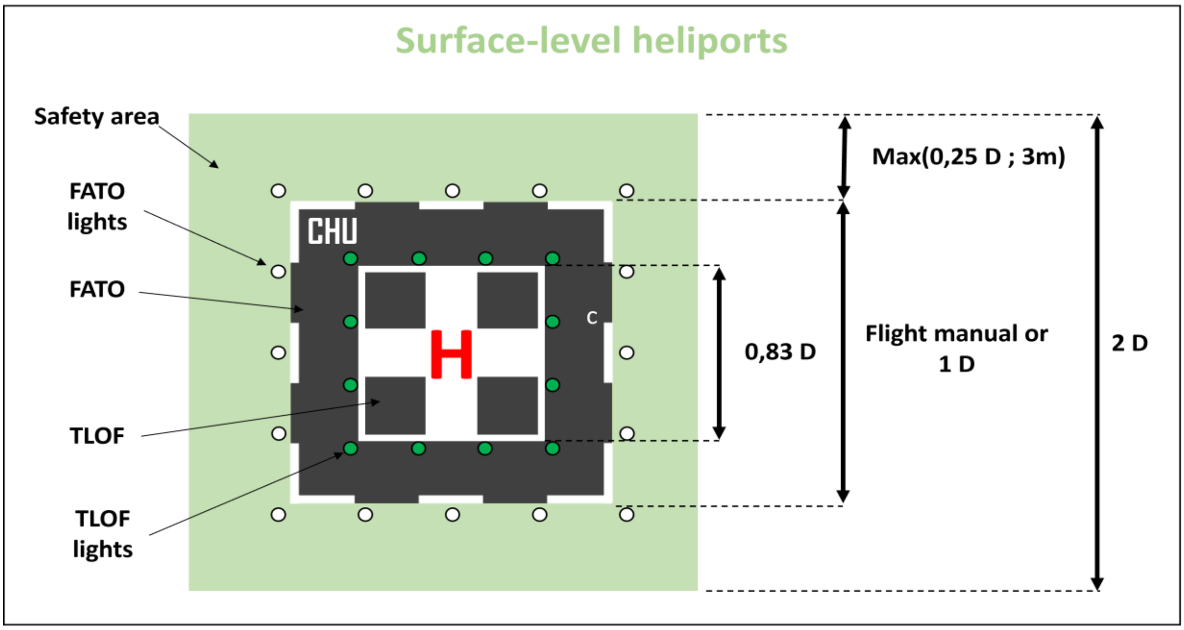
(Extract from French IS n° 1017/01)

✓ **Safety Area** (if present)

The safety area is defined as the area surrounding the final approach and take-off area, intended to reduce the risk of property damage should a helicopter accidentally stray from the final approach and take-off area.

(Annex I, « Arrêté » TAC helicopters of September 29, 2009)

The provision of a safety area is not a regulatory requirement but does not exempt the infrastructure manager from taking action.



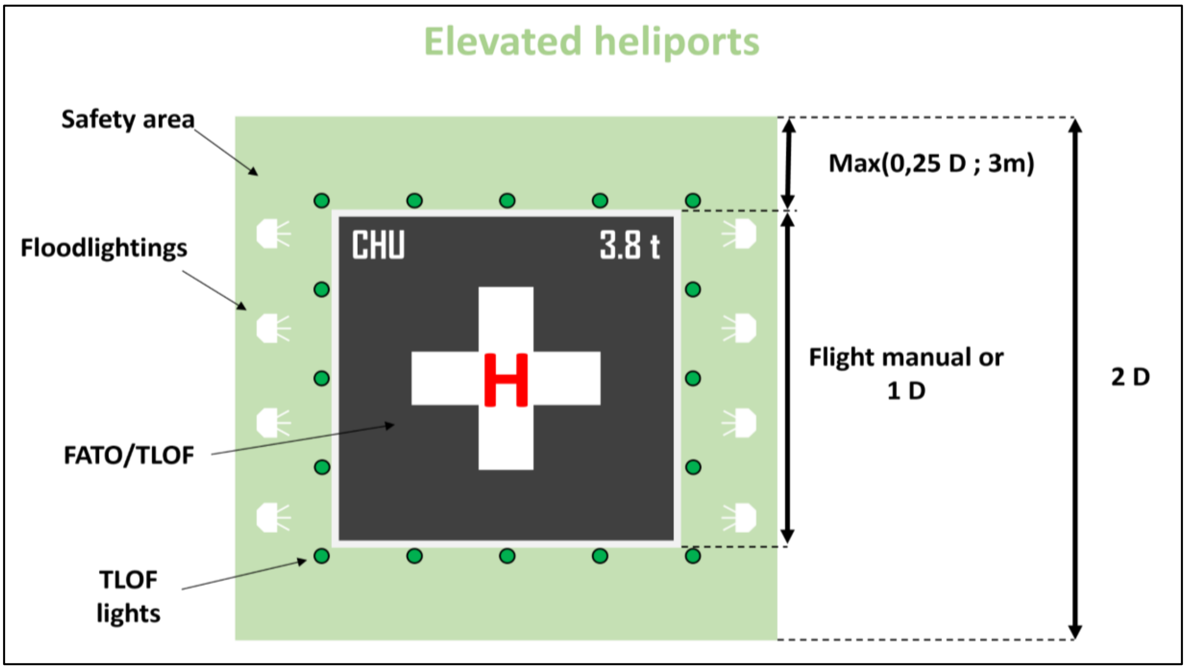


Fig 8: Different possible configurations of the safety area (source STAC: guidebook on site planning for use by helicopters delivering emergency medical services, v1 February 2010)

☒ If the safety area exists, its **surface is treated in such a way that there is no projection of debris by the blast of the rotors** (main rotor and tail rotor).

If there is no safety area, the area underneath it is considered

If the safety area does not actually exist, the area underneath it is such that there is no projection by the blast of the rotors (main rotor and anti-torque rotor).

(Requirements from « Arrêté » TAC helipads, annex II § 1.4.2)

✓ Ground surface taxi-routes for helicopters

taxi route on the circuit of Nevers Magny Cours (STAC photograph © Alexandre PARINGAUX / DGAC – STAC)

☒ **Surface is resistant to the effect of rotor downwash**
(Requirements from « Arrêté » TAC heliport, annex II § 1.5.2.3)

✓ Helicopter air taxi-routes surface with ground effect

Helicopter movement in the ground effect at the Nevers Magny-Cours circuit
(photograph STAC © Alexandre PARINGAUX / DGAC – STAC)

☒ The surface providing **the ground effect is resistant to the effect of rotor downwash**
(Requirements from « Arrêté » TAC heliport, annex II § 1.6.2.2.)

✓ Appropriate separation distances

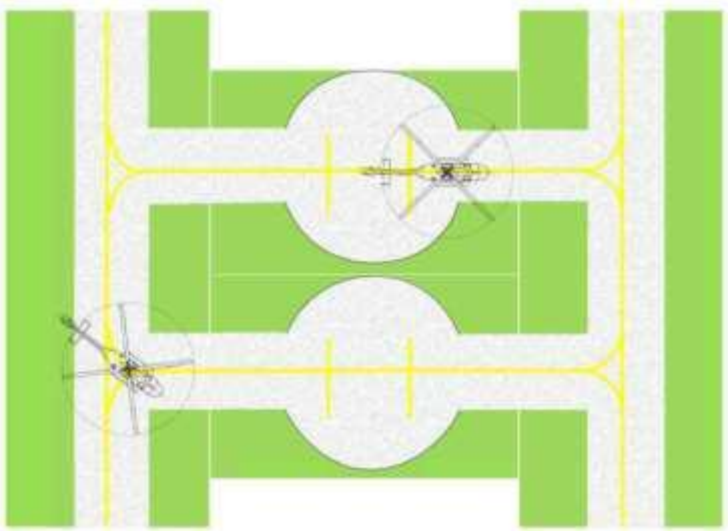


Fig 9: Ground stands used as ground taxi routes with simultaneous use (source: ICAO Annex 14, Volume 2, Heliport)

> ☒ Where infrastructure is used simultaneously, the margins of separation between these infrastructures are such that the effects of the blast from one helicopter on the other do not compromise the safety of the helicopters.
>
> (Requirements from « Arrêté » TAC heliport, annex annex II § 1.8.)

✓ FATO location in relation to an aircraft taxiway or in relation to a runway

Gap-Tallard aerodrome (© Richard METZGER/ DGAC – STAC)

☒ Where simultaneous operations are planned, **the locations and configurations of a final approach and take-off area and a runway or taxiway are such** that it is demonstrated that airflow disturbances, including **blast effects, induced by aircraft do not compromise their safety**

(Requirements from « Arrêté » TAC heliport, annex II § 1.9 et 1.10)

(2) Elevated Infrastructures

Aerial view of the Monaco heliport, the final approach and take-off area (FATO) with a Dauphin (© Alexandre PARINGAUX / DGAC – STAC)

2. EASA

For heliports falling under the scope of EASA framework, the certification specifications (CS) for heliports (CS-HPT-DSN - ED Decision 2019/012/R) specify the applicable technical requirements.

✓ **FATO**

☒ The surface of the FATO

- should be resistant to the effects of rotor downwash;
- should not be located near taxiway intersections or holding points where jet engine efflux is likely to cause high turbulence; or near areas where aeroplane wake vortex generation is likely to occur.

(Requirements from EASA CS-HPT-DSN - ED Decision 2019/012/R, CS HPT-DSN.B.100 Final approach and take-off areas (FATOs))

✓ Safety area

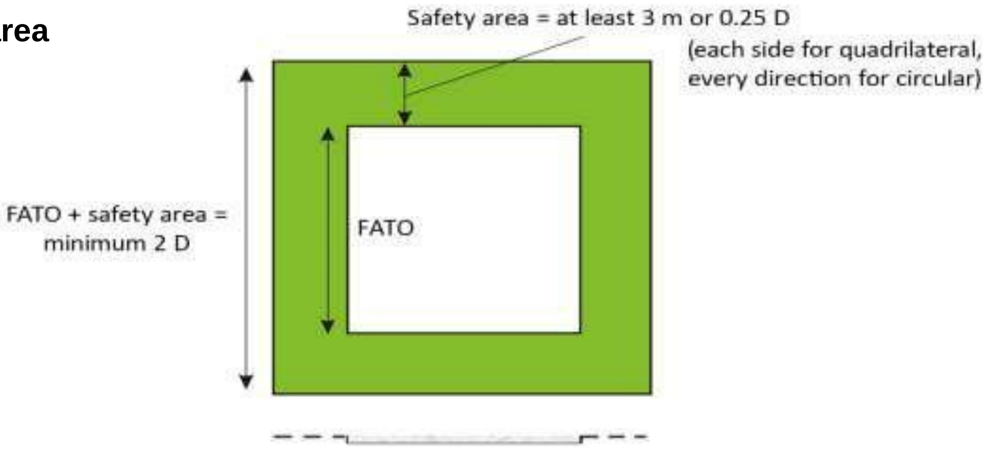


Fig 10 : FATO and associated **safety area (D is the largest dimension of the helicopter**) (AESA)

> ☒ The surface of the safety area should **be treated to prevent flying debris caused by rotor downwash.**
>
> (Requirements from EASA CS HPT - ED Decision 2019/012/R, CS HPT-DSN.B.130 Safety) areas)

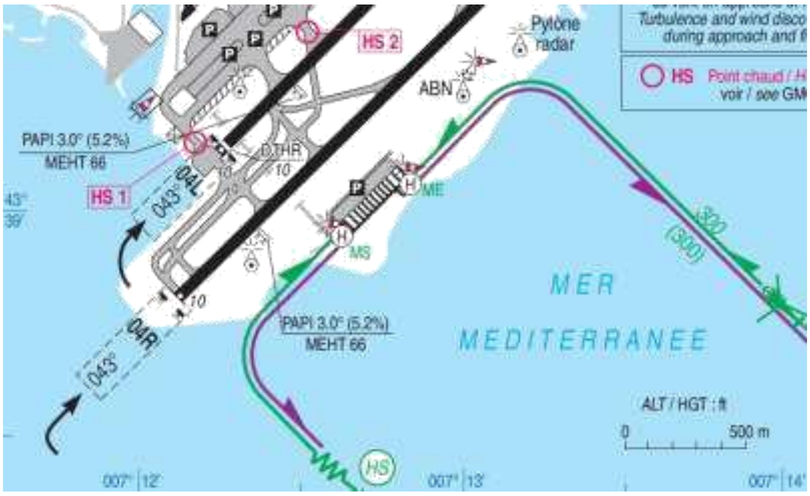
✓ Ground taxi-routes surface

> ☒ The surface of a helicopter air taxi-route **should be resistant to the effect of rotor downwash.**
>
> (Requirements from EASA CS HPT-DSN.C.210 Helicopter air taxiways and helicopter air taxi-routes §11)

✓ Runway and taxiway separation margins

A minimum distance must be maintained between the infrastructures intended for helicopter movements (landing and take-off) and ground traffic.

Pointe-à-Pitre Le Raizet Airport (PTP), FATO close to runway, threshold 30 (source: Google Earth)



FATO/TLOF location, extract from VAC Nice Cote d'Azur Airport (source SIA)

☒ Minimum distance between the edge of a FATO and the edge of a runway or taxiway

- 60 m for helicopters up to but not including 3 175 kg
- 120 m for helicopters from 3 175 kg but not including 5 760 kg
- 180 m for helicopters from 5 760 kg but not including 100 000 kg
- 250 m for aircraft or helicopters from 100 tons and over

(CS HPT - ED Decision 2019/012/R, GM1 HPT-DSN.B.100 Final approach and take-off areas (FATOs)

3. ICAO and United Kingdom

For information regarding downwash on ICAO and UK regulations, see Appendix IV.

III. Occurrence reporting and best practices

The purpose of the regulations is to regulate the activity by imposing strict safety rules, but feedback is also a source of data to be considered to address the risk of blast in all its aspects. The reader will find below various events for which simple measures would have avoided consequences.

1. Objects that can be blown around the helipad

Event 1

The event occurred in the vicinity of a hospital helipad (elevated helipad); barriers were blown away by the helicopter during its moving back phase and struck cars.

The barriers were used without the water-filled pads that would have held them down and were under the recoil path. While property damage was light, there was a possibility of injury.

Event 2

The event occurred in the vicinity of a hospital helipad; a barrier was blown away by the helicopter during its reversal phase and struck a car, leaving an impact on the car body.

In this case, the barrier was also unsecured and in the helicopters' back path.

Events 1 and 2 highlight the need to identify all objects (especially under the recoil or landing paths) that could be blown around the helipad, even for elevated or terraced helipads.

Good practice:

Beyond the safety zone, and around the FATO (up to a distance d, to be defined, with the blast calculation seen in the chapter 1) any free element will have to be weighted, or if possible fixed to the ground. Personnel working (even temporarily) on or around a FATO should be made aware of the proximity of the helipad and the effects of the blast.

Event 3

The event occurred on a hospital helipad. During the landing, the rotor blast damaged the roof of the hospital's infrastructure, despite the pilot's compliance with the trajectories.

Another event regarding the infrastructure risk occurred on a helipad on the ground. On return from a mission, a helicopter landed and translated on the parking area.

As the skids were being put down, the rolling shutter that had just been installed on a modular building lifted up under the effect of the blast, came off and fell back down near the parking area.

This illustrates the importance of regular maintenance of infrastructure around FATOs.

Good practice:

Infrastructure around helipads at height and on the ground should have regular inspections and a maintenance program appropriate to the blast risk of the type of helicopters using it regularly.

2. Occurrences in the work area

Event 4

The event occurred on a hospital helipad. The pilot spotted personnel pruning shrubs in the vicinity of the takeoff path. The pilot decided to modify his trajectory to avoid any personal injury due to the blast.

Event 5

During the approach phase for a recovery of passengers and cargo in baskets, a construction panel in the vicinity (about 20 meters below) of the landing zone was blown ten meters away by the main rotor blast. Workers were present in the area as part of the completion of the site development. As the panel flew away, it passed within one meter of a worker who was crossing the area.

Remedial action:

1) Immediate closure of the DZ to secure the area.

Corrective Action:

1) An on-site inspection will be conducted by City Council.
2) In the short term, the current DZ will no longer be used. A DZ dedicated to helicopter operations is being developed by the owner of the land.

Preventive actions:

1) The images of the event, from an amateur video, will be used for internal and external training materials (construction companies...).
2) The risk portfolio is updated to include a meeting at the beginning of the work and an on-site inspection for all DZs undergoing work.
3) Temporary marking and signage to aircrews (visual aids), ground handlers and other airfield personnel, as well as site personnel (service roads) must provide clear and useful information. See in particular the UAF&FA Infrastructure WG guidance documents on Apron Markings and Signage and Temporary (Construction) Markings and Signage.

3. Refueling Occurrences

Event 6

The event occurred at the refueling station of an airfield. During refueling, the rotor blast tossed the controls of a light aircraft (the controls were not locked).

Fortunately, no problems were detected, and the aircraft was able to fly all day.

This type of problem is due to the helicopter being too close to the aircraft.

Event 7

The incident as seen by the general aviation pilot:

The helicopter lands in close proximity to my single engine light aircraft. I am refueling on the step ladder. The plane is violently shaken in all directions by the rotor blast. I almost lose my balance. Once the refueling is done, I move the plane to get out of the persistent rotor wind (helicopter engine running, rotor spinning). Once the plane is held at a better distance, the helicopter translates and comes again to land at precisely 7 meters of the plane which is again shaken violently, the control surfaces being agitated in a repeated way until the stops by the blast. The phenomenon is so violent that the control tower personnel on the other side of the runways could observe the flapping of the aircraft's wings. Subject to damage to the aircraft.

The incident as described by the helicopter pilot:

[...] we take off again to the airfield [LFXX] to refuel. After landing on the runway, I translate to the refueling station. [A light aircraft] is then refueling, I move to the back of it and land to wait for it to move. After finishing the refueling, the pilot pushes the plane by hand and climbs back in. [...] Taking his gesture as an invitation to move to be able to refuel, I hover again to move a few meters and be within reach of the hose. In fact, the pilot does not hold his controls locked, the control surfaces are flapping, and the plane is rocking on its wheels. After cutoff, I go to see the pilot to explain and apologize for my mistake. He looks around his machine and seeing nothing, decides to continue his [activities]. I leave him my contact information in case of a hidden problem. Without any call from him in the evening, I call back the tower of [LFXX] who confirms me that the plane flew without any problem.

The incident as described by the helicopter pilot:

The plane is refueling at the jet A1 pump. The helicopter coming from a nearby city lands to refuel. It translates and lands behind the para plane. When the latter has finished, it moves forward a little to free the place to the pump. The helicopter then asks to translate to approach the pump. The pilot of the plane points out to me a very important blast in the controls of the plane, risking damaging it. He will then inform me of his wish to file an occurrence report. The problem of the blast of the helicopters to the pump is recurring and already caused problems. Unfortunately, no solution is possible, as the pump is located at the intersection of the taxiing areas, we do not have a satisfactory waiting area.

Event 8

The flying conditions of the day are particular. A wind of 40 to 50 kt gusting from 090° is established in the area. After my smooth approach, I move to the FATO following the ground markings. I move by translating by a free pad on the right of another helicopter landed and parked facing North. It is then close to the landing pad, while countering the strong wind coming from the right, that I stealthily see the neighboring helicopter rotate on itself and turn on about 90°, the 50 kt gusting wind combined with my downwash pushed on the tail of the neighboring helicopter causing this phenomenon. I quickly shifted and landed safely. After debriefing with the captain of the neighboring helicopter, we found no apparent damage. This problem occurred because of the following combination: wind generated by the arriving helicopter, daytime wind gusting to 50 kt, aircraft on the ground not parked headwind.

Actions taken:

1) A reminder will be provided to the company's pilots concerning the effects of the downwash generated by the machine.
2) Safety report transmitted to the company SMS.

4. Example of learning objectives that can be used in training

The table below proposes a list of learning objectives that can be used to establish a training program to raise operator awareness of helicopter downwash hazards. Each training entity, based on its population and job analysis (ADDIE analysis described in ICAO PANS Training 9868) may or may not select an instructional objective and define how to cover such issue in its own environment.

Topic	Learning objectives « the candidate is able to… »
Venturi Effect	Explain how the depression arises in the Venturi effect, give examples (vacuum cleaner, blocked water tap...)
Lift generation	Explain how the Venturi arises around the profile and that the profile in the flow is sucked by the Venturi vacuum
V_i Induced speed (Froude)	Provide the definition and formula
Influencing factors on induced speed	Does V_i increase with increasing mass, altitude, and rotor size?
Rotor downwash modelling	Explain that V_i generates a blast perpendicular to the rotor (pure rotor case)

Disturbed real downwash	Explain that the fuselage disturbs the flow under the rotor in an unpredictable way, making it difficult to be accurate and predictive
Ground effect on the vertical down wash	Explain that when the helicopter is close to the ground the blast is deflected by the terrain towards the horizontal, in an axial (and disturbed) way
Outwash speed vertical distribution	Describe the vertical velocity distribution in the outwash (shape of the velocity/height curve at a given distance)
Tangential blast	Describe the horizontal distribution of the maximum speed in the outwash (shape of the curve with stage)
Factors influencing the tangential blast	List the factors influencing the outwash value for a given helicopter (evolution height/3D rotor, ride speed, pressure altitude, mass, rotor tilt, wind, landing and take-off) and the need for a safety margin
Calculate the tangential blast	Calculate the peak of the max speed in the outwash without safety margin and disturbance in defined conditions (calculation or curves)
Identify possible hazards in the evolution area	Being able to identify possible hazards (people, animals, gravel, brown/white out, aeronautical equipment (ladders, fire extinguishers etc...), other parked or unparked aircraft, non-aeronautical objects (tarpaulins, cans, shelters/barrels, doors/windows/shutters, roofs, trees.)
Assess the associated risks	Tell if the generated blast can make an object fly according to its estimated mass, its shape, its position (if venturi is possible, where it is located) and the planned trajectory of the helicopter
Define the trajectory of least risk (including avoidance)	Define the trajectory to be adopted to limit the risks to an acceptable level (consider not flying in the environment as it is)
Reacting in case of surprise by a flying object	Explain what to do in case of flying object: brown/white out, object crossing the rotors, object displaced without crossing the rotors.

Note: For some objectives, there is no systematically correct answer; the aim is to ensure that the learner's logic is the expected one.

For example:

- An operator carrying out lifting operations should apply these objectives to his HESLO environment and to the personnel concerned (operations specialist, pilot, etc.).

- A firefighting operator fighting wildfires should apply these objectives to the forest fire environment and to any personnel involved.
- A design office working on helicopter platform projects should define these objectives in its environment (e.g. helipad in an urban environment) and for the personnel involved (architect, project manager, etc.).

For the purpose of this guide, these objectives are limited to the ground blast generated by helicopters. A pilot training organization should also add objectives related to wake turbulence generated by helicopters in flight and the associated risks to other users.

5. Accommodation of a helicopter outside FATO and heliports: good practices from the France Helicopter Air Safety Network

Due to a large number of reports in 2021, in particular during the pandemic crisis of COVID 19, DSAC coordinated work with an expert group to produce safety instructions. Two different documents were published, a safety leaflet (reference: IS 2021/05) and an educational sheet with images (safety instructions in the presence of a helicopter, see below).

These recommendations to be applied in the presence of a helicopter outside FATO or heliports are intended to reinforce the awareness of the ground personnel responsible for receiving the helicopter, in particular to the protection of SDIS (a French Firefighting and Emergency Medical Service), health or safety personnel. The rotor downwash is mentioned there and must be anticipated for the ground teams.

The comprehensive educational sheet is available for download, in different languages, on the website of the French Ministry in charge of transport.

- ✓ Leaflet in French (PDF Format)
- ✓ Leaflet in English (PDF Format)
- ✓ Leaflet in Italian (PDF format)

MINISTÈRE
CHARGÉ
DES TRANSPORTS
Liberté
Égalité
Fraternité

direction générale de l'Aviation civile
dgac DSAC

MINISTÈRE
CHARGÉ
DES TRANSPORTS
Liberté
Égalité
Fraternité

direction générale de l'Aviation civile
dgac DSAC

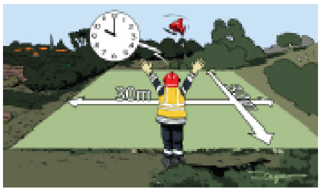
Safety Instructions for Ground Personnel in the Presence of a Helicopter - Intended for ground personnel and emergency services

The presence of helicopters at a landing site requires increased vigilance to ensure personnel and operations site safety.

1 Radio procedure and individual protection

- Continuously monitor the air-to-ground frequency if available before the helicopter arrives at the landing site. If possible, never interrupt radio communication with the helicopter without prior agreement.
- Protect your eyes against flying debris and dust.
- Protect your ears from noise.
- Be visible, wear a safety jacket.
- Do not smoke (or use naked flames) near the helicopter.

2 Selecting the landing zone



- Minimal landing zone dimensions to be considered by Ground Personnel: **30 x 30 metres.**
- Avoid dusty, sandy, loose or stony ground.
- Prefer hard and relatively flat surfaces, with ground obstacles less than 30cm in height.
- On the selected landing zone and its surroundings, make sure that no objects can become airborne, snapped or broken (for instance, partially opened or improperly locked windows and awnings).
- If possible, select an obstacle-free zone with upwind approach and landing axis.

Night operations:

- Comply with day operational instructions.
- Minimal landing zone dimensions to be considered by Ground Personnel: **100 x 50 metres.**
- Do not direct light at the helicopter during approach and landing and take-off!
- At night the visual and sound perceptions are different, do not be surprised.

3 Helicopter approaching

- Personnel signalling the helicopter should wear personal safety equipment (high visibility jacket, helmet, gloves, glasses, etc.).
- An authorised person should if available be in contact with the helicopter (VHF, FM, GSM network, etc.) during the approach.
- This person should stand downwind with arms in the air and keep most of the landing zone clear in front of him or her.
- Signal their position to the pilot with gestures (time-dial system).
- Signal the pilot of any dangers near the landing zone (cables, antennas, other aircraft, drones, paragliders, etc.).
- During final approach, kneel on one knee, keep arms up in V-shape, do not move and keep permanent visual contact with the pilot.
- No other person, object or vehicle is to be in the landing zone!

dgac DSAC Réseau Sécurité des Vols France

together 4safety SDIS

Leaflet – Safety instruction for ground personnel in the presence of a helicopter, May 2021

Appendix I: Regulation references

1. EASA regulations: Regulation (UE) N° 139/2014

i. Part ADR.OPS

- AMC1 ADR.OPS.B.033(a) b.4
- ADR.OPS.D.001 4.(v)
- *GM1 ADR.OPS.D.025 (b)(1) (g)*
- ADR.OPS.D.055
- *GM1 ADR.OPS.D.065*
- *GM3 ADR.OPS.B.070 (g)*

ii. Part CS-ADR-DSN

- CS-ADR-DSN.B.115
- *GM CS-ADR-DSN.B.125*
- CS-ADR-DSN.B.175
- *GM CS-ADR-DSN.B.175*
- *GM CS-ADR-DSN.D.240*
- *GM CS-ADR-DSN.D.300*
- *GM CS-ADR-DSN.D.340*
- CS-ADR-DSN.E.345
- *GM CS-ADR-DSN.G.380*
- *GM CS-ADR-DSN.T.910*

2. French regulations

- "TAC hélistations" bylaw of Septembre 29, 2009 (modified) on technical safety characteristics applicable to the design, development, operation, and maintenance of the ground aeronautical infrastructure exclusively used by helicopters with a single main rotor axis.
  Arrêté "TAC hélistations" du 29 septembre 2009 modifié relatif aux caractéristiques techniques de sécurité applicables à la conception, à l'aménagement, à l'exploitation et à l'entretien des infrastructures aéronautiques terrestres utilisées exclusivement par des hélicoptères à un seul axe rotor principal.

3. ICAO and international documents

Entity	Document	Applicability	Maximum Admissible Speed
ICAO	ICAO, Aerodrome Design Manual, Doc 9157 AN/901, Part 2 – Taxiways, Aprons and Holding Bays	Personal comfort	56 km/h
		Vehicles	
		Other equipment	
		Buildings	130 to 200 km/h
United States	Federal Aviation Administration, Advisory Circular 150/5300-13B, Airport Design – Appendix C	Area behind aircraft after pushback	80 km/h
		General structures, passenger boarding equipment, etc.	80 km/h
		General area aft of aircraft parking position	56 km/h
		Service roads and areas adjacent to parking positions and taxi routes	56 km/h
		Light objects and empty containers, etc.	48 km/h
		Ramp personnel (marshals, baggage handlers, etc.)	48 km/h
		Pedestrian areas (boarding passengers, GA parking areas, etc.)	38 km/h
		Unsecured trash, paper, and light weight debris	21-29 km/h
Australia	Australian Government Civil Aviation Safety Authority Part 139 (Aerodromes) Manual of Standards 2019D	For buildings and other structures	100 km/h
		For public areas where passengers or others are not likely to congregate; For any personnel working near an aeroplane;	80 km/h

		For equipment on an apron; For light aeroplane parking areas with zero risk of damage.	
		For areas of an aerodrome traversed by flight crew, or passengers, boarding or leaving an aircraft; For public areas, within or outside the aerodrome boundary, where passengers or members of the public are likely to walk or congregate; For public roads where the vehicle speed is likely to be less than 80 km/h; For light aeroplane parking areas with some risk of damage.	60 km/h
		Public roads where the vehicle speed is likely to be 80 km/h or more.	50 km/h
ACI World	Apron Safety Handbook - First edition	Can lead to loose objects becoming airborne. These objects have a great risk of injuring personnel and causing damage to airport equipment, facilities and pavement.	48 km/h

Appendix II: Documents providing information about jet blast

1. Original equipment manufacturers

i. Publications

- *Aérodynamique Rotor,* T. Dos Reis Marioni, Airbus Helicopters, April 2021
- *Safety Promotion Notice,* Airbus Helicopters, November 2021
- *JASA – Souffle avion, le point de vue du motoriste,* SAFRAN, August 2021

ii. Aircraft characteristics for airport planning (ACAP) documents, also known as Airport planning manuals (APMs) are published by the following manufacturers on their websites:
    - Airbus
    - Boeing
    - Embraer

Note: Other manufacturers may have published information on jet blast in other documents such as the Pilot Operating Handbooks (POHs).

2. Reference documents and studies

- *Methodology for assessing jet blast hazard on airport infrastructure and operations,* Gaël Le Bris, November 2017
- *What's new on the airfield? Assessing Jet Blast Hazard,* Gaël Le Bris, February 2019
- *Safety Considerations on the Operation of Electric Vertical and Takeoff Landing (VTOL) Aircraft at Airports and Vertiports,* Gaël Le Bris et Loup-Giang Nguyen, Proceedings of Forum 78 (Vertical Flight Society), May 2022
- *JASA – Souffle aéronefs – Paris Orly,* Groupe ADP, November 2020
- *Étude souffle rotor,* D. Desbois-Lavergne, ONERA, March 2005
- *Airport Jet Plume Zone Mapping,* J. Lee et. al., August 1996
- *Étude de la compatibilité des activités d'aviation légère avec les activités d'hélicoptère dans le développement aéroportuaire,* B. Lefort, August 2017
- *Rotorwash Analysis Handbook,* S. Ferguson, June 1994
- *Étude d'impact des sillages d'hélicoptères,* A. Taghizad, ONERA, April 2020
- Rapport du BEA réf. BEA2019-0234 « *Accident d'un parapente impliquant l'hélicoptère Airbus - EC135 - T2 PLUS immatriculé F-HTIN survenu le 11/05/2019* »

3. French DSAC and The French-Speaking Airports (UAF&FA)

- *Évaluer l'impact du souffle avion sur les aéroports,* UAF&FA, October 2020
- *Marquages et signalisation d'aire de trafic,* GT Infrastructures de l'UAF&FA, October 2018
- *Marquages et signalisation temporaires (chantier),* GT Infrastructures de l'UAF&FA, November 2017
- *Consignes de sécurité en présence d'un hélicoptère (IS 2021/05),* DSAC, May 2021
- *Safety Instructions for Ground Personnel in the Presence of a Helicopter,* DSAC, May 2021 (also available in Italian).
- *Conduire et analyser les mesures de souffle avion sur l'airside,* Infrastructure WG of The French-Speaking Airports (UAF&FA), March 2016

- *Obstacle sur aire de posé,* DSAC poster
- *Prise en compte de l'effet de souffle dans la réglementation applicable aux hélistations,* P-Y. Maubre, V. Pavius, DSAC, August 2021
- *IS2017-01 Vigilance souffle hélicoptères*, Info Sécurité DGAC n° 2017/01, DSAC, August 2017
- *IS2017-01 Affiche web vigilance souffle hélico* DSAC, August 2017

4. EASA and ICAO

- *Prototype technical specifications for the design of VFR vertiports for operation with manned aircraft with VTOL capability certified in the enhanced category,* PTS-VPT-DSN, EASA, January 2022
- *Heliport Manual,* Doc 9261, 5th edition, ICAO, 2021

5. Other national aviation authorities

- Airport Design, Advisory Circular 150/5300-13B, FAA, March 2022
- Heliport Design, Advisory Circular 150/5390-2C, FAA, April 2012
- Draft Engineering Brief N° 105, Vertiport Design, FAA, June 2022

Appendix III - CAP1264 "Standards for helicopter landing areas at hospital" UK CAA

1. Chapter 1 Introduction: planning considerations and safeguarding arrangements

1.10 *All helicopters in flight create a downward flow of air from the rotor system known as rotor downwash.*

The severity of downwash experienced is related to the mass of the helicopter, the diameter, and design of the rotor disc and the proximity of the helicopter to the surface.

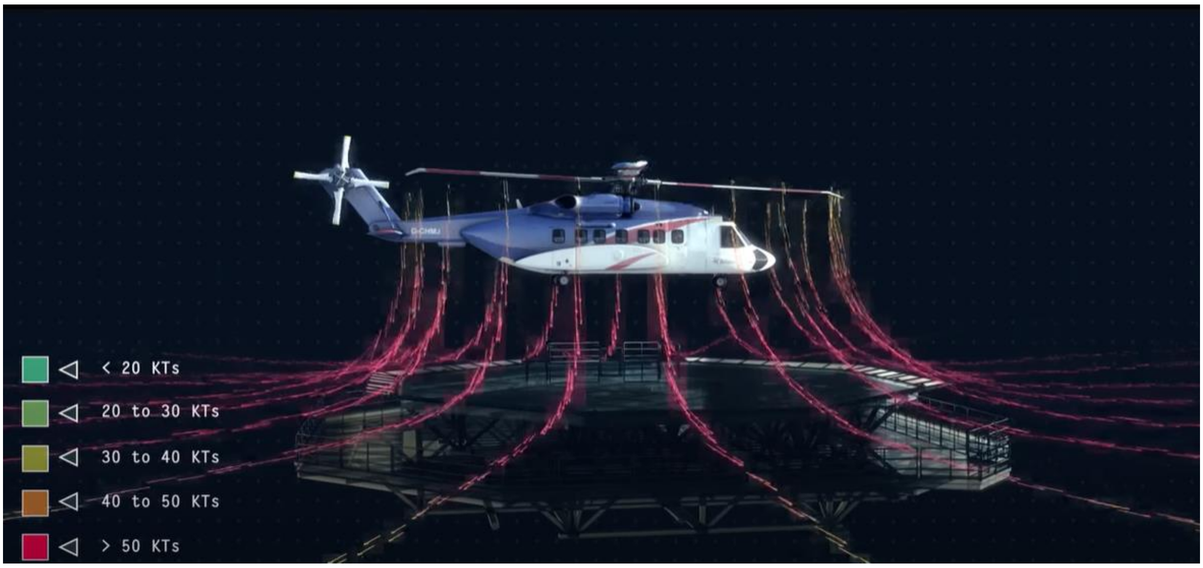
The effects of downwash can be unpredictable given they are influenced by ambient wind and temperature conditions at the time.

The characteristics of downwash *from some helicopters are known to exhibit a localised hard jet, as opposed to a disturbance that occurs over a larger area. Although more localised in its impact, a hard jet tends to be more intense and disruptive on the surface.*

The intensity of the downwash *may be affected by the dissipating action of any wind present or by the screening effect of local features such as buildings, trees, hedges etc.*

The downwash in an area beneath large and very large helicopters, and beneath even a small helicopter operating at high power settings (such as are used during the upwards and rearwards portion of the take-off maneuver by some air ambulance types) can be intense, displacing loose hoardings and blowing grit and debris at persons, property or vehicles in the vicinity of the heliport. Loose objects can pose a risk to the helicopter itself if sucked up by re-circulating air flows into the rotor blades or engines. *For small light air ambulance helicopters, performing clear area take-off maneuvers, the effects are greatly reduced but still need to be considered particularly as, depending on the meteorological conditions on any given day, these same helicopters may be required to use a helipad profile. Therefore, it is prudent for designers always to plan for the worst- case downwash profile for the design helicopter. The attached link gives some guidance on downwash effects and although the offshore operating environment is different, there are general principles cited that are common also to hospital HLS(Hospital Landing Sites).*

Helicopter Downdraft Dangers – YouTube



From the video: Helicopters Downdraft Dangers (source You tube)

https://www.youtube.com/watch?v=09bvuYRKwwc

1.11 *For a surface level heliport operating exclusively light air ambulance helicopters it is recommended that a minimum 30 m downwash zone be established around the heliport which is kept clear of people, property or parked vehicles (typically 2 to 3 rotor diameters of the helicopter). The downwash zone, to account for the approach to land and take-off maneuvers, may need to be extended in the portion below the helicopter flight path to account for operating techniques which promote local disturbances, such as when a helicopter pilot applies full power during the rearward portion of the take-off. If heavy or extra heavy helicopters are to be utilized at surface level, the downwash zone established around the heliport should be considerably larger; typically between 50m and 65m for the largest helicopters.*

2. Chapter 2: Heliport site selection

Heliport at surface (ground) level

1.21 *Heliports built at surface (ground) level are the least expensive to construct and to operate. However, suitable ground level areas are at a premium at most hospitals and are usually being used for buildings, for car parks or for amenity areas (car parking in particular is regarded a good revenue generator at hospitals and the economic case for sacrificing car parking areas to facilitate the considerable space requirements for a ground level heliport need to be carefully weighed). It should also be borne in mind that HLSs at surface level are the most difficult to secure from the public (whether from inadvertent or deliberate entry) and are most susceptible to noise nuisance and downwash effects. Moreover unless they can be located in close proximity to the ED, they may not satisfy the clinical needs of a critically ill patient.*

Elevated heliport (>3 m above ground level), at rooftop level

1.23 *From both the aviation, environmental and long-term planning perspectives the best position for an HLS is on the roof of the tallest building at the site. Rooftops are generally unused spaces and even if there is air conditioning plant situated on the roof, a purpose-built heliport can usually be constructed above it. Rooftop locations raise the helicopters' approach and departure paths by several storeys and reduce the environmental impact of helicopter operations; in particular noise nuisance and the effects of downwash at surface level. Rooftop heliports are likely to provide a greater choice of approach path headings (to realise maximum operability this will ideally be 360 degrees allowing the helicopter to take full advantage of a headwind component at all times. However, this 'ideal' situation needs to be weighed against the need to provide lift transfer, at or just below heliport level). In addition, elevated rooftop heliports are less likely to influence, or be influenced by, future building plans.*

Heliport on dedicated raised structures that are less than 3 meters above the surrounding surface.

1.27 *By raising an HLS by one storey this may have some limited beneficial impact on harmful environmental issues (such as noise nuisance, rotor downwash effect etc.) created by the helicopter operation; benefits are confined to the case of smaller air ambulance helicopters. However, it is unlikely that raising the HLS by just a single storey will provide any benefit for larger helicopter operations. In particular the severe downwash effects created by larger types can make operations to heliports on raised structures challenging; due to the risks posed to third parties who may be moving around under final approach areas and due to the possibility of damage to nearby vehicles and/or property e.g., a raised HLS directly above, and/or surrounded by a public car park. Where operations by very large helicopters are to be facilitated, often the only way to reduce the detrimental environmental impact is to locate the HLS above a tall building (preferably the tallest on the estate).*

Table 1-1: Comparison of ground level, mounded, raised and rooftop sites

	Ground level	Mounded	Raised structure	Elevated (rooftop)
Aircraft and public security	red	amber	amber	green
Freedom from obstructions at ground level	red	amber	amber	green
Freedom from obstructions in helicopter approach corridors	red	amber	amber	green
Provision of into-wind approaches	red	amber	amber	green
Minimising downwash effects / noise nuisance to the public and effects on property	red	amber	amber	green

Key: Colour coding indicates the relative ease or difficulty of meeting certain criterion for each main type of heliport.

Green = easiest, amber = moderate, red = most difficult

Table 1.1 (CAP 124): comparison of ground level, mounded and rooftop sites

3. Chapter 3: Helicopter landing area – physical characteristics

Heliport structural design Case B – helicopter at rest situation

b) Overall superimposed load

To allow for personnel, freight, refueling equipment and other traffic, snow and ice, and rotor downwash effects etc., a general area-imposed action of 2.0kN/m2 should be added to the whole area of the heliport.

Size obstacle protected surfaces / environment.

3.26 *The helicopter landing area (the FATO) should be surrounded by a safety area (SA) which need not necessarily be a solid surface. ... Where applicable, the surface should be prepared in a manner to prevent flying debris caused by rotor downwash.*

4. Chapter 4: Visual aids

Wind direction indicator(s)

4.3 *The location of the wind direction indicator should be in an undisturbed air stream avoiding any effects caused* by nearby structures (see also Section 2 in Chapter 3), and unaffected by *rotor downwash from helicopters. The location of the wind direction indicator should not compromise the established obstacle protected surfaces (see Chapter 3).*

5. Chapter 7: Heliport located on raised structures

Introduction

7.4 *Although the building costs are likely to be in a similar ballpark to those where the specification is for a rooftop structure, depending on the firefighting strategy / philosophy, the overall costs of a raised heliport may be lower than for a rooftop facility. However, when it comes to the preservation of unobstructed flight paths to and from the heliport, and the mitigation of rotor downwash effects, a raised heliport has more in common with a surface (ground) level* heliport *than with a rooftop heliport, particularly if the latter is located multiple storeys above the level of the surrounding surface.*

7.5 *In addition to the impact of obstacles, designers need to be aware of the effects caused by helicopter rotor downwash and blade tip vortices on persons and property (particularly loose objects) that may be present in the vicinity of, and below, the heliport. As with a surface level heliport, it is strongly recommended to establish a downwash zone around the touchdown and lift-off area which during helicopter operations* is kept clear of people and loose articles (e.g., *light and insecure objects) to avoid injuries and damage from any debris that might be disturbed as a result of downwash or blade tip vortices. For large helicopters such as are operated in the SAR role, and for military helicopters, an extended downwash zone should be provided which is typically 50m – 65m beyond the center of the touchdown and lift-off area. For small to medium air ambulance helicopters a 30m downwash zone is recommended.*

Helicopter performance consideration

7.8 [...]

Note: Where large or very large helicopters are required to operate to a heliport it is important to consider the third-party risk posed to persons and property on the ground, in particular as a result of the downwash effect generated. Where effects are pronounced the provision of a raised heliport, being only within 3m of the surrounding surface, may not be the appropriate option; in this case a better option could be to provide an elevated heliport located above the tallest building within the hospital complex, or, to cater for large or very large helicopters, a *surface level HLS located well away from the environment of the congested hospital (e.g. in a near-by playing field).*

6. Chapter 8: Surface level and mounded heliport

Introduction

8.3 *According to Table 1 in Chapter 1 comparing the design and construction of heliport facilities at ground level, mounded, raised and elevated (rooftop) sites, for the cost element of the design and for the operation of a ground level heliport, the ease or difficulty of meeting each criterion is comparatively gauged as "green" i.e. easiest. However, while a facility located at ground level is likely to be least expensive to construct and to operate, it is also the most difficult to provide (and to maintain) clear and unobstructed flight paths to and from the heliport and is also much more prone to the adverse effects of rotor downwash in the vicinity of the heliport. Also given the general scarcity of available real estate at hospitals, it is likely to be a significant challenge to locate a surface level heliport that is both within easy access of ED but sufficiently remote to ensure rotor downwash effects do not have a detrimental impact on persons and property around the heliport. To mitigate the potential adverse effects of rotor downwash, for small-medium air ambulance helicopters, it is recommended that a 30m downwash zone be established all around the touchdown and lift-off area which, during helicopter operations, is kept clear of people and loose articles or light or insecure objects, to avoid injuries and damage from debris that might be disturbed by the mass downwash effect and/or by vortices generated at the blade tips. For large and very large helicopters, where the effects of rotor downwash are likely to be even more pronounced, an appreciably larger downwash zone should be considered; typically, a 50m – 65m zone should be provided and measured from the center of the touchdown and lift-off area.*

Helicopter performance considerations

8.10 [...]

Note: Where large or very large helicopters are required to operate to a hospital it is important to consider the third-party risk posed to persons and property on the ground, in particular as a result of the significant downwash generated by large and very large helicopters (see section 8.3 above regarding the provision of a minimum 50m – 65m downwash zone). In this case the provision of a dedicated surface level or mounded heliport within the hospital complex may not be an appropriate option; a better option could be to identify an additional HLS well away from the congested hospital environment which may be operated by large or very large helicopters (e.g., in near-by playing fields).

Physical characteristics

8.12 *In accordance with Annex 14 Volume II (section 3.1), the FATO should provide rapid drainage with a mean slope in any direction not exceeding 3%. No portion of the FATO should have a local slope exceeding 5%. In addition, the surface of the FATO should be resistant to the effects of rotor downwash and be free of irregularities that would adversely affect the take-off or landing of helicopters operated in performance class 1.*

8.14 [...]

The surface of the safety area should be treated to prevent flying debris caused by rotor downwash.

7. Appendix E: Specifications for helicopter taxiways, taxi-routes and stands at surface level heliports

Helicopter ground taxiways and helicopter ground taxi-routes

E7 The surface of a helicopter ground taxi-route should be resistant to the effect of rotor downwash.

Helicopter air taxiways and helicopter air taxi-routes

E14 The surface of a helicopter air taxi-route should be resistant to the effect of rotor downwash and provide ground effect.

Appendix IV – ICAO and UK Documents

1. ICAO

(1) Annex 14, Volume II, Heliports

The "Annexes to the Convention"[5] include norms, recommended practices, and guidance applicable to member states.

In France, these norms were transposed into the national regulations, or are covered by European regulations (EASA standards and guidance materials).

The technical characteristics presented below were extracted from the Annex 14, Volume II that features norms and recommended practices applicable to various aspects of the planning, design, and operations of heliports. The latest version of this document is dated from July 2020.

Onshore heliports (§3.1) (the text in bold letters specifically address jet blast)

Note 2 — The design provisions given in this section assume when conducting operations to a FATO in proximity to another FATO, these operations will not be simultaneous. **If simultaneous helicopter operations are required, appropriate separation distances between FATOs need to be determined, giving due regard to such issues as rotor downwash** and airspace, and ensuring the flight paths for each FATO, defined in Chapter 4, do not overlap. Further guidance on this issue is given in the Heliport Manual (Doc 9261).

Note 6.— **Guidance on siting of a heliport and the location of the various defined areas, with due consideration of the effects of rotor downwash** and other aspects of helicopter operations on third parties, **is given in the Heliport Manual (Doc 9261)**.

Physical characteristics (Chapter 3)	Items addressing or discussing jet blast
Final approach and take-off area (FATO)	3.1.1 A FATO: a) shall provide: 2) when solid, a surface which is resistant to the effects of rotor downwash;
Safety area	3.1.8 Safety area

[5] The Convention of Chicago was signed in 1944 and went into effect on April 7, 1947. It has been signed by 193 states.

	A safety area shall provide: b) when solid, a surface which is contiguous and flush with the FATO, is resistant to the effects of rotor downwash and ensures effective drainage.
Helicopter clearway	3.1.16 A helicopter clearway shall provide: b) when solid, a surface which is contiguous and flush with the FATO, is resistant to the effects of rotor downwash and is free of hazards should a forced landing be required.
Touchdown and lift-off area (TLOF)	3.1.21 A TLOF shall: a) provide: 2) a surface which: iv) is resistant to the effects of rotor downwash;
Helicopter taxiways and taxi-routes	Note 1.— The specifications for ground taxi -routes and air taxi -routes are intended for the safety of simultaneous operations dining the maneuvering of helicopters. The effect of wind velocity/turbulence induced by rotor downwash would need to be considered. 3.1.33 A helicopter taxiway shall: a) provide: 2) a surface which: iii) is resistant to the effects of rotor downwash;
Helicopter stands	3.1.44 A helicopter stand shall: a) provide: 2) a surface which: i) is resistant to the effects of rotor downwash;
Protection areas	3.1.49 A protection area shall provide: b) when solid, a surface which is contiguous and flush with the stand, is resistant to the effects of rotor downwash and ensures effective drainage.
Location of a FATO in relation to a runway or taxiway	3.1.57 Recommendation. — A FATO should not be located: a) near taxiway intersections or holding points where jet engine efflux is likely to cause high turbulence; or b) near areas where aeroplane vortex wake generation is likely to exist.

Indicators (§5.1)

5.1.1 Wind direction indicators

Location

A wind direction indicator shall be located so as to indicate the wind conditions over the FATO and TLOF and in such a way as to be free from the effects of airflow disturbances caused by nearby objects or rotor downwash. It shall be visible from a helicopter in flight in a hover or on the movement area.

(2) Heliport Manual, Doc 9261 (5th edition, 2021)

PHYSICAL CHARACTERISTICS OF ONSHORE HELIPORTS (Part II)	Elements taken into consideration
2.1.3 Elevated heliports	**Elevated heliports provide a range of safety** and environmental benefits over heliports at ground level **which include,** but may not be limited to, improvements in aircraft and public security, **a reduction** in noise nuisance **and downwash effects at ground level…**
2.1.4.3 Rotor downwash considerations	2.1.4.3.1 **When maneuvering at slow speeds especially during take-off and landing, helicopters generate significant rotor downwash extending out to a distance of 2 to 3 rotor diameters below the generating aircraft**. **This downwash produces effects comparable to high and gusty wind conditions** which may cause light or insecure cladding and other light objects and structures to become detached.
	2.1.4.3.2 The design of a FATO should minimize the exposure of persons or loose objects to the downwash of helicopters. **Within a distance of 3 rotor diameters from the FATO, no loose objects or light cladding should be allowed in areas which might be overflown by helicopters at low level, and no non-essential personnel should be present in these areas during helicopter operations.** The backwards or sideways initial climb phase of PC1 operations should also be considered when assessing areas sensitive to the potential exposure to helicopter rotor wash. Experience suggests, when adopting these procedures, the characteristics of the downwash may exhibit a hard jet on the surface, which though localized can nevertheless be quite intense.

3.1.3.2 Surface Conditions	3.1.3.2.1 **The surface condition is an attribute that establishes** the type of surface and relationship to associated areas, permitted presence of essential objects, surface loading, surface friction, **resistance to rotor downwash,** durability, and required drainage. **Periodic inspections should ensure that the surface continues to meet the objective.**
	3.1.3.2.6 **Resistance to rotor downwash is likely to be an issue on surfaces that are not paved.**
	3.1.3.2.6.2 Rotor downwash on unpaved surfaces could result in foreign object debris (FOD), injury to persons and damage to surrounding property. **In order to prevent this the surface should be treated to avoid break up resulting in debris that might be lifted and scattered by the downwash**
3.1.8 Structural design of heliports	3.1.8.3.2 To allow for personnel, freight, refueling equipment and other traffic, snow and ice, **and rotor downwash effects etc., a general area-imposed action of 2.0 kN/m2 should be added to the surface.**
3.4 Helicopter taxiway and taxi-routes	3.4.1.2 Helicopters engaged in air taxiing produce rotor downwash; its effects can be felt far beyond the boundaries of the air taxi-route, especially with larger helicopters. **The effect of rotor downwash can be extremely destructive to light aircraft and to small buildings.** It is recommended that air taxi-routes are sited to avoid locations where this might occur and, where possible, ground taxiing for larger helicopters (with a mass in excess of 3,175 kg) is facilitated.
3.4.3 Taxi-routes	**3.4.3.2.1 When a surface is solid, it should be resistant to the effects of rotor downwash** and free of hazards.
	3.4.3.4.2 The probability of having to land on an air taxi-route does not justify a paved surface providing it is free of hazards that might prevent a safe forced landing and **is resistant to the effects of rotor downwash.**
	3.4.3.4.3 The effect of downwash on other users and infrastructure should be considered when siting at an air taxi-route. **Because of potential interference, adjacent siting of air taxi-routes is not recommended or encouraged.**

2. UK case

The United Kingdom has transposed into its national regulatory framework, the ICAO standards for the landing of helicopters around hospitals, with the CAP[6] *1264 "Standards for helicopter landing areas at hospital".*

Description (Extract regarding situation)

(..) This focus is chosen because heliports located at a good height above ground level, usually at rooftop level, tend to provide the best long-term operating environment for helicopters, by raising the landing area up above obstacles which might otherwise compromise flight operations.

An elevated heliport, in addition to delivering the best safety outcomes for the helicopter and facilitating the complex needs of a critically ill patient, also has the best potential to deliver more effectively on environment performance, by reducing the incidence of helicopter noise and downwash at surface level, and delivering a more secure HLS - by creating a landing site that is securely protected from inadvertent or deliberate entry by members of the public.

[6] Civil Aviation Publication

Glossary

FATO Final Approach and Take Off area	A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by helicopters operated in performance class 1, the defined area includes the rejected take-off area available.
Protection area	A defined area surrounding a stand intended to reduce the risk of damage from helicopters accidentally diverging from the stand
TLOF Touch down and Lift Off area	An area on which a helicopter may touch down or lift off.
Safety area	A defined area on a heliport surrounding the FATO which is free of obstacles, other than those required for air navigation purposes, and intended to reduce the risk of damage to helicopters accidentally diverging from the FATO.
DZ Drop Zone	Helicopter landing zone which was not initially intended for this purpose. It can be sports fields, outdoor car parks, medians Strip, or even a road or a highway.
FOD	Foreign Object Debris (FOD): an inanimate object within the movement area which has no operational or aeronautical function, and which has the potential to be a hazard to aircraft operations
HAPI Helicopter Approach Path Indicator	A visual slope indicator system which provides information on the approach angle necessary to maintain a safe height over obstacles on the approach to a heliport. (Ref EASA CS HPT-DSN.F.660 (a))
Helicopter taxi-route	A defined path established for the movement of helicopters from one part of a heliport to another. a) *Air taxi-route.* A marked taxi-route intended for air taxiing, b) *Ground taxi-route*. A taxi-route centered on a taxiway.
Helicopter stand	A defined area intended to accommodate a helicopter for purposes of loading or unloading passengers, mail or cargo; fuelling, parking or maintenance; and, where air taxiing operations are contemplated, the TLOF.
SAR	Search And Rescue