Safety Study

Weather Threat For VMC Flights - IIMC

AIRPOWER Safety Department

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This Safety Study was prepared for helicopter pilots to help understand and mitigate the risk of weather threats and inadvertent flight into IMC conditions.

Controlled Flight into Terrain (CFIT) – How Does it Happen?

Controlled Flight into Terrain, or CFIT, occurs when an airworthy aircraft under the control of a pilot is flown unintentionally and without prior awareness into terrain, water, or an obstacle.

The nature of many helicopter operations exposes helicopter pilots to greater risk of CFIT.
It is common for helicopters to fly at low altitudes or adjacent to terrain, increasing the likelihood of CFIT should a loss of situational awareness occur. CFIT is often associated with low visibility. These conditions do create an extreme hazard of CFIT because pilots often rely on their eyes to identify danger.

A typical day in the life of a helicopter pilot is anything but typical. Unlike airplanes that fly from point A to point B, "point B" for a helicopter might be a rooftop, an accident scene in the middle of nowhere, or a helipad protruding from the middle of the ocean. Because of these unique destinations, helicopter pilots must be able to handle dynamic situations on the fly, which include unkown or rapidly changing weather conditions.

Weather and Inadvertent entry into Instrument Meteorological Conditions (IIMC) is a top killer!

Weather and Inadvertent entry Into Instrument Meteorological Conditions (IIMC), also known as Unintended Flight into IMC (UIMC), by non-Instrument Flight Rules (IFR) qualified pilots is the **number 2 killer** in aviation, including for Rotorcraft.

This Safety Study helps you **understand aviation weather, including the appropriate threat assessments and strategies to adopt** in relation to pre-flight and in-flight operation, for a helicopter flight to be conducted under Visual Meteorological Conditions (VMC).

Weather forecast and in-flight reassessment

Weather forecasts allow identifying the anticipated weather and related threats and put in place a strategy to mitigate those threats when preparing the flight. However, **a forecast only describes what is *most likely to happen***. You must account for possible changes and consider other possible outcomes associated with particular weather patterns. **It is not rare for in-flight weather to differ from the forecast weather.** When this occurs, you must recognise the unanticipated threat of deteriorating weather and put into place a timely strategy.

Which weather criteria are relevant?

Relevant weather criteria include:

- Air mass
- Pressure patterns: anticyclones (high pressure) and depressions (low pressure)
- Cloud patterns
- Visibility: ground from the air (slant) and ground visibility (horizontal)
- Wind: surface wind velocity, wind shear or wind gradient and microburst
- Turbulence
- Precipitation: rain, freezing rain, snow, drizzle, hail, sleet
- Ice: clear ice or glaze ice, rime ice, cloudy or mixed ice, frost ice and Supercooled Large Droplet (SLD) ice
- Lightning

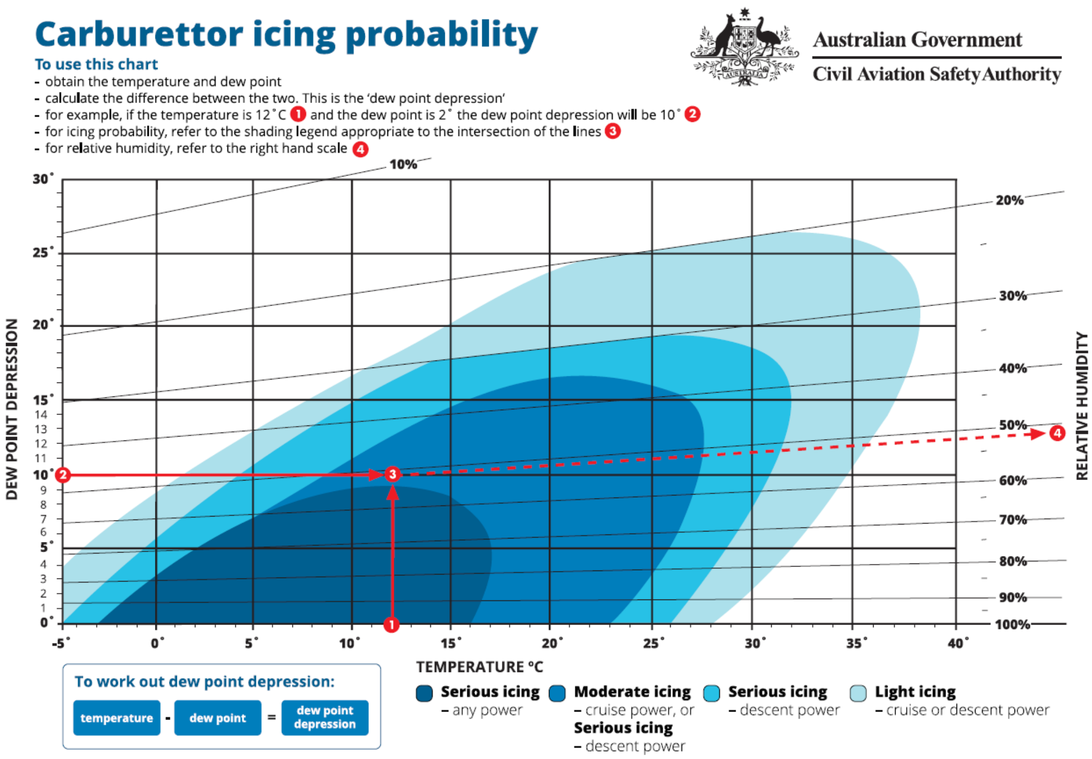
These factors are developed in the **EHEST Leaflet HE 13 Weather Threat for VMC Flights** (see Appendix A) and **EGAST Leaflet GA 3 Weather Anticipation** (see Appendix B). Refer also to the **FAA General Aviation Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making** (see Appendix C), one of the most comprehensive source of weather information.

Certain weather-related factors affect aircraft performance, like air mass and density (which depends on pressure, temperature and humidity) and density altitude (combined effect of pressure altitude and temperature), and wind. Certain non-weather factors also affect aircraft performance, like aircraft mass, ground effect, and slope and surface. Refer to the **EHEST Leaflet HE 12 Helicopter Performance** (see Appendix D).

Carburettor icing

Many accidents, in light General Aviation helicopters, have been attributed to engine stoppage due to carburettor ice. When used properly, the carburettor heat and carb heat assist systems will prevent carburettor ice (**Ref. Robinson Safety Notice SN-25**) (see Appendix E).

Always consider how carburettor icing probability is affected by atmospheric factors such as Dew Point depression, temperature and relative humidity, see chart below:



Clouds

All clouds are a threat to non-Instrument Flight Rules (IFR) qualified pilots. Most helicopters are not certified to fly in icing conditions. Even for IFR qualified pilots flying on an IFR certified helicopter, an inadvertent loss of external references can lead to loss of control.

Cumulonimbus clouds are dense vertical clouds associated with thunderstorms and atmospheric instability. They are a deadly threat to aviators: never fly into a cumulonimbus, even if IFR qualified!

You must also avoid shelf clouds forming at an early stage of a thunderstorm!

How to mitigate weather risks?

Prepare your flight thoroughly, and update your situational awareness and plan as the flight unfolds.
Get and study weather reports, compare actual weather with the forecast and update situational awareness and flight strategy accordingly. Check the area forecast for your route, and also Terminal Aerodrome Forecast (TAFs) and Meteorological Aerodrome Reports (METARs) for all aerodromes you expect to pass, and which might be useful as diversion aerodromes.

Know the weather minima and limits to be applied by helicopter pilots
Refer to the Standardised European Rules of the Air SERA.5001 VMC visibility and distance from cloud minima and SERA.5010 Special VFR in control zones. Even if in some conditions, helicopters may be permitted to operate with 800 m flight visibility, check if you really need to perform this flight.

Use modern technology
Modern technologies allow displaying current and forecast ceiling and visibility levels 24/7, as well as other low level adverse weather conditions and can provide real-time information on various types of precipitation events happening on the flight path, such as rain, snow, etc. Applications on tablet and Smartphone also allow sending flight plans in advance to weather service experts. Integration with flight planning applications, which can overlay weather onto aeronautical charts, enable receipt of weather warnings and alerts during flight to avoid such hazardous areas.

However, know and understand the technology limitations! Weather information shown on the screen does not always reflect reality and actual conditions could be worse than shown on the screen! Weather images shown on weather-apps may not be a true depiction of reality, because of radar coverage limitations. Be ready to meet worse conditions. Complement weather-radar information with other weather information sources. In-flight, look out and assess in real-time how the weather evolves.

Contact Flight Information Service (FIS) and Aerodrome Flight Information Service (AFIS)
FIS is a form of Air Traffic Service (ATS) and is available to any aircraft within a Flight Information Region (FIR). Services may include the provision of weather-related information, both reported and forecast, for example SIGMET (Significant Meteorological Information) and AIRMET (Airman's Meteorological Information), weather-reports en-route and/or for destination and alternate aerodromes.
In Greece where FIS is provided by Air Traffic Control units, you will be talking to a controller. Remember that the provision of ATC always takes precedence over the provision of FIS. Notify the FIS-unit before leaving its frequency. It also avoids unnecessary alerting phases!
Moreover, an Aerodrome Flight Information Service (AFIS) is provided at airfields where, despite not being busy enough for full air traffic control, the traffic is such that some form of service is necessary. In contrast to ordinary FIS-frequencies, two-way radio communication is usually mandatory at AFIS-aerodromes. Both AFIS and FIS use the radio call sign “information”, so be aware of whom you are talking to and what level of service is available at a given station.

Build options for your flight and make informed operational decisions
Having weather information is only part of weather-related decision making. Knowing how to acquire and interpret weather-related information, build options for your flight, and make informed operational decisions is essential for a safe flight.

Good Practices

These good weather-related practices will help you avoid weather and IIMC related accidents and keep you safe:

- ✓ Plan your flight thoroughly.
- ✓ Get free information and weather Apps on the internet: just search on the internet with the keywords "Weather Apps for Pilots".
- ✓ Use modern technology but know and understand the limitations.
- ✓ Understand weather patterns and their likely effects on your flying.
- ✓ Always obtain an aviation forecast.
- ✓ Expect conditions to be worse than forecast.
- ✓ Know how to perform a weather briefing.
- ✓ Only commence or continue a VMC flight if the information available indicates that at the place of departure, along the route and at the intended destination, conditions will be at or above VMC minima.
- ✓ Look for and consider PROBs (Probabilities of Precipitation), TEMPOs (temporary used for any conditions in wind, visibility, weather, or sky condition which are expected to last for generally less than an hour at a time (occasional), and are expected to occur during less than half the time period), OCNL (Occasional weather forecast) and ISOL (Isolated weather forecast).
- ✓ Know how to decode a Terminal Aerodrome Forecast (TAF).
- ✓ Check actual conditions against the forecast. Do not make the flight if the conditions are poor or quickly deteriorate. When conditions are marginal compared to regulatory or personal minima, the decision to continue, postpone or cancel the flight is more difficult to take: refer for instance to the AOPA video Weather Wise: Beyond Go/No-Go mentioned in the Videos section of this article. In case of doubt, do not take chances!
- ✓ Establish personal minima and stick to them!
- ✓ Identify alternative routes and suitable diversion airfields.
- ✓ Always carry enough fuel for unexpected situations.
- ✓ Scan the sky and horizon for possible problems and note local surface winds.
- ✓ Check weather reports while flying.
- ✓ Be prepared to divert, turn around or land - i.e. make sure there is an alternative course of action available should the weather conditions preclude the completion of the flight as planned. IIMC is very dangerous: **in an airplane you have 178 seconds to live if not IFR rated, in a helicopter this drops to about 56 seconds if you don't take appropriate action.** The biggest challenge in IIMC is admitting that you are in IMC and you no longer have visual reference! Never hesitate to land when in trouble.

- ✓ Resist the pressure to complete the flight as planned when the weather and/or visibility deteriorate, a well-known dangerous bias known as Get-there-itis or Press-on-itis.
- ✓ Never hesitate to ask for help when in trouble! FIS and/or ATC are there to help and will give you priority.
- ✓ Maintain and develop competences. Enhance your confidence in weather decision-making, both when flight planning and during the flight, for example watch forecasts on TV. Keep an eye on METAR's and TAF's (Terminal Aerodrome Forecasts) even when not flying, study radar and satellite imagery. Share weather experiences, talk to fellow pilots and join aviation social media, read books and articles.

NOTE

One simple resource available in deteriorating weather conditions is called a "trigger-point". According to this philosophy, when pilots find themselves in deteriorating conditions requiring them to reduce airspeed by a pre-determined amount in relationship to normal cruise speed, they have reached a "trigger-point". At trigger-points, pilots are encouraged to land, turn-around, or change direction in order to break this potential accident chain.

Always have a plan B and don't be afraid to act on it should you become uncomfortable.

Remember, it's better to be on the ground wishing you were in the air versus desperately wishing you were safely on the ground.

When in doubt, keep your helicopter skids planted firmly on the surface and wait things out.

It's as simple as that.

The International Helicopter Safety Foundation (IHSF) eight Golden Rules

8 Golden Rules about Weather and Helicopter Flight

1. Always obtain an aviation forecast.
2. Expect conditions to be worse than forecast.
3. Check actual conditions against the forecast.
4. Identify alternative routes and suitable diversion airfields.
5. Always carry enough fuel for unexpected situations.
6. Scan the sky and horizon for possible problems and note local surface winds.
7. Check weather reports while flying.
8. Be prepared to divert, turn around or land (i.e., Make sure there is an alternative course of action available should the weather conditions preclude the completion of the flight as planned. In other words, don't be afraid to land and live).

Tips for commercial pilots

For VFR flights: SERA.5001 VMC visibility and distance from cloud minima allows you to operate in less than 1500 m and even down to 800 m flight visibility (if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collision). The biggest issue in IIMC is admitting that you are in IMC and you no longer have visual reference. Commercial pilots have the tendency to push further: don't do that! Land the helicopter when in trouble!

Follow the Four "C's"

Inadvertent IMC encounters are some of the most demanding, disorienting, and dangerous conditions a pilot can experience and they result in the highest percentage of fatal injuries from helicopter accidents.

A pilot's immediate actions after encountering inadvertent IMC usually will determine the outcome of the entire event. Pilots who possess a plan of action prior to encountering it are more likely to experience a successful outcome (staying alive) than those who are less trained and less proficient in the recognition and recovery procedures.

Immediate Actions

If Inadvertent IMC occurs, helicopter pilots can follow the 4 "Cs":

Control, Climb, Course, and Communicate.

- **Control** - Fly the aircraft. Refocus the scan inside the cockpit to the primary flight instruments – airspeed, altitude, and attitude.

- **Climb** - As soon as the aircraft is under control by reference to the instruments, a controlled climb should be initiated. Inadvertent IMC encounters often occur at low altitudes where rising terrain poses a serious threat. The pilot should initiate a straight ahead controlled climb to an altitude that will provide obstruction clearance in the area of operation. Always review Maximum Elevation Figures (MEF) on VFR charts prior to departure.

- **Course** - After the aircraft is in a controlled climb, the pilot can elect to turn to a new heading if known obstacles are ahead and/or divert to a different location with forecasted weather conditions or better known weather conditions.

- **Communicate** - After the pilot has control of the aircraft, initiated a climb, and is on a course, he should communicate with Air Traffic Control regarding their intentions and need for assistance.

Fly prepared. Fly safe.

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APPENDIXES

A	EHEST Leaflet HE 13 Weather Threat for VMC Flights
B	EGAST Leaflet GA 3 Weather Anticipation
C	FAA General Aviation Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making
D	EHEST Leaflet HE 12 Helicopter Performance
E	Robinson Safety Notice SN-25

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Appendix A

EHEST Leaflet HE 13 Weather Threat for VMC Flights

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EHEST
Component of ESSI
European Helicopter Safety Team

Weather Threat For VMC Flights

FOR HELICOPTER PILOTS AND INSTRUCTORS

TRAINING LEAFLET

HE 13

TABLE OF CONTENTS

INTRODUCTION

This leaflet was developed by the European Helicopter Safety Implementation Team (EHSIT), a component of the European Helicopter Safety Team (EHEST). The EHSIT is tasked to process the Implementation Recommendations (IRs) identified from the analysis of accidents performed by the European Helicopter Safety Analysis Team (EHSAT)[1].

Data from EHSAT has highlighted the importance for pilots to have a sound understanding of the threats associated with aviation weather and the impact that weather can have on the safe outcome of a flight [2].

Aviation forecasts are important for pilots to identify the anticipated weather threats and put in place a strategy to mitigate those threats during the pre-flight planning stage. However, a forecast only describes what is most likely to happen, and pilots must use their knowledge and experience to consider other possible outcomes associated with particular weather patterns.

It is not unusual for in-flight weather to differ from the forecast weather. When this occurs pilots are required to recognise the unanticipated threat of deteriorating weather and put into place a timely strategy to mitigate the threat of an undesired aircraft state.

The purpose of this leaflet is to reinforce to pilots the essential need for the detailed understanding of aviation weather, including the appropriate threat assessments and strategies to adopt in relation to pre-flight, in-flight and post flight operations for a helicopter flight to be conducted under Visual Meteorology Conditions (VMC).

1 Refer to the EHEST Analysis reports of 2006-2010 and 2000-2005 European Helicopter Accidents

2 For further reference see HE 8 The Principles of Threat and Error Management (TEM) for Helicopter Pilots, Instructors and Training Organisations

1. RELEVANT WEATHER CRITERIA

1.1 AIR MASS

An "air mass" is a body of air extending hundreds or thousands of miles horizontally and sometimes as high as the stratosphere and maintaining as it travels nearly uniform conditions of temperature and humidity at any given level. Over your route, it will bring certain types of general weather.

- A "**tropical maritime**" air mass, coming perhaps from the Azores, has high humidity at low altitudes and is generally stable, with poor visibility. In the warm sector of a depression, there is often also low stratus cloud and possibly drizzle, although visibility above the cloud may be good. Advection fog is also possible. In a summer anticyclone, you will usually find either clear skies or overcast stratocumulus cloud. "Returning polar maritime" air, starting from Canada but travelling across the warmer parts of the Atlantic, will give similar conditions, but usually less pronounced. These air masses are frequently found in Western Europe.

- "**Tropical continental**" air, from North Africa or Arabia, brings stable conditions. There is a deep and thick haze layer, with little cloud. "Polar continental" air, from Siberia, brings clear skies and often overnight frost. Visibility is generally good except in any showers (often sleet or snow) from the moisture it may have collected if it has travelled across water. Any cloud is likely to be cumulus type.

- "**Polar continental**" air, from Central Europe and Siberia; hot air coming from these areas will generate dry summers, whereas cold air will bring snow in winter. However, it usually happens from November to April, bringing clear skies and very negative temperatures.

- "**Polar maritime**" air, direct from Canada, is generally unstable, with good visibility outside precipitation, but because it has collected moisture there is usually much more cloud. In summer, the base of "fair weather cumulus" may be high, but especially in winter frequent, possibly heavy showers from deeper cumulus are likely. Thunderstorms are also possible if there is a suitable "trigger" to start them. In winter, cumulus may form over the sea and coastal areas even when the land is too cold to produce convection.

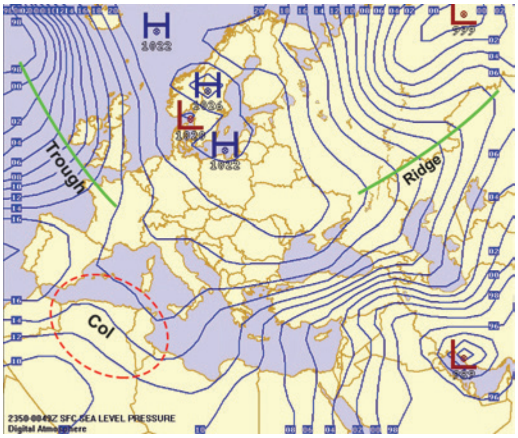
- If "**Arctic maritime**" air from North of Norway, is forecast, the cold unstable air will include cumulonimbus clouds which form over the sea and drift a short distance over land, and snow will almost certainly fall in coastal areas. Although the visibility outside showers will be excellent, snow will reduce that dramatically.

- Weather fronts mark the boundary between two air masses, which often have contrasting properties. For example, one air mass may be cold and dry and the other air mass may be relatively warm and moist. These differences produce a reaction in a zone known as a front. Across a front there can be large variations in temperature, as warm air comes into contact with cooler air. The difference in temperature can indicate the 'strength' of a front, e.g. if very cold air comes into contact with warm tropical air the front can be 'strong' or 'intense'. If, however, there is little difference in temperature between the two air masses the front may be 'weak'. Warm air follows a warm front and cold air follows a cold front. We also tend to see increased amounts of cloud and rainfall along the front itself particularly when warm and moist air is forced to lift up by the cold air mass and, as a consequence towering cumulus or cumulonimbus develop.

1.2 PRESSURE PATTERNS

Anticyclones (HIGH) produce settled weather with light winds. However, the air becomes progressively more stable, and surface visibility becomes steadily worse (and the inversion at the top of the haze layer lower) unless the air mass changes. There may be no cloud, but especially in winter stratocumulus cloud may form daily, dispersing at night. In summer, with no cloud (or thin cumulus) temperatures may increase daily and slow down the visibility reduction, but in winter the clear skies may lead to radiation fog which takes daily longer to clear.

In an anticyclone (high pressure) the winds tend to be light and blow in a clockwise direction (in the northern hemisphere). Also the air is descending, which reduces the formation of cloud and leads to light winds and settled weather conditions.



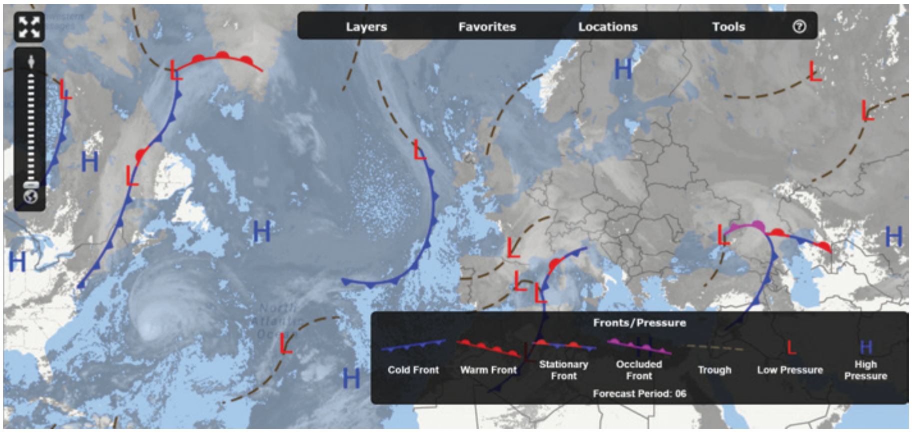
Ridges of high pressure tend to move away quickly, so although the weather will again be settled for a time, the disadvantages are less likely to take effect.

Depressions (LOW) move quickly, produce unsettled weather with strong winds, and their effects are mainly associated with frontal systems. However, even if no frontal system is marked on a chart, the centre of a depression generally contains thick convective cloud with few gaps, and often showers with a low cloud base.

In a depression (low pressure), air is rising and blows in an anticlockwise direction around the low (in the northern hemisphere). As it rises and cools, water vapour condenses to form clouds and perhaps precipitation. This is why the weather in a depression is often unsettled - there are usually weather fronts associated with depressions.

Troughs of low pressure are often a combination of fronts. Lines of showers or periods of continuous precipitation are common. Especially over or near high ground there will be a lot of cloud at low altitude, possibly triggering thunderstorms.

Cols, areas surrounded by 2 ridges and 2 troughs, may encourage radiation fog in autumn or winter, and thunderstorms in summer.



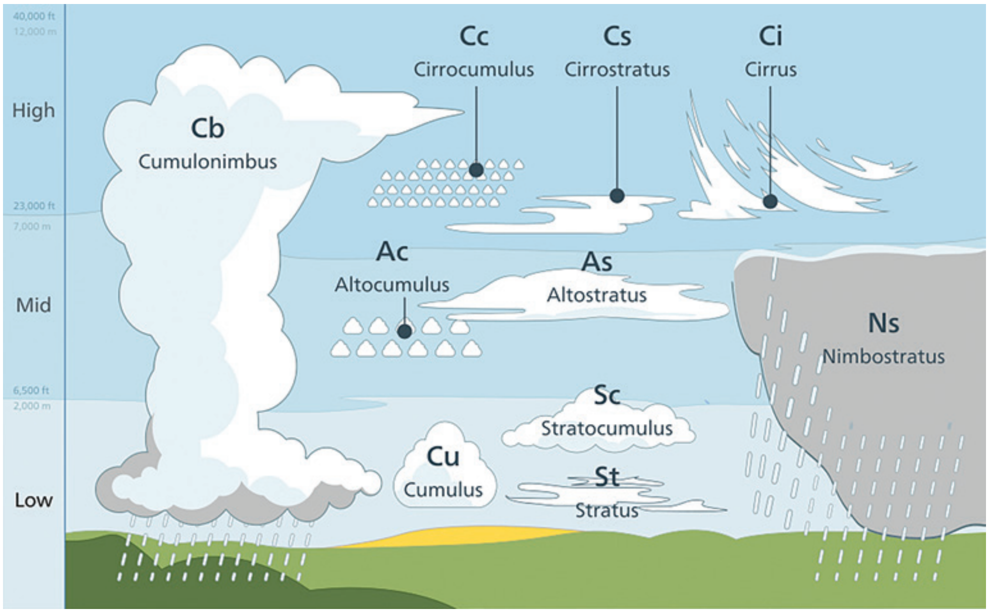
View of fronts and pressures

Source: Schneider Electric

1.3 CLOUDS

1.3.1 Patterns From The Ground

Clouds can provide information about weather in the distance. Increasing amounts of thickening upper cloud are the classic sign of an approaching warm front. However, often the cloud changes come in different forms. More frequently, small amounts of stratus type cloud will appear in bands, far in advance of the surface front. The rain which we expect about fifty miles before a surface warm front often comes in surges, not a progressively increasing amount. The picture shows a sky with a warm front coming from the direction of a range of hills which has broken up the theoretical cloud pattern.



Various types of clouds and their altitudes

Source: Wikipedia

You will seldom see an approaching cold front; it will be hidden by low cloud in the warm sector. However, when it has arrived, perhaps giving heavy rain, often rays of sunlight can be seen in the distance to indicate the clearance behind it. The actual passage of the cold front will be indicated by the surface wind veering as the air temperature and dew point drop, even if the sky does not immediately clear.

Thunderstorms bring many hazards for aviation, including surface wind changes a long distance away, and can spread rapidly. Light aircraft pilots should avoid them by at least 10 nautical miles.

Especially in frontal zones, cumulonimbus clouds are sometimes “embedded” (hidden by other clouds). However, individual distant cumulonimbus will often be indicated either by the cirrus cloud of an “anvil” (a flat top), or by towering cumulus with large vertical extent, which will themselves turn into storm clouds.

Cumulus type clouds at high altitudes, “altocumulus castellanus”, will often turn into cumulonimbus very soon.

1.3.2 Estimating Cloudbase From The Ground

It is often difficult to decide the amount and height of the cloud base (the lowest altitude of the visible portion of the cloud) from the ground. If you have no direct cloud base measurement at your location, and cannot receive reports from nearby aerodromes, it is often tempting to take-off and find the base yourself.

View of cloud base

Source: istockphoto.com

If cloud is touching a mast or other obstruction, the height of the cloud base is obvious. However, experienced pilots can also estimate cloud base by watching patches of cloud drifting in the wind. The relative movement of the patches as you watch is affected by wind speed and cloud height.

If you know the temperature and dew point, you can calculate the approximate cloud base, temperature and dew point close together indicating that cloud may form at very low heights.

1.3.3 Cloud Patterns From The Air

When you are flying, the same information is usually available as from the ground, although nearby cloud may hide some indications such as cumulonimbus anvils. However, if a pilot looks ahead and around, he can see other clues to possible problems. Darkening clouds suggest precipitation, and a rainbow guarantees it!

In generally good visibility, if the visibility changes around the horizon, either cloud is below the aircraft's present altitude, or precipitation is falling there. Neither is good news for a private pilot, so descend, but not below your planned minimum VFR altitude. If you cannot see a clear horizon, change your route, away from the precipitation. "Curtains" of cloud which appear to be falling from above indicate precipitation, which may obscure the horizon. Precipitation may spread quickly, especially around the base of a large cumulus, so have another safety option (diversion, turn around or land) before you try to fly around precipitation from an overcast (or even broken) cloud base.

In good visibility under broken cloud, the areas of sunlit ground, or beams of sunlight shining through gaps, can indicate how much cloud is in that direction. This can help to plan possible route changes if the cloud base starts to lower.

Cloud shapes can give warning of hazards. Cloud which forms below the main cloudbase usually indicates not only precipitation, but often turbulence. “Funnel” cloud may indicate an embedded cumulonimbus which must be avoided. A cloud which “rolls”, or forms a “hook” as you see it, is an indication of at least moderate turbulence at cloud level and below.

Lenticular cloud: smooth, round or oval lens-shaped cloud often seen near a mountain ridge.

Source: Strangesounds.org

Cumulonimbus clouds: dense vertical cloud associated with thunderstorms and atmospheric instability

Source: istockphoto.com

Shelf clouds: early stage of a thunderstorm

Source: istockphoto.com

Roll clouds: low, horizontal, tube-shaped, and relatively rare type of cloud.

Source: Strangesounds.org

1.3.4 Cloud Base And Ceiling

- 'Cloud ceiling' refers to the lowest cloud that covers more than half the sky – so broken (BKN) or overcast (OVC) cover would constitute a cloud ceiling.

- 'Cloud base' refers to the lowest visible cloud, which could also be the cloud ceiling, or it could be few (FEW) or scattered (SCT) cloud.

From your review of the weather you should have established what the likely cloud base and ceiling will be at the different points of the flight. When considering your ability to remain in visual conditions at a given altitude, consider what the cloud cover is reported as, and whether there is a likelihood that it will lower during any stage of the flight.

Remember cloud height figures from TAFs and METARs are from aerodrome level – a 1500ft cloud ceiling at an airfield may be shrouding the tops of hills not too far away from it.

The typical problem with cloud is when it is too low to enable safe flight without hitting the ground or other obstacles.

But how low is too low? It depends on a number of factors:

- What sort of flight are you going for?

- What are the terrain and obstacles like along the route?

- Is the weather getting better or worse in the direction you are going?

- What will it be like at your destination?

Generally speaking VMC flight with a cloud ceiling of (1500ft AGL) or less warrants special attention to terrain and obstacles. VMC flight below (1000ft AGL) is generally only suitable for local flying in areas you are familiar with – actually going anywhere of distance, even with reasonable visibility below cloud, is likely to involve close encounters with hills, radio masts and other low level hazards.

1.4 VISIBILITY

1.4.1 The Ground From The Air (Slant)

It is good to fly above a haze layer. However, if the air to ground slant visibility reduces, expect the visibility when the aircraft descends, to also become worse.

Patches of low cloud or mist may be seen in valleys; these warn of probable radiation fog ahead. Any cloud appearing below your cruising altitude must be treated as a potential threat. Often you will see the first low cloud on hill slopes, but further cloud is likely to form over flatter terrain. Patches of cloud indicate probable carburettor icing conditions, as does the top of a haze layer.

A pilot should always be aware of a possible Degraded Visual Environment (DVE). A pilot can note an object on the ground ahead that has just become visible and record the time until he/she is over it. If the time reduces you should consider whether to turn back, divert or land. At low heights, you must be able to see the ground beyond the next ridge before crossing it. If the same objects remain at the limit of your vision as you fly towards them, that indicates a fog bank or very low cloud.

Even if the cloud ceiling is high enough, you still need sufficient in flight visibility to control the aircraft visually, navigate and avoid other aircraft. Aviation forecasts and reports will give an indication of surface visibility, however actual in-flight visibility can only be judged while in the air. Watch out for warm high pressure days in the summer when the visibility is often surprisingly poor due to haze, especially into the sun. During the winter, low sun can also dramatically reduce forward visibility when flying towards it.

1.4.2 Ground Visibility (Horizontal)

It is worth noting that weather (precipitation) and visibility are closely linked. For example, slight rain or drizzle may have little or no impact on visibility but heavy drizzle could reduce visibility to less than 2500m.

Horizontal visibility is reduced by the presence of the following events:

- Fog (radiation, advection)
- Mist
- Precipitation (rain, snow)
- Inversions (suspended particles)

1.5 WIND

The forecast gradient wind (2000 ft) velocity is likely to be quite accurate, however it can be subject to change. The wind at the surface is impacted by frictional drag due to the Earth surface resulting in a reduction and a change in direction. By contrast, hills, forests, valleys, force the wind to slow down/speed up and change direction (see HE7 "Techniques for helicopter operations in hilly and mountainous terrain", chapter 2). An indication of surface wind velocity can be given by wind socks, smoke, GPS, wind farms, wind lanes on water, etc.

Wind shear or wind gradient, is a difference in wind speed and/or direction over a relatively short distance in the atmosphere. It may be vertical or horizontal if the variation of speed and directions occurs vertically or horizontally and it is the most frequent cause of the atmospheric turbulence.

Usually wind shear is a microscale meteorological phenomenon occurring over a very small distance, but it can be associated with mesoscale or synoptic scale weather features such as squall lines and cold fronts. Sometimes the origin of wind shear is the microburst.

A microburst is a localized column of exceptionally intense and localized sinking air that results in a violent outrush of air at the ground. It is connected with the presence of a thunderstorm and its size is less than or equal to 3 miles in diameter.

There are two primary types of microbursts: 1) wet microbursts if are accompanied by significant precipitation and 2) dry microbursts if it is not accompanied with precipitations.

The microburst go through three stages in their cycle, the **downburst**, **outburst**, and **cushion stages**.

Microbursts can cause extensive damage at the surface, and in some instances, can be life-threatening. The strong straight-line winds are similar to that in some tornadoes, but without the tornado's rotation, it can be particularly dangerous to aircraft, especially during landing, due to the wind shear caused by its gust front.

1.6 TURBULENCE

A turbulence can be defined as small-scale, short term, random and frequent changes to the velocity of air. This can either be mechanical turbulence (due to the friction of the air over uneven ground at low levels), or thermal turbulence (due an air temperature instability at mid-levels).

Reading the local terrain is an important skill for anticipating turbulence. For example, a 10kt wind could create challenging turbulence if it spills over a local feature. Winds above 35kts or so are often indicative of bumpy conditions.

Turbulence affects the behaviour of the aircraft in flight and increases the threat of retreating blade stall, vortex ring and LTE as the ground and air speed fluctuates. For helicopters equipped with teetering rotor systems there is the additional danger of main rotor mast bumping and rotor / tail strike.

Severity of turbulence:

- Light turbulence: is the least severe, with slight, erratic changes in attitude and/or altitude.
- Moderate turbulence: is similar to light turbulence, but of greater intensity - variations in speed as well as altitude and attitude may occur but the aircraft remains in control all the time.
- Severe turbulence: is characterised by large, abrupt changes in attitude and altitude with large variations in airspeed. There may be brief periods where effective control of the aircraft is impossible. Loose objects may move around the cabin and damage to aircraft structures may occur.
- Extreme turbulence: is capable of causing structural damage and resulting directly in prolonged, possible terminal loss of control of the aircraft.

In addition to the above helicopter pilots can also encounter the following types of turbulence at low level:

- Temperature inversion
- Frontal turbulence
- Mountain wave turbulence
- Thunderstorm turbulence

Turbulence can be experienced anywhere and without warning, therefore it should always be anticipated, especially in hilly and mountainous terrain where mountains wave turbulence can occur frequently. Pilots should always be prepared for turbulence by keeping a positive grip on the flying controls and reducing the airspeed to the recommended RFM 'turbulent airspeed'.

1.7 PRECIPITATION

Precipitation can have adverse effects on the flight and therefore should be treated as a threat to be managed.

Types of precipitation to be considered are rain, freezing rain, snow, drizzle, hail, sleet.

1.8 ICE

By definition ice is the solid state of the water and it is a transparent solid crystal. The transition occurs when the water is cooled at a temperature below 0 °C.

The ambient conditions favourable to ice formation are:

- OAT ≤ 10 °C with any form of visible moisture (fog with visibility of one mile or less, rain, drizzle, snow, ect.), or
- OAT ≤ 10 °C with dew point 3 °C or less from OAT.

In-Flight Airframe Icing occurs when supercooled water freezes on impact with any part of the external structure of an aircraft during flight. Liquid drops are present at outside air temperatures (OAT) below 0 °C in these clouds. At OAT close to 0 °C, the cloud may consist entirely of such drops, with few or no ice particles present. At decreasing temperatures, the probability increases that ice particles will exist in significant numbers along with the liquid drops. In fact, as the ice water content increases, the Liquid Water Content (LWC) tends to decrease since the ice particles grow at the expense of the water particles. At temperatures below about -20 °C (-4 °F), most clouds are made up entirely of ice particles.

Thera are different types of airframe ice:

- **Clear ice or Glaze ice** is often clear and smooth. Supercooled water droplets, or freezing rain, strike a surface but do not freeze instantly. Often “horns” or protrusions are formed and project into the airflow.
- **Rime ice** is rough, milky and opaque, formed by supercooled drops rapidly freezing on impact. Forming mostly along an aerofoil’s stagnation point, it generally conforms to the shape of the aerofoil.
- **Cloudy or Mixed ice** is a combination of clear and rime ice.
- **Frost ice** is the result of water freezing on unprotected surfaces while the aircraft is stationary. This can be dangerous when flight is attempted because it disrupts an aerofoil’s boundary layer airflow causing a premature aerodynamic stall and, in some cases, dramatically increased drag making takeoff dangerous or impossible.
- **SLD ice** refers to ice formed in Supercooled Large Droplet (SLD) conditions. It is similar to clear ice, but because droplet size is large, it extends to unprotected parts of the aircraft and forms larger ice shapes, faster than normal icing conditions.

1.9 LIGHTNING

A lightning strike is a brilliant electric spark discharge in the atmosphere, occurring within a thundercloud, between clouds, or between a cloud and the ground.

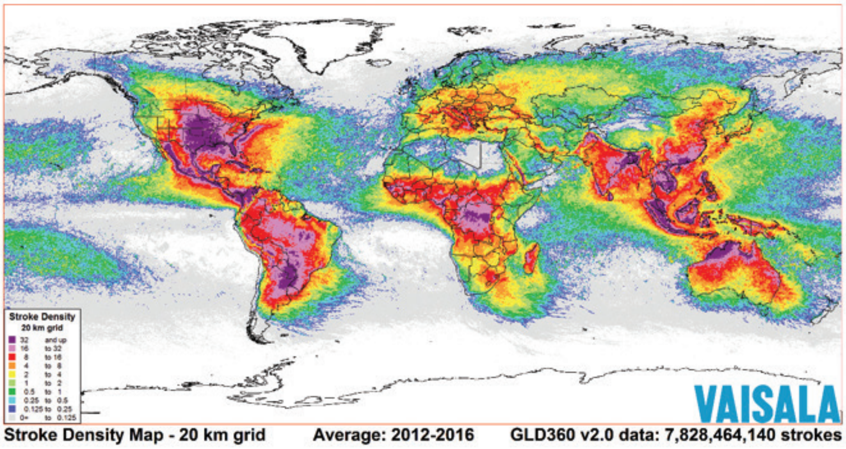
It mostly originates in a cumulonimbus cloud and terminates on the ground, called cloud to ground (CG) lightning. A less common type of strike, called ground to cloud (GC), is upward propagating lightning initiated from a tall grounded object and reaches into the clouds. About 25% of all lightning events worldwide are strikes between the atmosphere and earth-bound objects. The bulk of lightning events are intra-cloud (IC) or cloud to cloud (CC), where discharges only occur high in the atmosphere.

A single lightning event is a “flash”, which is a complex, multi-stage process, some parts of which are not fully understood. Most cloud to ground flashes only “strike” one physical location, referred to as a “termination”. The primary conducting channel, the bright coursing light that may be seen and is called a “strike”, is only about one inch in diameter, but because of its extreme brilliance, it often looks much larger to the human eye and in photographs. Lightning discharges are typically miles long, but certain types of horizontal discharges can be upwards of tens of miles in length. The entire flash lasts only a fraction of a second. Most of the early formative and propagation stages are much dimmer and not visible to the human eye.

Severe thunderstom with significant lightning

Source: istockphoto.com

Historical world map of lightning strokes



Source: Vaisala

2. READING REPORTS

Although you may have considered the likely conditions before flight, you will never have all the information which a forecaster has, and you must never fly without a helicopter weather forecast. You must check the area forecast for your route, and also TAFs and METARs for all aerodromes you expect to pass, and any which might be useful as diversion aerodromes. Compare the actual weather with the forecast; if it is worse now, what will happen later?

TAFs are forecasts, METARs are reports and you should be able to read and decode these (some websites provide plain language interpretation of METARs). For example, remember TAFs/METARs give the cloud based on the ground level at the reporting airport – take account of that when comparing them to the planned altitude of your route.

The values in TAFs do not represent a single forecast value but rather a range of potential values which represent the most likely forecast conditions expected for a particular period of time. These ranges are defined by ICAO and change groups in the TAF exist to represent changes in the weather that are expected to occur outside of a particular range of values. Therefore forecasts are not normally amended until certain criteria for change are exceeded.

The specific value of any of the elements given in a forecast should be understood to be the most probable value which the element is likely to assume during the period of the forecast. Similarly, when the time occurrence or change of an element is given in a forecast, this time should be understood to be the most probable time.

"TEMPO", "OCNL", and even "ISOL" will almost certainly affect your flight, as will any gusts in the forecast wind. Always be ready to divert to another aerodrome if you cannot land at your intended destination, but take note of the possible weather problems and know which other aerodrome is most suitable. If there is uncertainty in the TAFs (forecasts) for example if the time of a weather change is not precisely forecast or there are periods where 'PROB30' or 'PROB40' are being used, delve a bit deeper into the wider weather picture.

TAFs/METARs will give a good indication as to when particular weather will be passing through and when it is likely to get better or worse. By looking at several over a given area you will likely see a pattern of weather and as such TAFs and METARs are an invaluable weather resource but by also making use of other information available it is possible to build an even more comprehensive picture of expected conditions. For example consulting a rainfall map and radar images can help to understand the intensity of showers and thunderstorms and how they are developing.

Also, use of surface pressure charts are useful from around four days in advance of a flight. They give indications of where fronts and their associated areas of high pressure and low pressure are and where they will likely move to. A skill in forecasting weather is often in working out when fronts will arrive in particular places and how they will interact with the other air masses they meet. Using these charts to gain an initial understanding of the general conditions which might be expected can be a valuable tool, for example air mass that arrives from the south over Europe is more likely to be dry, but might be hazy and polluted. Weather from the south-west is likely to contain moisture, bringing rain and low cloud, while weather from the north-west is likely to bring clear air following a cold front but with a higher risk of showers.

When there is either frontal, convective weather or fog around, it can be hard to predict exactly what conditions at a certain point will be, study the weather carefully and consider escape options in different scenarios should the weather be worse than anticipated – calculate altitudes that if forced below by weather, you will turn back or divert.

3. NEW TECHNOLOGIES

Tools exist nowadays to help improve safety by displaying current and forecasted ceiling and visibility levels 24/7, as well as other low level adverse weather conditions. Thus, pilots can make swift go/no-go decisions at any time.

In addition, pilots may use the same cutting-edge tools to view in real-time the various types of precipitation events happening on their flight path: rain, snow, etc..

The most recent technologies, including online tablet and Smartphone, even allow ground operators and/or pilots to send their flight routes in advance to some weather services experts.

Such integration with flight planning applications, which can overlay weather onto aeronautical charts, enable receipt of receive weather warnings and alerts during flight to avoid such hazardous areas.

4. WEATHER MINIMUMS FOR HELICOPTERS

SERA.5001 VMC visibility and distance from cloud minima

VMC visibility and distance from cloud minima are contained in Table S5-1.

TABLE S5-1 (*)			
ALTITUDE BAND	**AIRSPACE CLASS**	**FLIGHT VISIBILITY**	**DISTANCE FROM CLOUD**
At and above 3.050 m (10.000 ft) AMSL	A(**) B C D E F G	8 km	1.500 m horizontally 300 m (1.000 ft) vertically
Below 3.050 m (10.000 ft) AMSL and above 900 m (3000ft) AMSL, or above 300 m (1000 ft) above terrain, whichever is the higher	A(**) B C D E F G	5 km	1.500 m horizontally 300 m (1.000 ft) vertically
At and below 900 m (3000ft) AMSL, or 300 m (1000 ft) above terrain, whichever is the higher	A(**) B C D E	5 km	1.500 m horizontally 300 m (1.000 ft) vertically
	F G	5 km (***)	Clear of cloud and with the surface in sight

(*) When the height of the transition altitude is lower than 3 050 m (10 000 ft) AMSL, FL 100 shall be used in lieu of 10 000 ft.

(**) The VMC minima in Class A airspace are included for guidance to pilots and do not imply acceptance of VFR flights in Class A airspace.

(***) When so prescribed by the competent authority:

(a) flight visibilities reduced to not less than 1 500 m may be permitted for flights operating: (1) at speeds of 140 kts IAS or less to give adequate opportunity to observe other traffic or any obstacles in time to avoid collision; or (2) in circumstances in which the probability of encounters with other traffic would normally be low, e.g. in areas of low volume traffic and for aerial work at low levels;

(b) helicopters may be permitted to operate in less than 1 500 m but not less than 800 m flight visibility, if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collision.

AMC1 SERA.5010(a)(3) - Special VFR in control zones

Speed limit to be applied by helicopter pilots

The 140 kt speed should not be used by helicopters operating at a visibility below 1 500 m. In such case, a lower speed appropriate to the actual conditions should be applied by the pilot.

GM1 SERA.5010(a)(3) Special VFR in control zones

Speed limit to be applied by helicopter pilots

The 140 Kt. speed is to be considered as an absolute maximum acceptable speed in order to maintain an acceptable level of safety when the visibility is 1 500 m or more. Lower speeds should be applied according to elements such as local conditions, number and experience of pilots on board, using the guidance of the table below:

Visibility (m)	Advisory speed (Kt)
800	50
1500	100
2000	120

Note: In some areas (i.e. London CTR) for flight in VFR/SVF, the local airspace requirements may require higher visibility minima than that prescribed by SERA, and of course pilots must always be able to meet the 500 foot rule.

5. OPERATIONAL REQUIREMENTS - FLIGHT DECISION

5.1 Pre-Flight Planning

The basic principles of planning and preparation as outlined in the EHEST HE1 Safety Considerations Leaflet still apply, see Appendix 1 Pre-flight Planning Checklist.

Monitoring information in the days leading up to a flight will help build an understanding of how the weather is evolving. Use of all the relevant information available on the day will help to make effective go/no-go decisions and to make any weather changes en route less of a surprise. In practice of course conditions can change quickly and CAVOK can turn into OVC200 in a short space of time so having a back-up plan is critical.

For planning more than a few days in advance of the flight, normal weather forecasts are the main source of information – nearer the time, aviation weather forecasts should be consulted when making flight decisions so Ensure that you get an aviation weather forecast from an authorised source, including synoptic charts, SIGMET, AIRMET and TAFs and METARs for all aerodromes you expect to pass, and a diversion aerodrome. Compare the actual weather with the forecast; if it is worse now, what will happen later heed what it says, (decodes are available on the internet) and make a carefully reasoned GO/NO GO decision.. Have a planned detour route if you are likely to fly over high ground which may be cloud covered.

Study the forecasts for “PROBs”, which indicate uncertainty, “TEMPO”, “OCNL”, “BECMG” and even “ISOL” will almost certainly affect your flight, as will any gusts in the forecast wind. Always be ready to divert, turn back or land if you cannot reach at your intended destination.

Fuel planning should consider forecast meteorological conditions in accordance with the appropriate regulation for fuel contingency. In flight the pilot should constantly monitor the fuel state.

In helicopters be aware of the conditions that lead to the formation of engine icing, comply with the Rotorcraft Flight Manual (RFM) / Pilot’s Operating Handbook (POM) instructions regarding the use of Carb heat or Engine anti-ice and remember to include Carb Air Temp and OAT in your regular instrument scan.

In wet weather beware of misting of windshield and windows, especially when carrying passengers with wet clothes and carry a cloth to assist demisting the windshield prior to take-off, note: some aircraft when the cabin heating system is started to be used, can produce mist in windshield.

As the destination may be remote from an airfield and associated met facilities, the pilot will be required to interpolate the information provided in the synoptic charts, TAFs, and METARs. If possible, a telephone call to speak to somebody at the landing site for a local weather observation is advised. Information should be collated for both the outbound and return flight, including the anticipated dusk time - in case of a delay. It is important to carry a telephone number/’app” for a met service so that updated weather forecasts can be collected from the LS.

5.2 Pre-Flight Threat Assessment

When planning a VMC flight, there are a number of obvious threats risk factors which should be taken into consideration prior to take-off.

Even for local flights, you should have a reasonable understanding of the general weather conditions before you go flying, particularly how the weather may evolve while during the flight. This should include both an overall appreciation of the weather conditions on the day, as well as the forecast for you specific destination and any alternates if you are going somewhere. This will ultimately inform your decision as to whether it is safe to fly or not. Below are some of the factors you should consider:

- Give yourself **time** before flying to adequately prepare for it (Check the weather for all flights – pilots normally pay special attention to long and complex flights, however many accidents in poor weather are actually relatively local ones. Avoid the false sense of security that may come from short flights in familiar airspace.)

- Does the information available indicate that weather conditions along the route and at the intended destination will be at or above VMC minima

- What equipment is the helicopter fitted with?

- As the pilot the required currency/recency for the flight'

- What navigational equipment in addition to aeronautical charts is carried (GPS, tablet, radio nav. aids) are they up to date and is the pilot trained to their use?

- Is flight planned to take place at a safe height above the ground and has the route minimum safe altitude have been calculated?

- Does a segment of the route involves over-flight of a rural, unpopulated area or large featureless areas such as water, snow etc.?

- Is flight at night when there is no moon, or the stars and moon are obscured?

- Are there, or are likely to be, significant layers of low level cloud en-route (4/8 – 8/8 SCT/BKN/OVC)?

- Is the visibility, or is likely to be, limited en-route, i.e. visual range at or close to the minimum required for conducting a safe flight, (which may be significantly higher than the stated state minima).

- Is there an any probability of encountering DVE?

5.3 In-Flight Threat Assessment

Once a flight is underway additional threats factors may come into play:

- There is a low level of ambient light.
- There is no visual horizon, or the horizon is only weakly defined at best.
- DVE due to deteriorating weather
- The view from the cockpit is obscured due to precipitation/misting.
- A lowering of cloud base forcing an unplanned descent below planned safe height.

To mitigate any of the above threats a pilot should initially reduce speed to maintain ground reference (recommended V_y) and then, if necessary, consider diverting, turning back or carrying out a precautionary land.

5.4 Enroute – Use Of Radio

A Flight Information Service can provide METARs, SPECIs and TAFs as well as advisories (SIGMET and AIRMET) which the pilot requires. Major aerodromes transmit ATIS (automated terminal information service) messages. “VOLMET” groups the many weather reports on published frequencies. A “TREND” at the end of a report may mention reducing cloud base or visibility; that can indicate general deterioration.

5.5 Winter Flying

It should be noted that there are NO light general aviation helicopters cleared for flight in icing conditions. Flight in falling snow generally requires the fitment of snow guards; refer to your RFM/POM. You should use weather forecasts to avoid snow and icing conditions.

Snow, ice and frost should be completely removed from helicopters before flight. Ice can be shed and endanger persons or property, snow can become loosened and be sucked into engine intakes causing the engine to shutdown. Ice build up not only has a detrimental effect on the efficiency of the rotor blades but also increases the mass of the helicopter and significantly affects the C of G.

Dress for the weather. Wear warm clothing in case of heater failure or a forced/ precautionary landing – you can’t put them on in flight!

Snow hides familiar landmarks, making navigation difficult; roads, rivers and railway lines can disappear under snow. Disorientation can occur when snow-covered featureless terrain blends into an overcast (especially high overcast) sky. The horizon disappears and disorientation can quickly set in.

6. GOLDEN RULES

›› Understand weather patterns and their likely effects on your flying

›› Always obtain an aviation forecast

›› Only commence or continue a VMC flight if the information available indicates that at the place of departure, along the route and at the intended destination, conditions will be at or above VMC minima

›› Look for and consider PROB s, TEMPO s, OCNL and ISOL

›› Expect conditions to be worse than forecast

›› Check actual conditions against the forecast

›› Identify alternative routes and suitable diversion aerodromes

›› Carry enough fuel

›› Scan the sky and horizon for possible problems

›› Note local surface winds

›› Check weather reports while flying

›› Be prepared to divert, turn around or land - i.e. make sure there is an alternative course of action available should the weather conditions preclude the completion of the flight as planned

›› Enhance your confidence in weather decision-making, both when flight planning and during the flight, for example watch forecasts on TV, keep an eye on METARs and TAFs even when not flying, study radar and satellite imagery, talk to fellow pilots, share weather experiences, read books and articles and attend courses.

7. GLOSSARY AND METEOROLOGICAL ABBREVIATIONS

Glossary:

Anticyclone	An area of higher surface pressure than its surroundings
Col	Area surrounded by 2 ridges and 2 troughs
Depression	An area of lower surface pressure than its surroundings
METAR	MÉTéorologique Aviation Régulière *(English: Aviation Routine Weather Report)*
Ridge	High pressure between 2 areas of low pressure
TAF	Terminal Aerodrome Forecast
Trough	Low pressure between 2 areas of high pressure
Volmet	Meteorological information for aircraft in flight

Meteorological Abbreviations:

ISOL	Isolate
OCNL	Occasional
PROB	Probability Forecast The probability or chance of thunderstorms or other precipitation events occurring
BECMG	Becoming The BECMG group is used when a gradual change in conditions is expected over a longer time period, usually two hours
TEMPO	Temporary The TEMPO group is used for any conditions in wind, visibility, weather, or sky condition which are expected to last for generally less than an hour at a time (occasional), and are expected to occur during less than half the time period

NOTES

NOTES

IMPRINT

EHEST
Component of ESSI
European Helicopter Safety Team

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Component of ESSI

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Appendix B

EGAST Leaflet GA 3 Weather Anticipation

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EGAST
Component of ESSI

WEATHER ANTICIPATION

FOR GENERAL AVIATION PILOTS

SAFETY PROMOTION LEAFLET

GA 3

CONTENT

INTRODUCTION

Aviation forecasts are important, and pilots must always expect to meet the forecast conditions. However, a forecast only describes what is most likely to happen, and pilots must consider other possible outcomes. This leaflet should help pilots to recognise the approach of worsening weather before they fly into it.

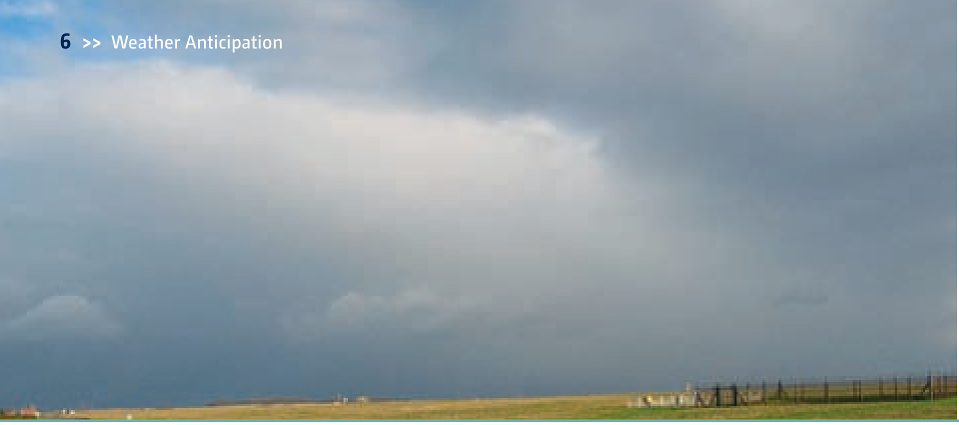
Pilots should expect some weather from particular situations. A synoptic forecast chart, or information from a forecast on television, can prepare you even before you have your aviation forecast. Some pilots have difficulty understanding weather information, including TAFs and METARs (which are international). National Meteorological Offices, and others, produce leaflets, and sometimes applications for mobile phones, which can help.

GENERAL ASSESSMENT - AIR MASS

The **'air mass'** over your route will bring certain types of general weather. A *'tropical maritime'* air mass, coming perhaps from the Azores, has high humidity at low altitudes and is generally stable, with poor visibility. In the warm sector of a depression, there is often also low stratus cloud and possibly drizzle, although visibility above the cloud may be good. Advection fog is also possible. In a summer anticyclone, you will usually find either clear skies or overcast stratocumulus cloud. *'Returning polar maritime'* air, starting from Canada but travelling across the warmer parts of the Atlantic, will give similar conditions, but usually less pronounced. These air masses are frequently found in Western Europe.

'Tropical continental' air, from North Africa or Arabia, brings stable conditions. There is a deep and thick haze layer, with little cloud. *'Polar continental'* air, from Siberia, brings clear skies and often overnight frost. Visibility is generally good except in any showers (often sleet or snow) from the moisture it may have collected if it has travelled across water. Any cloud is likely to be cumulus type.

'Polar maritime' air, direct from Canada, is generally unstable, with good visibility outside precipitation, but because it has collected moisture there is usually much more cloud. In summer, the base of "fair weather cumulus" may be high, but especially in winter frequent, possibly heavy showers from deeper cumulus are likely. Thunderstorms are also possible if there is a suitable



↑ **SNOW MAY FALL IN COASTAL AREAS**

‘trigger’ to start them. In winter, cumulus may form over the sea and coastal areas even when the land is too cold to produce convection.

If *‘arctic maritime’* air from North of Norway, is forecast, the cold unstable air will include cumulonimbus clouds which form over the sea and drift a short distance over land, and snow will almost certainly fall in coastal areas. Although the visibility outside showers will be excellent, snow will reduce that dramatically.

PRESSURE PATTERNS

ANTICYCLONES produce settled weather. However, the air becomes progressively more stable, and surface visibility becomes steadily worse (and the inversion at the top of the haze layer lower) unless the air mass changes. There may be no cloud, but especially in winter stratocumulus cloud may form daily, dispersing at night. In summer, with no cloud (or thin cumulus) temperatures may increase daily and slow down the visibility reduction, but in winter the clear skies may lead to radiation fog which takes daily longer to clear.

RIDGES tend to move away quickly, so although the weather will again be settled for a time, the disadvantages are less likely to take effect.

DEPRESSIONS move quickly, and their effects are mainly associated with their frontal systems. However, even if no frontal system is marked on a chart, the centre of a depression generally contains thick convective cloud with few gaps, and often showers with a low cloud base.

TROUGHS are often a combination of fronts. Lines of showers or periods of continuous precipitation are common. Especially over or near high ground there will be a lot of cloud at low altitude, possibly triggering thunderstorms.

COLS may encourage radiation fog in autumn or winter, and thunderstorms in summer.

READING REPORTS

Although you may have considered the likely conditions before flight, you will never have all the information which a forecaster has, and you must **never** fly without an aviation forecast. You must check the area forecast for your route, and also TAFs and METARs for all aerodromes you expect to pass, and any which might be useful as diversion aerodromes. Compare the actual weather with the forecast; if it is worse now, what will happen later?

However, the forecaster will only tell you what he/she (or his/her computer) believes is most likely. He will seldom tell you what he thinks might happen if he is wrong. Study the forecasts for "PROBs", which indicate uncertainty.

"TEMPO", "OCNL", and even "ISOL" will almost certainly affect your flight, as will any gusts in the forecast wind. Always be ready to divert to another aerodrome if you cannot land at your intended destination, but take note of the possible weather problems and know which other aerodrome is most suitable. Carry enough fuel to get there and fly some circuits before you must land.

Local features will affect the reported weather. For example, high ground may reduce the surface wind and increase the cloud base downwind of it, but not at other nearby places.

↑ ABOVE HAZE

↑ GLARE ON APPROACH

Always expect the weather to be about 30% worse than the forecast. If the wind (including gusts) is forecast to be near your crosswind limit, be ready to fly to a diversion with a runway much closer to the wind. If the cloud base is a little low, either avoid high ground altogether, or plan alternative routes over low ground which you can fly if necessary. Carry enough fuel for the alternative route.

IF VISIBILITY IS NOT VERY GOOD, plan your route so that the best navigation features are always down sun from you, and approach your destination from the direction of the sun. If you can, select a flying altitude above the haze layer. If you expect to arrive at your destination when the sun is low in the sky, check the forecast wind and available runways to try to avoid landing into sun.

CLOUD PATTERNS FROM THE GROUND

↑ STORMY WEATHER WITH ‘ANVIL’

Clouds can provide information about the weather in the distance. Increasing amounts of thickening upper cloud are the classic sign of an approaching warm front. However, often the cloud changes come in different forms. More frequently, small amounts of stratus type cloud will appear in bands, far in advance of the surface front. The rain which we expect about fifty miles before a surface warm front often comes in surges, not a progressively increasing amount. The picture shows a sky with a warm front coming from the direction of a range of hills which has broken up the theoretical cloud pattern.

You will seldom see an approaching **cold front**; it will be hidden by low cloud in the warm sector. However, when it has arrived, perhaps giving heavy rain, often rays of sunlight can be seen in the distance to indicate the clearance behind it. The actual passage of the cold front will be indicated by the surface wind veering as the air temperature and dew point drop, even if the sky does not immediately clear.

Thunderstorms bring many hazards for aviation, including surface wind changes a long distance away, and can spread rapidly. Light aircraft pilots should avoid them by at least 10 nautical miles. Especially in frontal zones, cumulonimbus clouds are sometimes “embedded” (hidden by other clouds). However, individual distant cumulonimbus will often be indicated either by the cirrus cloud of an ‘anvil’ (a flat top), or by towering cumulus with large vertical extent, which will themselves turn into storm clouds. Cumulus type clouds at high altitudes, “altocumulus castellanus”, will often turn into cumulonimbus very soon.

ESTIMATING CLOUDBASE FROM THE GROUND

↑ **A WARM FRONT APPROACHING**

It is often difficult to decide the height of the cloud base from the ground. If you have no direct cloud base measurement at your location, and cannot receive reports from nearby aerodromes, it is often tempting to take-off and find the base yourself. Pilots often mistakenly think that the area forecast is too pessimistic.

If cloud is touching a mast or other obstruction, the height of the cloud base is obvious. However, experienced pilots can also estimate cloud base by watching patches of cloud drifting in the wind. The relative movement of the patches as you watch is affected by wind speed and cloud height. If you practise watching cloud moving across the sky when you already know both the wind speed and cloud height, you can develop the skill of estimating cloud height. Practise and check on good weather days. Fast moving cloud patches when the wind is moderate are very low! Forecasts of gradient (2000 feet) wind speed are usually more accurate than forecasts of cloud base. Pilots should also learn the relationship between the windsleeve at their own airfield and the actual wind strength.

If you can find temperature and dew point measurements, high humidity (temperature and dew point close together) indicates that cloud will form at very low heights.

Precipitation often indicates a lowering cloud base. Rain may fall from relatively high cloud, but drizzle usually indicates a very low base, and likely carburettor icing.

CLOUD PATTERNS FROM THE AIR

↑ DARKENING CLOUD AND RAINBOW

When you are flying, the same information is usually available as from the ground, although nearby cloud may hide some indications such as cumulonimbus anvils. However, if a pilot looks ahead and around, he can see other clues to possible problems. Darkening clouds suggest precipitation, and a rainbow guarantees it!

In generally good visibility, if the visibility changes around the horizon warn, either cloud is below the aircraft's present altitude, or precipitation is falling there. Neither is good news for a private pilot, so descend, but not below your planned minimum VFR altitude. **IF YOU CANNOT SEE A CLEAR HORIZON, CHANGE YOUR ROUTE, AWAY FROM THE PRECIPITATION.** "Curtains" of cloud which appear to be falling from above indicate precipitation, which may obscure the horizon. Precipitation may spread quickly, especially around the base of a large cumulus, so have another safety option (preferably a diversion aerodrome in sight) before you try to fly around precipitation from an overcast (or even broken) cloudbase.

In good visibility under broken cloud, the areas of sunlit ground, or beams of sunlight shining through gaps, can indicate how much cloud is in that direction. This can help to plan possible route changes if the cloud base starts to lower. A large area of sunlit ground may indicate a gap which is big enough to allow you to

↑ PRECIPITATION AHEAD ↑ BECOMES THIS WHEN CLOSER

climb away from dangerously low cloud (small gaps are unlikely to allow a safe climb). If the gaps line up across the wind, however, they may be the result of wave motion. The surface wind strength will vary, and you must expect your rate of climb to reduce in the gap, especially at the upwind end.

Cloud shapes can give warning of hazards. Cloud which forms below the main cloudbase usually indicates not only precipitation, but often turbulence. 'Funnel' cloud may indicate an embedded cumulonimbus which must be avoided. A cloud which 'rolls', or forms a 'hook' as you see it, is an indication of at least moderate turbulence at cloud level and below.

THE GROUND FROM THE AIR

↑ CLOUD CLOSING IN

It is good to fly above a haze layer. However, if the air to ground visibility reduces, expect the visibility when the aircraft descends, to also become worse. If you fly above scattered cloud, watch for gaps closing, not only ahead but also behind you.

Patches of low cloud or mist may be seen in valleys; these warn of probable radiation fog ahead. Any cloud below your cruising altitude should be treated as a potential hazard. Often you will see the first low cloud on hill slopes, but further cloud is likely to form over flatter terrain. Patches of cloud close to cruising altitude indicate probable carburettor icing conditions, and so does the top of a haze layer.

A pilot may become used to poor conditions, and not notice that visibility is gradually becoming worse. Occasionally note an object on the ground ahead that has just become visible and record the time until you are over it. If the time reduces you should consider whether to turn back or divert. At low heights, you must be able to see the ground beyond the next ridge before crossing it. If the same objects remain at the limit of your vision as you fly towards them, that indicates a fog bank or very low cloud.

The forecast **wind velocity** is likely to be quite accurate at cruising altitudes, but be aware of any changes. You should consider the local surface wind, not only in case a forced landing is required, but also to indicate possible crosswind problems at your destination.

Wind strength is difficult to estimate, although if it becomes very strong dust or snow may be blown around. However, cloud

↑ SEE THE GROUND BEYOND THE NEXT RIDGE

↑ SMOKE INDICATES LOCAL SURFACE WIND

shadows moving across the ground can indicate the speed of the gradient wind, as can an aircraft's drift when flying crosswind, or its groundspeed when flying into or down wind.

Valleys usually 'funnel' wind along them, and the direction often changes during the day. Smoke can indicate the direction of the local surface wind. However, if convection is taking place in generally light wind conditions, the actual surface wind may be very different from the gradient wind, and may change rapidly. This may cause problems when attempting a forced landing; a pilot may approach into the wind indicated by a single smoke column, and find he is landing from the wrong direction. It may be better to remember the forecast surface wind and plan accordingly.

If you cannot remember the forecast surface wind, or the actual wind on take-off, you may discover the gradient wind by flying a steady 360 degree turn; see which way the aircraft drifts. Unfortunately, if the engine has already failed, you may not have enough time! It is therefore useful to mark the surface wind you find at take-off on a spare instrument indicator, so you can refer to it in an emergency. Try to remember (or calculate) the position of the sun when you are flying into wind; it should be there when you are on final approach.

However, if several sources of smoke indicate a different surface wind to the forecast, think of possible reasons. Is a front moving faster or slower than forecast? Is a cumulonimbus cloud affecting the winds? Has a sea breeze arrived? Is the **valley** wind changing?

USE OF RADIO

↑ ADVECTION FOG

Pilots who do not talk to air traffic service units lose a useful source of information. A Flight Information Service must provide the METARs, SPECIs and TAFs which the pilot asks for. Ask for these when conditions are not ideal. Check the METARs for your intended destination and possible diversion aerodromes every half hour.

However, pilots can detect changes in weather patterns by listening to the radio without talking. Major aerodromes transmit ATIS (automated terminal information service) messages, and you can expect similar conditions at nearby aerodromes. 'VOLMET' groups the many weather reports on published frequencies. A 'TREND' at the end of a report may mention reducing cloud base or visibility; that can indicate general deterioration. Reducing pressure also suggests that weather is becoming worse. If surface wind backs and increases earlier or later than forecast, this can warn that an approaching front is changing speed.

In summer, wind changes at coastal aerodromes indicate the presence of sea breezes, possibly bringing advection fog or low stratus. Wind changes elsewhere may be caused by nearby showers or thunderstorms. In autumn and winter, reported temperatures and dew points provide useful indications of possible radiation mist or fog, especially at low lying aerodromes, even before the visibility reduces. When the gradient wind is strong, light winds in the lee of a ridge of hills indicate lee wave or rotor turbulence in the area, and much stronger winds can be expected when the wave length changes. When the wind changes at aerodromes in valleys, any bad weather which has previously been at some distance may arrive soon.

SUMMARY

- ›› Understand weather patterns and their likely effects on your flying
- ›› Always obtain an aviation forecast
- ›› Look for and consider PROBs, TEMPOs, OCNL and ISOL
- ›› Expect conditions to be worse than forecast
- ›› Check actual conditions against the forecast
- ›› Identify alternative routes and suitable diversion aerodromes
- ›› Carry enough fuel
- ›› Scan the sky and horizon for possible problems
- ›› Note local surface winds
- ›› Check weather reports while flying
- ›› Be prepared to divert

GLOSSARY AND METEOROLOGICAL ABBREVIATIONS

Glossary:

ANTICYCLONE	An area of higher surface pressure than its surroundings
COL	Area surrounded by 2 ridges and 2 troughs
DEPRESSION	An area of lower surface pressure than its surroundings
METAR	MÉTéorologique Aviation Régulière *(english: Aviation Routine Weather Report)*
RIDGE	High pressure between 2 areas of low pressure
TAF	Terminal Aerodrome Forecast
TROUGH	Low pressure between 2 areas of high pressure
VOLMET	meteorological information for aircraft in flight

Meteorological Abbreviations :

DRIZZLE	very small raindrops
ISOL	Isolate
OCNL	Occasional
PRECIPITATION	Rain, drizzle, snow, or hail
PROB	Probability Forecast *(The probability or chance of thunderstorms or other precipitation events occurring)*
SEA BREEZE	Wind from the sea after land heating and convection
TEMPO	Temporary

IMPRINT

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Appendix C

FAA General Aviation Pilot’s Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making

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Federal Aviation Administration

General Aviation Pilot’s Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making

General Aviation Pilot's Guide

Preflight Planning, Weather Self-Briefings, and Weather Decision Making

Foreword

This guide is intended to help general aviation (GA) pilots, especially those with relatively little weather-flying experience, develop skills in obtaining appropriate weather information, interpreting the data in the context of a specific flight, and applying the information and analysis to make safe weather flying decisions.

It has been developed with assistance and contributions from a number of weather experts, aviation researchers, air traffic controllers, and general aviation instructors and pilots. Special thanks are due to Dr. Dennis Beringer and Dr. William Knecht of the FAA's Civil Aviation Medical Institute (CAMI); Dr. Michael Crognale, Department of Psychology and Biomedical Engineering, University of Nevada/Reno; Dr. Douglas Wiegmann, Institute of Aviation, University of Illinois; Dr. B.L. Beard and Colleen Geven of the NASA Ames Research Center; Dr. Paul Craig, Middle Tennessee State University; Paul Fiduccia, Small Aircraft Manufacturers Association; Max Trescott, SJFlight; Arlynn McMahon, Aero-Tech Inc.; Roger Sharp, Cessna Pilot Centers; Anthony Werner and Jim Mowery, Jeppesen-Sanderson; Howard Stoodley, Manassas Aviation Center; Dan Hoefert; Lawrence Cole, Human Factors Research and Engineering Scientific and Technical Advisor, FAA; Ron Galbraith, FAA Air Traffic Controller, Denver ARTCC; Michael Lenz, FAA General Aviation Certification and Operations Branch, Christine Soucy, FAA Office of Accident Investigation; Dr. Rich Adams, Engineering Psychologist, FAA Flight Standard Service; and Dr. William K. Krebs, Human Factors Research and Engineering Scientific and Technical Advisor, FAA.

This guide is intended to be a living document that incorporates comments, suggestions, and ideas for best practices from GA pilots and instructors like you. Please direct comments and ideas to: susan.parson@faa.gov.

Happy – and safe – flying!

Introduction

Aviation has come a long way since the Wright brothers first flew at Kitty Hawk. One thing that has unfortunately not changed as much is the role that weather plays in fatal airplane accidents. Even after a century of flight, weather is still the factor most likely to result in accidents with fatalities.

From the safe perspective of the pilot's lounge, it is easy to second-guess an accident pilot's decisions. Many pilots have had the experience of hearing about a weather-related accident and thinking themselves immune from a similar experience, because "I would never have tried to fly in those conditions." Interviews with pilots who narrowly escaped aviation weather accidents indicate that many of the unfortunate pilots thought the same thing -- that is, until they found themselves in weather conditions they did not expect and could not safely handle.

Given the broad availability of weather information, why do general aviation (GA) pilots continue to find themselves surprised and trapped by adverse weather conditions? Ironically, the very abundance of weather information might be part of the answer: with many weather providers and weather products, it can be very difficult for pilots to screen out non-essential data, focus on key facts, and then correctly evaluate the risk resulting from a given set of circumstances.

This guide describes how to use the **P**erceive – **P**rocess – **P**erform risk management framework as a guide for your preflight weather planning and in-flight weather decision-making. The basic steps are:

--**Perceive** weather hazards that could adversely affect your flight.

--**Process** this information to determine whether the hazards create risk, which is the potential impact of a hazard that is not controlled or eliminated.

-- **Perform** by acting to eliminate the hazard or mitigate the risk.

Let's see how the 3-P model can help you make better weather decisions.

Preflight Weather Planning

Perceive – Understanding Weather Information

When you plan a trip in a general aviation (GA) airplane, you might find yourself telling friends and family that you are first going to "see" if weather conditions are suitable. In other words, your first major preflight task is to *perceive* the flight environment by collecting information about current and forecast conditions along the route you intend to take, and then using the information to develop a good mental picture of the situation you can expect to encounter during the flight.

Because there are many sources of weather information today, the first challenge is simply knowing where and how to look for the weather information you need.

For many GA pilots, the FAA Flight Service Station (FSS) remains the single most widely used source of comprehensive weather information. Like other weather providers, the FSS bundles, or "packages," weather products derived from National Weather Service (NWS) data and other flight planning information into a convenient, user-friendly package that is intended to offer the pilot not only specific details, but also a big picture view of the flight environment. In this respect, you might think of the FSS as "one-stop shopping" for GA weather information.

Flight Service offers four basic briefing packages:

- Outlook (for flights more than six hours away),
- Standard (for most flights),
- Abbreviated (to update specific items after a standard briefing); and
- TIBS (telephone information briefing service), which provides recorded weather information.

The specific weather information packaged into a standard briefing includes a weather synopsis, sky conditions (clouds), and visibility and weather conditions at the departure, en route, and destination points. Also included are adverse conditions, altimeter settings, cloud tops, dew point, icing conditions, surface winds, winds aloft, temperature, thunderstorm activity, precipitation, precipitation intensity, visibility obscuration, pilot reports (PIREPs), AIRMETs, SIGMETs, Convective SIGMETS, and Notices to Airmen (NOTAMs), including any temporary flight restrictions (TFRs).

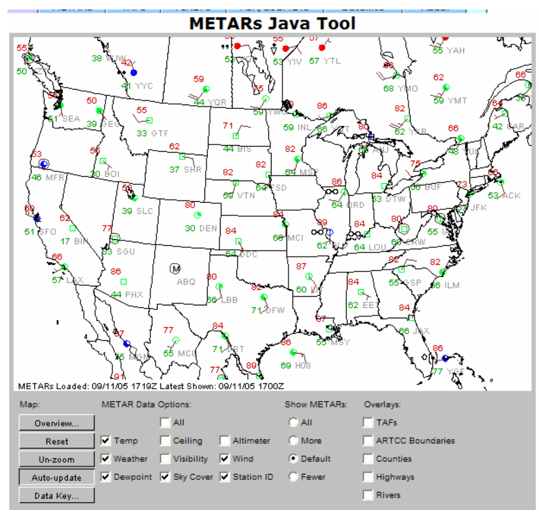
Although a Flight Service weather briefing is still the single most comprehensive source of weather data for GA flying, it can be difficult to absorb all the information conveyed in a telephone briefing. Pictures are priceless when it comes to displaying complex, dynamic information like cloud cover and precipitation. For this reason, you may find it helpful to begin the preflight planning process by looking at weather products from a range of providers. The goal of this self-briefing process is to develop an overall mental picture of current and forecast weather conditions, and to identify areas that require closer investigation with the help of an FSS briefer.

Here is one approach to conducting your initial self-briefing. Keep in mind a simple rule-of-thumb as you work through the weather data collection process: the more doubtful the weather, the more information you need to obtain.

Television/Internet Sources. For long-range weather planning, many pilots start with televised or online weather, such as The Weather Channel (TWC) on television or the Internet. TWC is not an FAA-approved source of weather information, but its television and Internet offerings provide both tactical and strategic summaries and forecasts (up to 10 per day). TWC provides compact, easy-to-use information that can be a useful supplement to approved sources. For example, one TWC Internet page includes a weather map with color-coding for Instrument Flight Rules (IFR) and Marginal Visual Flight Rules (MVFR) conditions at airports around the country (http://www.weather.com/maps/aviation.html). This and other TWC features can give you a very useful first snapshot of weather conditions you will need to evaluate more closely. The National Weather Service's Aviation Weather Center (http://aviationweather.gov/) is another useful source of initial weather information. A look at the AIRMET and SIGMET watch boxes can quickly give you an idea of areas of marginal or instrument weather.

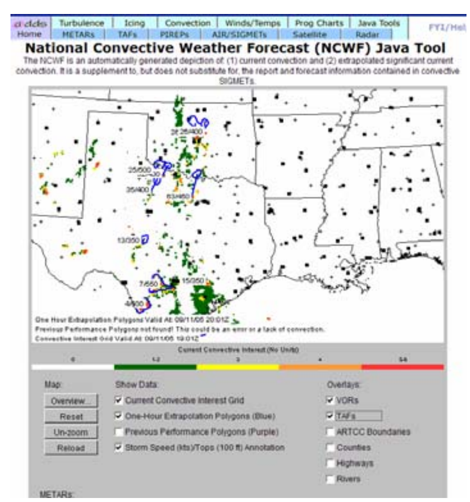
Direct User Access Terminal System (DUATS). Next, get a printed version of the FSS briefing package by obtaining a standard briefing for your route on DUATS. Free and accessible to all pilots via the Internet at www.duat.com (DTC) or www.duats.com (CSC), this resource provides weather information in an FAA-approved format and records the transaction as an official weather briefing. You might want to print out selected portions of the DUATS computer briefing for closer study and easy reference when you speak to a Flight Service briefer.

Aviation Digital Data Service (ADDS): You should also take a look at the wealth of weather information and resources available online via the Aviation Digital Data Service (ADDS), a joint effort of NOAA Forecast Systems Laboratory, NCAR Research Applications Program (RAP), and the National Centers for Environmental Prediction (NCEP) Aviation Weather Center (AWC). Available at http://adds.aviationweather.noaa.gov, ADDS combines information from National Weather Service (NWS) aviation observations and forecasts and makes them available on the Internet along with visualization tools to help pilots use this information for practical flight planning. For example:



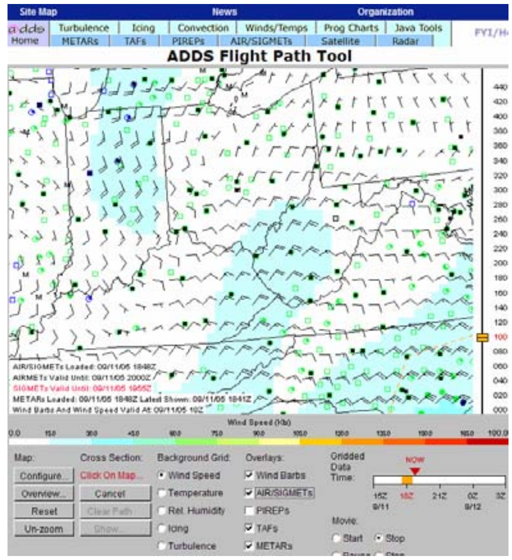
- For METARs, TAFS, AIRMETS, and SIGMETS, the ADDS java tool can zoom in on specific parts of the country.

- For pilot reports (PIREPs), the ADDS Java tool can zoom in on a specific part of the country and specify the type of hazard reported (icing, turbulence, sky and weather). The tool also allows you to limit data to specified altitudes and time periods. Map overlays including counties, highways, VORs, and Air Route Traffic Control Boundaries are available.



- For the National Convective Weather Forecast (NCWF), the latest convection diagnostic is shown together with the one hour forecast. The java tool allows the user to select the height and speed of the forecasted thunderstorm, as well as the one-hour forecast from the previous hour to help the user understand how well the NCWF is performing.

- ADDS also includes a Flight Path Tool that helps pilots visualize high resolution weather products together with winds aloft and pilot reports.



Although some of the other ADDS tools (e.g., icing potential and maximum turbulence potential) are only authorized for operational use by meteorologists and dispatchers, these products can still help you develop a mental picture of vertical and horizontal "weather hazard areas" for your flight.

Flight Service Station Briefing. Once you have formed a basic mental picture of the weather conditions for your trip, it is time to call the FSS. If you have just obtained a DUATS briefing or if the weather situation and mission are both simple, ask for an abbreviated briefing. If not, ask for a standard briefing. Armed with what you already know from your self-briefing process, you will find that it is much easier to absorb information from the briefer – and to know what questions you should ask.

A few guidelines for getting weather data from FSS:

✓ ***DO*** be sure to get the right FSS. When you dial the standard number, 1-800-WX-BRIEF from a cell phone, this number will connect you to the FSS associated with your cell phone's area code – not necessarily to the FSS nearest to your present position. If you are using a cell phone outside your normal calling area, check the *Airport/Facility Directory* to find the specific telephone number for the FSS you need to reach.

✓ ***DO*** know what you need, so you can request the right briefing "package" (outlook, standard, or abbreviated).

✓ ***DO*** use the standard flight plan form to provide the background the briefer needs to obtain the right information for you. Review the form before you call, and develop an estimate for items such as altitude, route, and estimated time en route so you can be sure of getting what you need to know.

- ✓ ***DO*** be honest – with yourself and with the briefer – about any limitations in pilot skill or aircraft capability.

- ✓ ***DO*** let the FSS specialist know if you are new to the area or unfamiliar with the typical weather patterns, including seasonal characteristics. If you are unfamiliar with the area, have a VFR or IFR navigation chart available while you listen to help sharpen your mental picture of where the weather hazards may be in relation to your departure airport, proposed route of flight, and destination.

- ✓ ***DO*** ask questions, and speak up if you don't understand something you have seen or heard. Less experienced pilots sometimes hesitate to be assertive. Smart pilots ask questions to resolve any ambiguities in the weather briefing. The worse the weather, the more data you need to develop options.

- ✓ ***DO*** be sure to get all the weather information you need. If you are flying in IMC or MVFR that could deteriorate, don't end the briefing without knowing which direction (north, south, east, west) to turn to fly toward better weather, and how far you would have to fly to reach it.

Process – Analyzing Weather Information

Obtaining weather information is only the first step. The critical next step is to study and evaluate the information to understand what it means for your circumstances.

The knowledge tests for most pilot certificates include questions on weather theory and use of weather products in aviation. However, it takes continuous study and experience to develop your skill in evaluating and applying weather data to a specific flight in a GA airplane. You might find it helpful to approach the task of practical, real world weather analysis with several basic concepts in mind.

What creates weather? Most pilots can recite the textbook answer -- "uneven heating of the earth's surface" – but what does that mean when you are trying to evaluate weather conditions for your trip? Let's take a look.

The three basic elements of weather are:

- *Temperature* (warm or cold);
- *Wind* (a vector with speed and direction); and
- *Moisture* (or humidity).

Temperature differences (e.g., uneven heating) support the development of low pressure systems, which can affect wide areas. Surface low pressure systems usually have fronts associated with them, with a "front" being the zone between two air masses that contain different combinations of the three basic elements (temperature, wind, and moisture).

The illustration shows the "classic" northern hemisphere low pressure system with the associated cold and warm fronts. Remembering that air circulates counterclockwise around a low pressure system in the Northern Hemisphere will help you visualize the overall temperature, wind, and moisture patterns in a given area. Because weather is associated with fronts, which are in turn associated with low pressure systems, you can get some idea of possible conditions just by looking to see where the low pressure systems are in relation to your route.

What can weather do to you? Temperature, wind, and moisture combine to varying degrees to create conditions that affect pilots. The range of possible combinations is nearly infinite, but weather really affects pilots in just three ways. Specifically, the three basic weather elements can:

- *Reduce visibility*
- *Create turbulence*
- *Reduce aircraft performance*

How do you evaluate weather data? One approach to practical weather analysis is to review weather data in terms of how current and forecast conditions will affect visibility, turbulence, and aircraft performance for your specific flight.

Here's how it works. Suppose you want to make a flight from Cincinnati Municipal Airport (KLUK) to Ohio State University Airport in Columbus, Ohio (KCMH). You want to depart KLUK around 1830Z and fly VFR at 5,500 MSL. Your estimated time enroute (ETE) is approximately one hour. Your weather briefing includes the following information:

METARs:

KLUK 261410Z 07003KT 3SM -RA BR OVC015 21/20 A3001
KDAY 261423Z 14005KT 3SM HZ BKN050 22/19 A3003
KCMH 261351Z 19005KT 3SM HZ FEW080 BKN100 OVC130 22/17 A3002

TAFs

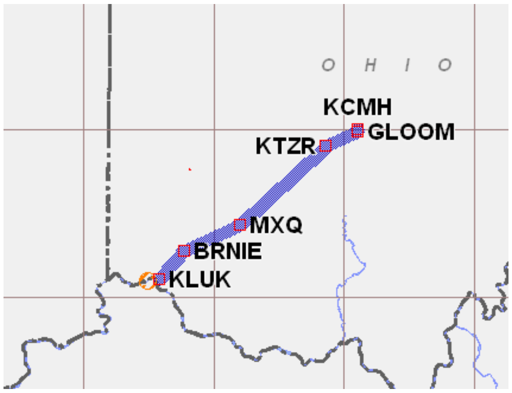
KLUK 261405Z 261412 00000KT 3SM BR BKN015
TEMPO 1416 2SM -SHRA BR
FM1600 14004KT 5SM BR OVC035
TEMPO 1618 2SM -SHRA BR BKN015
FM1800 16004KT P6SM BKN040
FM0200 00000KT 5SM BR BKN025
TEMPO 0912 2SM BR BKN018

KDAY 261303Z 261312 06003KT 5SM BR SCT050 OVC100
TEMPO 1315 2SM -RA BR BKN050
FM1500 15006KT P6SM BKN050
TEMPO 1519 4SM -SHRA BR BKN025
FM1900 16007KT P6SM BKN035
FM0200 14005KT 5SM BR BKN035
FM0600 14004KT 2SM BR BKN012

KCMH 261406Z 261412 19004KT 4SM HZ SCT050 BKN120
FM1800 17006KT P6SM BKN040
TEMPO 1922 4SM -SHRA BR
FM0200 15005KT 5SM BR BKN035
FM0700 14004KT 2SM BR BKN012

WINDS ALOFT

	3000	6000	9000	12000	15000	18000	21000	24000	27000
CMH	1910	2108+15	2807+10	2712+05	2922-07	2936-17	294532	294540	313851
CVG	2310	2607+16	2811+11	2716+06	3019-05	2929-16	293430	293240	293652



Remember that you have the option of getting this information in "plain English" format if you prefer not to decode. Whichever format you select, the first step is to look at your weather data in terms of three specific ways that weather can affect your flight: turbulence, visibility, and aircraft performance.

Organize the information into tables such as the one below, (*see Appendix 5 for blank forms*). This kind of format allows you to see and make "apples-to-apples" comparisons more easily. The column headings in the top row – arranged to match the order in which the briefing information is presented – can help you quickly identify the specific weather hazard(s) you might face on this trip. You may also find it helpful to convert Zulu (UTC) times to local time, and to write note expected ETAs for each waypoint on your flight plan.

Using the Cincinnati (KLUK) to Columbus (KCMH) trip as example:

CURRENT CONDITIONS

		Turbulence	Ceiling & Visibility			Visibility & Performance	Trends
Place	**Time**	**Wind**	**Visibility**	**Weather**	**Ceiling**	**Temp/Dewpt**	**Altimeter**
KLUK	1410Z	07003KT	3SM	RA, BR	OVC015	21/20	A3001
KDAY	1432Z	14005KT	3SM	HZ	BKN050	22/19	A3003
KCMH	1351Z	19005KT	3SM	HZ	FEW080, OVC130	22/17	A3002

FORECAST CONDITIONS

		Turbulence	Ceiling & Visibility		
Place	**Time**	**Wind**	**Visibility**	**Weather**	**Ceiling**
KLUK	FM1800Z	16004KT	P6 SM		BKN040
KDAY	TEMPO 1519Z	--	4SM	-SHRA	BKN025
	FM1900Z	16007KT	P6 SM	--	BKN035
KCMH	FM1800Z	17006KT	P6 SM	--	BKN040
	TEMPO 1922Z	--	4SM	-SHRA, BR	--

WINDS ALOFT

		Turbulence	Visibility & Performance
Place	**Altitude**	**Wind**	**Temp**
CVG	6000	260/07	16 C
CMH	6000	210/08	15 C

1. *Ceiling & Visibility*. First, look at the weather data elements that report ceiling and visibility.

In the case of the proposed VFR flight from KLUK to KCMH, current visibility at your departure and destination airports is marginal, and the small temperature/dew point spread should trigger a mental red flag for potentially reduced visibility. The forecasts call for conditions to improve at your departure airport, KLUK, by the time you plan to launch (1830Z).

Note, however, that you could encounter marginal conditions, including light rain showers, en route and also at your destination (KCMH). Since the forecast ceilings will probably not allow you to fly VFR at the planned altitude (5,500 MSL), this part of the analysis tells you that terrain and obstacle avoidance planning (discussed in the next section) will be necessary for this flight if you choose to depart at the originally scheduled time.

2. *Aircraft Performance*. Next, carefully review current and forecast temperatures – departure, en route, and destination – for possible adverse impact on aircraft performance. If the temperatures are high, you need to know and plan for the effects of high density altitude, especially on takeoff, climb, and landing. If temperatures are low and you plan on flying in the clouds, you should pay special attention to known or forecast icing and freezing levels.

In the sample VFR flight from KLUK to KCMN, temperatures on the surface and at your planned altitude are moderate, so performance problems associated with density altitude or icing are not likely to occur on this flight.

3. *Turbulence*: Review wind conditions for departure airport, enroute, and destination airport. You will also need a mental picture of vertical wind profiles, so as to select the best altitude(s) for cruise flight, and to determine whether wind shear is present.

For the sample flight from KLUK to KCMH, the chart format allows you to see quickly that you will encounter light southerly surface winds at your departure and destination airports. Winds aloft will also be light, but from a westerly direction. There are no indications for wind shear or convective activity (thunderstorms), so you can conclude that turbulence is not likely to be a hazard for this particular flight.

For checklist questions and weather analysis worksheets to help you analyze the impact of these weather elements on your specific flight, see Appendix 6 (VFR) and Appendix 7 (IFR).

Perform – Making a Weather Plan

The third step in practical preflight weather planning is to perform an honest evaluation of whether your skill and/or aircraft capability are up to the challenge posed by this particular set of weather conditions. It is very important to consider whether the combined "pilot-aircraft team" is sufficient. For example, you may be a very experienced, proficient, and current pilot, but your weather flying ability is still limited if you are flying a 1980s-model aircraft with no weather avoidance gear. On the other hand, you may have a new technically advanced aircraft with moving map GPS, weather datalink, and autopilot – but if you do not have much weather flying experience, you must not count on the airplane's capability to fully compensate for your own lack of experience. You must also ensure that you are fully proficient in the use of onboard equipment, and that it is functioning properly.

One way to "self-check" your decision (regardless of your experience) is to ask yourself if the flight has any chance of appearing in the next day's newspaper. If the result of the evaluation process leaves you in any doubt, then you need to develop safe alternatives.

Think of the preflight weather plan as a strategic, "big picture" exercise. The goal is to ensure that you have identified all the weather-related hazards for this particular flight, and planned for ways to eliminate or mitigate each one. To this end, there are several items you should include in the weather flying plan:

Escape Options: Know where you can find good weather within your aircraft's range and endurance capability. Where is it? Which direction do you turn to get there? How long will it take to get there? When the weather is IMC (ceiling 1,000 or less and visibility 3 nm or less), identify an acceptable alternative airport for each 25-30 nm segment of your route. The worksheets in Appendices 5, 6, and 7 include space to record some of this information.

Reserve Fuel: Knowing where to find VFR weather does you no good unless you have enough fuel to reach it. Flight planning for only a legal fuel reserve could significantly limit your options if the weather deteriorates. More fuel means access to more alternatives. Having plenty of fuel also spares you the worry (and distraction) of fearing fuel exhaustion when weather has already increased your cockpit workload.

Terrain Avoidance: Know how low you can go without encountering terrain and/or obstacles. Consider a terrain avoidance plan for any flight that involves:

- Weather at or below MVFR (ceiling 1,000 to 3,000; visibility 3 to 5 miles)
- A temperature/dew point spread of 4° C. or less;
- Any expected precipitation; or
- Operating at night.

Know the minimum safe altitude for each segment of your flight. All VFR sectional charts include a maximum elevation figure (MEF) in each quadrangle. The MEF is determined by locating the highest obstacle (natural or man-made) in each quadrangle, and rounding up by 100 to 300 feet.

Charts for IFR navigation include a Minimum Enroute Altitude (MEA) and a Minimum Obstruction Clearance Altitude (MOCA). Jeppesen charts depict a Minimum Off Route Altitude (MORA), while FAA/NACO charts show an Off Route Obstruction Clearance Altitude (OROCA) that guarantees a 1,000-foot obstacle clearance in non-mountainous terrain and a 2,000 foot obstacle clearance in mountainous terrain.

In addition to these sources, many GPS navigators (both panel-mount and handheld) include a feature showing the Minimum Safe Altitude (MSA), Enroute Safe Altitude (ESA), or Minimum Enroute Altitude (MEA) relative to the aircraft's position. If you have access to such equipment, be sure you understand how to access and interpret the information about safe altitudes.

The Air Safety Foundation's Terrain Avoidance Plan is another helpful resource.

Passenger Plan: A number of GA weather accidents have been associated with external or social pressures, such as the pilot's reluctance to appear "cowardly" or to disappoint passengers eager to make or continue a trip. There is almost always pressure to launch, and pressure to continue. Even the small investment in making the trip to the airport can create pressure to avoid "wasted" time.

For this reason, your weather planning should include preflighting your passengers (and anyone waiting at your destination) as well as your aircraft. If you jointly plan for weather contingencies and brief your passengers before you board the aircraft, you as the pilot will be less vulnerable later on to the pressure to continue in deteriorating weather conditions. Suggestions:

- ✓ ***DO*** use the worksheet in Appendix 4 to develop personal minimums that will help you make the toughest go / no-go and continue / divert decisions well in advance of any specific flight.

- ✓ ***DO*** be aware that the presence of others can influence your decision-making and your willingness to take risks, and let your passengers know up front that safety is your top priority. Share your personal minimums with your passengers and anyone who might be waiting for you at the destination.

- ✓ ***DO*** establish "weather check" checkpoints every 25-30 nm along the route, at which you will reevaluate conditions. If possible, have your passengers assist by tracking progress and conditions at each weather checkpoint.

- ✓ ***DO*** use your pre-established personal minimums to determine exactly what conditions will trigger a diversion at any given weather checkpoint. Let your passengers know what these conditions are.

- ✓ ***DO*** decide specifically what you will do if you have to divert at any particular point, and inform your passengers of these plans. Preflight is the time to make alternative arrangements (e.g., hotel and rental car reservations) in the event that weather conditions worsen. You can always put passengers (or yourself) on an airliner if you absolutely have to return on time.

- ✓ ***DO*** advise anyone meeting you at your destination that your plans are flexible and that you will call them when you arrive. Be sure that they too understand that safety is your top priority, and that you will delay or divert if weather becomes a problem.

- ✓ ***DO*** remember that one of the most effective safety tools at your disposal is waiting out bad weather. Bad weather (especially involving weather fronts) normally does not last long, and waiting just a day can often make the difference between a flight with high weather risk and a flight that you can make safely.

In-flight Decision-Making

Perceive – Obtaining In-flight Weather Information

Many times, weather is not forecast to be severe enough to cancel the trip, so pilots often choose to take off and evaluate the weather as they go. While it is not necessarily a bad idea to take off and take a look, staying safe requires staying alert to weather changes. GA pilots and their aircraft operate in (rather than above) most weather. At typical GA aircraft speeds, making a 200-mile trip can leave a two to three hour weather information gap between the preflight briefing and the actual flight. In-flight updates are vital!

Let's take a closer look at in-flight weather data sources.

Visual Updates. One of the most important things you can do is to look outside. Use your eyes to survey the weather and literally see whether the conditions around you match the conditions that were reported or forecast. Sometimes there are local deviations in weather conditions (isolated cells, fog, etc.) that may not be immediately known to the FSS specialist or that may not appear on weather-product depictions, especially if there is no weather-reporting capability at your departure point. Even if you looked at radar during your preflight briefing process, remember that NEXRAD data is at least 8 minutes old by the time you see it on a display, and older still by the time you are ready to depart. Weather can change very rapidly.

ATIS/ASOS/AWOS. One of the easiest ways to monitor conditions en route is to listen to ATIS and ASOS/AWOS broadcasts along your route. These broadcasts can help you update and validate preflight weather information about conditions along your route of flight.

Enroute Flight Advisory Service (EFAS, or Flight Watch). Available on 122.0 in the continental United States from 5,000 AGL to 17,500 MSL, EFAS, addressed as Flight Watch, is a service specifically designed to provide en route aircraft with timely and meaningful weather advisories pertinent to the type of flight intended, route of flight, and altitude. If you are in contact with ATC, request permission to leave the frequency to contact EFAS. Provide your aircraft identification and the name of the VOR nearest to your position.

Air Traffic Control (ATC). Simply monitoring ATC frequencies (available on aeronautical charts) along the way is one way to keep abreast of changing weather conditions. For example, are other GA aircraft along your route requesting diversions? You can also request information on the present location of weather, which the controller will try to provide if workload permits. When you ask ATC for weather information, though, you need to be aware that radar – the controller's primary tool – has limitations, and that operational considerations (e.g., use of settings that reduce the magnitude of precipitation returns) will affect what the controller can see on radar.

Datalink and Weather Avoidance Equipment. Radar and lightning detectors have been available in some GA aircraft for many years. These devices can contribute significantly to weather awareness in the cockpit. An increasing number of GA aircraft are now being equipped with weather datalink equipment, which uses satellites to transmit weather data such as METARs, TAFs, and NEXRAD radar to the cockpit, where it is often shown as an overlay on the multifunction display (MFD). Handheld devices with weather datalink capability are also a popular source of en route weather information.

There are several basic methods for transferring weather data from a weather data network provider to an aircraft:

- **Request/Reply** - In these systems, the pilot must decide what is needed and then request the specific information and coverage area. This request must then be sent from the aircraft to the satellite, from the satellite to the ground, processed by the ground system and transmitted back to the airplane. Transmission time can require as long as 10 or 15 minutes. Since weather can change very rapidly, this delay can significantly reduce utility of the data.

- **Narrowcast** - Some providers offer "narrowcast," which automatically sends data directly to the aircraft according to the pilot's pre-established preferences for products, update rate, resolution, coverage area, and other parameters.

- **Broadcast** - Broadcast systems continuously send available weather products to every user in the area through a satellite network and a system of interconnected ground stations. Satellite broadcast systems use high-power geosynchronous satellites to deliver large amounts of data in a very short time.

One of the most important, and critical, things to know about datalink is that regardless of the transmission method, it does not provide "real-time" information.

Process – (Honestly) Evaluating and Updating In-flight Conditions

Safe weather flying requires continuous evaluation of in-flight weather conditions.

Visual Updates. Seeing is believing – or so we are conditioned to think. Although you should certainly use your eyes during the flight to perceive the weather, you need to be aware that our prior visual experience largely determines our ability to “see” things. In the narrow runway illusion, for instance, the aircraft appears to be at a greater height over the runway because we have learned through previous experience what a typical runway should look like at a given altitude. The human brain prefers to adjust the apparent height of the aircraft rather than adjust the concept of what a runway should look like.

Similarly, scientists who study human vision have determined that weather transitions are sometimes too subtle for the limits of the visual system. Like other sensory organs, the eye responds best to changes. It adapts to circumstances that do not change, or those that change in a gradual or subtle way, by reducing its response. Just as the skin becomes so acclimated to the “feel” of clothing that it is generally not even noticed, the eye can become so accustomed to progressive small changes in light, color, and motion that it no longer “sees” an accurate picture. In deteriorating weather conditions, the reduction in visibility and contrast occurs quite gradually, and it may be quite some time before the pilot senses that the weather conditions have deteriorated significantly. In essence, you have to learn how to look past the visual illusion and see what is really there.

Certain weather conditions also make it particularly difficult to accurately perceive with the eye. For instance, a phenomenon called “flat light” can create very hazardous operating circumstances. Flat light is a condition in which all available light is highly diffused, and information normally available from directional light sources is lost. The result is that there are no shadows, which means that the eye can no longer judge distance, depth features, or textures on the surface with any precision. Flat light is especially dangerous because it can occur with high reported visibility. It is common in areas below an overcast, and on reflective surfaces such as snow or water. It can also occur when blowing snow or sand create flat light conditions accompanied by “white-out,” which is reduced visibility in all directions due to small particles of snow, ice or sand that diffuse the light.

Awareness is important in overcoming these challenges, but you can also develop your visual interpretation skills. Appendix 8 provides tips and techniques you can use to estimate in-flight visibility and cloud clearance, thus enhancing your ability to evaluate in-flight weather conditions accurately.

ATIS/ASOS/AWOS. In-flight weather information obtained from ATIS and ASOS/AWOS broadcasts can contribute useful pieces to the en route weather picture, but it is important to understand that this information is only a weather "snapshot" of a limited area. ATIS and ASOS/AWOS broadcasts are primarily intended to provide information on conditions in the airport vicinity. The information reported is derived from an array of sensors. While these systems are designed to be as accurate as possible and are increasingly sophisticated, the automated system is actually monitoring only a very small area on the airfield and that it reports only what it can "see." For example, sensors that measure visibility are actually measuring a section of air less than 24 inches wide. Even a dense fog on a portion of the airfield will go undetected by the system unless the fog actually obscures the sensors. The system will not "see" an approaching thunderstorm until it is almost directly over the automated site's ceiling instruments.

EFAS. Assuming that you do find or suspect deteriorating conditions while en route, be sure to contact the En route Flight Advisory Service (EFAS – Flight Watch) for additional information. EFAS can be an immensely helpful resource, but interpreting and applying the information you receive while you are also flying the aircraft – especially if you are in adverse or deteriorating conditions with no autopilot – can be very challenging. The key is understanding where the weather is in relation to your position and flight path, where it is going, and how fast it is moving. A good practice is to have an aeronautical chart with your route clearly marked readily available before you call Flight Watch. The chart will help you visualize where the weather conditions are in relation to your current position and intended route of flight, and determine whether (and where) you need to deviate from the original plan.

Another interpretation useful tool is the In-flight Advisory Plotting Chart (figure 7-1-2 in Chapter 7 of the Aeronautical Information Manual (AIM)). This chart includes the location and identifier for VORs and other locations used to describe hazardous weather areas. Consider keeping copies of this chart in your flight bag for easy reference whenever you call EFAS.

ATC. ATC radar can detect areas of precipitation, but does not detect clouds or turbulence. The existence of turbulence may be implied by the intensity of a precipitation return: the stronger the return, the more likely the presence of turbulence. Similarly, icing may be inferred by the presence of moisture, clouds, and precipitation at temperatures at or below freezing.

ARTCC facilities and many of the terminal approach control facilities now have digital radar display systems with processors that can better determine the intensity (dBZ) of radar weather echoes and display that information to the controller. Consequently, approach controllers, center controllers, and AFSS specialists have all begun using four terms to describe weather radar echoes to pilots: "light," "moderate," "heavy," and "extreme." Each term represents a precipitation intensity level paired with a decibel (dBZ) range to help pilots interpret the severity of the flight conditions present. (*Note: A dBZ is a measure of radar reflectivity in the form of a logarithmic power ratio with respect to radar reflectivity factor "Z."*)

Although the terms are consistent, there are still some equipment-related differences in what can be described.

✓ In Air Route Traffic Control Centers, NEXRAD data is fed through the **W**eather **a**nd **R**adar **P**rocessor (WARP), which organizes 16 NEXRAD levels into four reflectivity (dBZ) categories. Reflectivity returns of less than 30 dBZ are classified as "LIGHT" and are filtered out of the center controllers' display, which means that center controllers cannot report areas of "light" weather radar echoes.

✓ A terminal radar approach control has neither NEXRAD nor WARP, so weather radar echoes are displayed by the Airport Surveillance Radar (ASR) systems using Common Automated Radar Terminal System (Common ARTS) or Standard Terminal Automation Replacement System (STARS) digital weather processors. Paired with a weather processor, digitized ASR 9 and 11 systems display the four weather radar echo intensity categories to the controller.

✓ Terminal radar approach control facilities can, and do, display "light" (less than 30 dBZ) areas of precipitation. Not all terminal facilities have digitized systems, however, and systems without digital processors cannot discern radar echo intensity. In these cases, ATC can describe the position of weather radar echoes, but will state "intensity unknown" instead of using the terms, "light," "moderate," "heavy," or "extreme."

A critical element in interpreting weather information from ATC is a thorough understanding of pilot-controller communications. Be sure to review the AIM Pilot/Controller Glossary, and clarify points you do not understand.

Datalink and Weather Avoidance Equipment. When analyzing this information, it is vital to remember that the quality of the information depends heavily upon update rate, resolution, and coverage area. When flying an aircraft that has datalink equipment, safe and accurate interpretation of the information you receive depends on your understanding of each of these parameters.

Datalink does not provide real-time information. Although weather and other

navigation displays can give pilots an unprecedented quantity of high quality weather data, their use is safe and appropriate only for *strategic* decision making (attempting to avoid the hazard altogether). **Datalink is not accurate enough or current enough to be safely used for *tactical* decision making** (negotiating a path through a weather hazard area, such as a broken line of thunderstorms).

Be aware that onboard weather equipment can inappropriately influence your decision to continue a flight. No matter how "thin" a line of storms appears to be, or how many "holes" you think you see on the display, it is not safe to fly through them.

Perform – Putting It All Together

In the preflight planning process, you used weather data and analysis to develop a strategic, "big picture" weather flying plan. During the en route phase, use the data and analysis to make tactical weather decisions. Good tactical weather flying requires you to perceive the conditions around you, process (interpret) their impact on your flight, and perform by taking appropriate action at each stage.

✓ ***DO*** reassess the weather on a continuous basis. Designate specific fixes (e.g., airports) on or near your flight path as "weather check" checkpoints and use one of the in-flight resources described above to get updated information.

✓ ***DO*** take action if you see or suspect deteriorating weather:

- Trust your eyes if you see weather conditions deteriorating.
- Contact EFAS for detailed information.
- Head for the nearest airport if you see clouds forming beneath your altitude, gray or black areas ahead, hard rain or moderate turbulence, or clouds forming above that require you to descend. It is much easier to reevaluate conditions and make a new plan from the safety of an airport.

✓ ***DO*** contribute to the system by making pilot reports (PIREPS) when you call Flight Watch. To learn more about making good PIREPS, take the Air Safety Foundation's free online "Skyspotter" course.

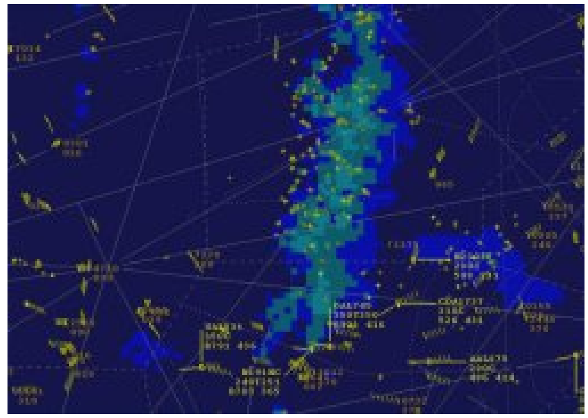
ATC. If you need help from ATC in avoiding or escaping weather, ask sooner rather than later. Guidelines:

✓ ***DO*** be sensitive to ATC communications workload, but keep controllers advised of your weather conditions. Tell the controller if you need to deviate.

✓ ***DO*** remember that navigational guidance information issued to a VFR flight is *advisory* in nature. Suggested headings do not authorize you to violate regulations, and they are not guaranteed to keep you clear of all weather.

✓ ***DON'T*** hesitate to ask questions if you do not understand or if you are unsure.

✓ ***DON'T*** make assumptions about what the controller knows about your flight:



- If you need ATC's help to avoid convective weather, it never hurts to remind the controller that you have no onboard weather avoidance equipment.

- If you are handed off while on a suggested heading for weather avoidance, confirm that the next controller knows you are requesting weather avoidance assistance. For example, your initial call might be: "Center, N2817S, level 5,000, zero two zero heading for weather avoidance."

- ***Never*** assume that "cleared direct when able" means that flying a direct course at that time will keep you clear of weather. To ATC, "direct when able" means to fly direct when you are able to receive a signal and navigate directly to the fix. If you have any doubt, ASK whether a direct course will keep you clear of areas with moderate and heavy radar returns indicative of thunderstorm activity.

- Words such as "showers" and "precipitation" can be very misleading. Some pilots mistakenly assume that these words indicate areas of rain with no thunderheads present. In the world of ATC, weather radar echoes are all referred to as "precipitation." Do not proceed into areas of "showers" or "precipitation" without clarifying whether the level of precipitation is "light," "moderate," or "heavy."

DON'T terminate VFR flight following or other services and leave an ATC frequency without informing the controller that you are doing so.

Post-Flight Weather Review

When you land after a challenging flight in the weather, you may want nothing more than to go home and unwind. The immediate post flight period, however, is one of the best opportunities to increase your weather knowledge and understanding. Studies show that pilots sometimes fly into bad weather simply because they lack relevant experience, and thus did not recognize that certain weather "cues" might create a safety hazard to the flight. Make it a point to learn something from every weather encounter. At the end of a flight involving weather, take a few minutes to mentally review the flight you just completed and reflect on what you learned from this experience. To guide your post flight weather review:

- ✓ What weather conditions/hazards existed, and how did they impact this flight?

  Turbulence / Winds ____
  Ceilings / Visibility ____
  Aircraft Performance ____

- ✓ How did the conditions encountered during this flight compare with the information obtained in the preflight briefing?

- ✓ Which source(s) of preflight weather information provided the best (or most useful, most accurate, most relevant) data for this flight?

- ✓ Which source(s) of en route weather information provided the best (or most useful, most accurate, most relevant) data for this flight?

Another way to develop your weather experience and judgment is simply to observe and analyze the weather every day. When you look out the window or go outside, observe the clouds. What are they doing? Why are they shaped as they are? Why is their altitude changing? This simple habit will help you develop the ability to "read" clouds, and understand how shape, color, thickness, and altitude can be valuable weather indicators. As your cloud-reading skill develops, start trying to correlate the temperature, dew point, humidity, and time of day to the types of clouds that have formed. Take note of the wind and try to visualize how it wraps around the tree or whips around the corner of a building. This exercise will help you become more aware of wind at critical points in your flight.

Weather is a fact of life for pilots. Developing your weather knowledge and expertise is well worth the time and effort you put into it, because weather wisdom will help keep you – and your passengers – safe in the skies.

Resources

Appendix 1 Weather Products and Weather Providers Chart

Appendix 2 Items for Standard Briefing

Appendix 3 Automated Weather Observing Systems

Appendix 4 Developing Personal Weather Minimums

Appendix 5 Aviation Weather Analysis Worksheets

Appendix 6 Weather Analysis Checklist - VFR

Appendix 7 Weather Analysis Checklist - IFR

Appendix 8 Estimating In-flight Visibility and Cloud Clearance

Appendix 1
Weather Products and Weather Providers

The table below lists some of the most common weather products and providers:

Source	AC (Severe Wx Outlook)	AIRMET / SIGMET	charts, Convective outlook	charts, Prog.	charts, Radar (NEXRAD)	charts, Radar summary	charts, Surface analysis	Center Weather Advisory (ATC)	charts, Weather depiction	FA (18-hr area forecast)	FD (winds/temps aloft forecast)	FD (winds/temps aloft forecast)	METAR	PIREP	Satellite	SD (hourly radar)	TAFs	TWEB	
	***Format:* T = text; G = Graphic**. Text may be written or spoken.																		
Preflight	T	T	G	G	G	G	G	T	G	T	T	G	T	T	G	T	T	T	
Commercial vendor	**Search Internet for "commercial weather products."**																		
Public NWS or NOAA site		X	X	X	X		X			X		X	X	X	X	X	X	X	
ADDS (aviation digital data)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
DUATS	X	X						X	X	X	X		X	X	X	X	X		
FSS (automated TIBS)	Short automated briefing, origin & radius, advisories & summary, ceil, vis, w. easy link to FS Specialist																		
FSS (standard)	Verbal synopsis of all available information																		
FSS (abbreviated)	Short, verbal synopsis, based on all available information																		
FSS (outlook)	Short, verbal forecast based on all available information																		
The Weather Channel					X								X		X				
En route																			
cockpit avionics	**products vary**																		
EFAS	Verbal synopsis, based on all available information																		
HIWAS		X						X						X					
TWEB	Short automated synopsis, origin & radius, wx advisories, ceil, vis, winds, radar, PIREPS, alerts																		
Both																			
ASOS	ASOS, ATIS, AWOS are similar to METAR, incl. Place, Time, Wind direction/speed, Visibility, Ceiling, Temp/Dewpoint, Altimeter																		
ATIS																			
AWOS																			
CWA	Short, verbal synopsis, based on all available information																		

(NOTE: Products directly accessible to the user are marked with an "X.")

ADDS	Aviation Digital Data Service (ADDS) (http://adds.aviationweather.noaa.gov/)
ASOS	Automated Surface Observing System
ATIS	Automated Terminal Information Service
AWOS	Automated Weather Observing System
CWA	Center Weather Advisory
DUATS	Direct User Access Terminal System
EFAS	En route Flight Advisory System
FSS	Flight Service Station
HIWAS	Hazardous In-flight Weather Advisory System
LLWAS	Low Level Wind Shear Alert System
NOAA	National Oceanic and Atmospheric Association
NWS	National Weather Service
TIBS	Telephone Information Broadcast Service
TWEB	Transcribed Weather Broadcast

Appendix 2
Items for Standard Briefing

- ✓ Type of Flight (VFR or IFR)
- ✓ Aircraft identification
- ✓ Aircraft Type / Special Equipment
- ✓ True Airspeed
- ✓ Departure Point
- ✓ Proposed Departure Time
- ✓ Cruising Altitude
- ✓ Route of Flight
- ✓ Destination
- ✓ Estimated Time En Route
- ✓ Remarks (e.g., “no weather avoidance equipment on board”)
- ✓ Fuel
- ✓ Alternate Airports
- ✓ Pilot’s Name

Appendix 3
Automated Weather Observing Systems

AWOS- Automated Weather Observing System.

ASOS- Automated Surface Observing System.

AWOS-3 reports all the items in a METAR – time of observation, wind, visibility, sky coverage/ceiling, temperature, dew point and altimeter setting. The designator "**A02**" in the remarks portion of the observation indicates the station has a precipitation discriminator that determines the difference between liquid and freezing/frozen precipitation.

ASOS reports the same data as AWOS-3 **plus** precipitation type and intensity like the AWOS-3 sites with the A02 capabilities.

AWOS-2 reports the same METAR items as an AWOS-3 except it **does not report sky coverage/ceiling information.**

AWOS-1 reports the time of observation, wind, temperature, dew point and altimeter setting. **It does not report visibility or sky coverage information.**

AWOS-A reports **only** the time of observation and altimeter setting.

The prefix "AUTO" indicates the data is derived from an automated system. A certified weather observer may provide augmented weather and obstruction to visibility information in the remarks of the report at AWOS locations.

The "AUTO" prefix disappears when the report has been augmented by human observers.

Baseline Personal Minimums

Weather Condition		VFR	MVFR	IFR	LIFR
Ceiling					
	Day				
	Night				
Visibility					
	Day				
	Night				

Turbulence		SE	ME	Make/Model
	Surface Wind Speed			
	Surface Wind Gust			
	Crosswind Component			

Performance		SE	ME	Make/Model
	Shortest runway			
	Highest terrain			
	Highest density altitude			

	If you are facing:	Adjust baseline personal minimums to:	
Pilot	Illness, medication, stress, or fatigue; lack of currency (e.g., haven't flown for several weeks)	Add	*At least* 500 feet to ceiling
		Add	*At least* ½ mile to visibility
Aircraft	An unfamiliar airplane, or an aircraft with unfamiliar avionics/ equipment:	Add	*At least* 500 ft to runway length
enVironment	Airports and airspace with different terrain or unfamiliar characteristics	Subtract	*At least* 5 knots from winds
External Pressures	"Must meet" deadlines, passenger pressures; etc.	Subtract	*At least* 5 knots from winds

Federal Aviation Administration

Getting the Maximum from Personal Minimums

Step 1 – Review Weather Minimums

Step 2 – Assess Your Experience and Personal Comfort Level

Step 3 – Consider Other Conditions

Step 4 – Assemble and Evaluate

Step 5 – Adjust for Specific Conditions

Step 6 – Stick to the Plan!

Category	Ceiling		Visibility
VFR	greater than 3,000 feet AGL	and	greater than 5 miles
Marginal VFR	1,000 to 3,000 feet AGL	and/or	3 to 5 miles
IFR	500 to below 1,000 feet AGL	and/or	1 mile to less than 3 miles
LIFR	below 500 feet AGL	and/or	less than 1 mile

Think of personal minimums as the human factors equivalent of reserve fuel. Personal minimums should be set so as to provide a solid safety buffer between the *skills required* for the specific flight you want to make, and the *skills available* to you through training, experience, currency, and proficiency.

Review and record your certification, training, and recent experience history on the chart below.

CERTIFICATION LEVEL	
Certificate level (e.g., private, commercial, ATP)	
Ratings (e.g., instrument, multiengine)	
Endorsements (e.g., complex, high performance, high altitude)	
TRAINING SUMMARY	
Flight review (e.g., certificate, rating, Wings)	
Instrument Proficiency Check	
Time since checkout in airplane 1	
Time since checkout in airplane 2	
Time since checkout in airplane 3	
Variation in equipment (e.g., GPS navigators, autopilot)	
EXPERIENCE	
Total flying time	
Years of flying experience	
RECENT EXPERIENCE (last 12 months)	
Hours	
Hours in this airplane (or identical model)	
Landings	
Night hours	
Night landings	
Hours flown in high density altitude	
Hours flown in mountainous terrain	
Crosswind landings	
IFR hours	
IMC hours (actual conditions)	
Approaches (actual or simulated)	

Summarize values for weather experience and "comfort level" in the chart below, and enter values for turbulence & performance.

Experience & "Comfort Level" Assessment Combined VFR & IFR

Weather Condition		VFR	MVFR	IFR	LIFR
Ceiling					
	Day				
	Night				
Visibility					
	Day				
	Night				

Experience & "Comfort Level" Assessment Wind & Turbulence

		SE	ME	Make/ Model
Turbulence				
	Surface wind speed			
	Surface wind gusts			
	Crosswind component			

Experience & "Comfort Level" Assessment Performance Factors

		SE	ME	Make/ Model
Performance				
	Shortest runway			
	Highest terrain			
	Highest density altitude			

Appendix 5
Aviation Weather Analysis Forms

CURRENT CONDITIONS (from METARs)

		Turbulence	Ceiling & Visibility			Visibility & Performance	Trends
Place	**Time**	**Wind**	**Visibility**	**Weather**	**Ceiling**	**Temp/Dewpt**	**Altimeter**

FORECAST CONDITIONS (from TAFs)

		Turbulence	Ceiling & Visibility		
Place	**Time**	**Wind**	**Visibility**	**Weather**	**Ceiling**

WINDS ALOFT

		Turbulence	Visibility & Performance
Place	**Altitude**	**Wind**	**Temp**

Appendix 6
Weather Analysis Checklists – VFR Flight

Ceiling & Visibility

- ✓ How much airspace do I have between the reported/forecast ceilings and the terrain along my route of flight? Does this information suggest any need to change my planned altitude?
- ✓ If I have to fly lower to remain clear of clouds, will terrain be a factor?
- ✓ How much ground clearance will I have?
- ✓ Do I have reliable ceiling information?
- ✓ Will I be over mountainous terrain or near large bodies of water where the weather can change rapidly, or where there may not be a nearby weather reporting station?
- ✓ What visibility can I expect for each phase of flight (departure, enroute, destination)?
- ✓ Given the speed of the aircraft, expected light conditions, terrain, and ceilings, are the reported and forecast visibility conditions sufficient for this trip?
- ✓ Are there conditions that could reduce visibility during the planned flight? (Hint: look for indications such as a small and/or decreasing temperature/dew point spread).
- ✓ Are reported and forecast ceiling & visibility values above my personal minimums?

Aircraft Performance

- ✓ Given temperature, altitude, density altitude, and aircraft loading, what is the expected aircraft performance?
  - o Takeoff distance
  - o Time & distance to climb
  - o Cruise performance
  - o Landing distance
- ✓ Are these performance values sufficient for the runways to be used and the terrain to be crossed on this flight?

  (*Remember that it is always good practice to add a 50% to 100% safety margin to the "book numbers" you derive from the charts in the aircraft's approved flight manual (AFM)*).

Turbulence

- ✓ Are the wind conditions at the departure and destination airports within the gust and crosswind capabilities of both the pilot and aircraft? (*Note: For most GA pilots, personal minimums in this category might be for a maximum gust of 5 knots and maximum crosswind component 5 knots below the maximum demonstrated crosswind component*.)
- ✓ What is the maneuvering speed (V_A) for this aircraft at the expected weight?

  (*Note: Remember that V_A is lower if you are flying at less than maximum gross weight.)*

VFR Analysis Worksheet		Turbulence	Ceiling & Visibility			Visibility & Performance	Trends
Place	**Time**	**Wind**	**Visibility**	**Weather**	**Ceiling**	**Temp/Dewpt**	**Altimeter**

Nearest Good Weather

Direction:
N S E W

Distance:_____
nm

Flying time to nearest good VFR:_________

Turbulence Analysis

Personal Minimums:
Wind speed = ______
Gust factor = _______
Crosswind = _______

Departure wind = ______@_______
Destination wind = _____@_______
En route wind = _______@_______
Maneuvering speed = ___________*

Convective SIGMETS? Yes ☐ No ☐

* V_A *decreases as weight decreases*

Ceiling and Visibility Analysis

Personal Minimums:
Ceiling = ___________
Visibility = __________

Planned altitude = _____________
- Lowest en route ceiling = ______
} ___________ ground clearance

Planned altitude = _____________
- Highest en route obstacle =_____
} ___________ clearance

Planned altitude = _____________
- Highest en route terrain =______
} ___________ clearance

AIRMETS? Yes ☐ No ☐

SIGMETS? Yes ☐ No ☐

Reliable ceiling information? Yes ☐ No ☐

Over mountainous terrain ? Yes ☐ No ☐

Over large bodies of water ? Yes ☐ No ☐

Departure visibility = ________________
Lowest en route visibility = ___________
Destination visibility = _______________

Performance Analysis

Density altitude = _____________
Freezing level = ______________

Takeoff distance = ____________
Runway length = ____________

Landing distance = ____________
Runway length = ____________

Cruise performance = _________

Fuel available = ____gal____hrs
Fuel required = ____gal____hrs
Fuel reserve = ____gal____hrs

Note: It is good practice to add a 50% to 100% safety margin to the "book numbers" you derive from charts in the approved flight manual (AFM).

Appendix 7
Weather Analysis Checklist – IFR Flight

Ceiling and Visibility

- ✓ Is the forecast ceiling for my estimated time of arrival high enough to make the approach?
- ✓ What visibility can I expect for each phase of flight (departure, enroute, destination)?

  --Will I have enough visibility to legally make an instrument approach at the destination?

  --Do current or forecast ceiling and visibility conditions require me to select and file an alternate? (1-2-3 rule.)

  --Where is the nearest GOOD weather alternative?
- ✓ How do reported and forecast conditions for ceiling and visibility compare with my personal minimums for IFR?

Aircraft Performance

- ✓ Given temperature, altitude, density altitude, and aircraft loading, what is the expected aircraft performance?
  - o Takeoff distance
  - o Time & distance to climb
  - o Cruise performance
  - o Landing distance
- ✓ Are these performance values sufficient for the runways to be used and the terrain to be crossed on this flight?

  (*Remember that it is always good practice to add a 50% to 100% safety margin to the "book numbers" you derive from the charts in the aircraft's approved flight manual (AFM*)).
- ✓ Will weight restrictions allow me to carry more than the normal fuel reserve?

  (*More fuel means that you have more options to escape weather*.)
- ✓ *Icing*. What is the forecast freezing level for this flight?
  - o Are there any pilot reports (PIREPS) for my route, or points on the route that support or rebut the icing forecast?
  - o Where are the cloud bases and cloud tops?

Turbulence

- ✓ Are the wind conditions at the departure and destination airports within the gust and crosswind capabilities of both the pilot and aircraft?
- ✓ What is the maneuvering speed (V_A) for this aircraft at the expected weight?

  (*Remember that V_A is lower if you are flying at less than maximum gross weight.)*
- ✓ *Thunderstorms*. Does the forecast include convective activity at any point along my proposed route?

IFR Analysis Worksheet		Turbulence	Ceiling & Visibility			Visibility & Performance	Trends
Place	**Time**	**Wind**	**Visibility**	**Weather**	**Ceiling**	**Temp/Dewpt**	**Altimeter**

Nearest VFR Weather

Direction:
N S E W

Distance:
_____ nm

Flying time to nearest good VFR:________

Turbulence Analysis

Personal Minimums:
Wind speed = ______
Gust factor = _______
Crosswind = _______

Departure wind = ______@_______
Destination wind = _____@_______
En route wind = _______@_______
Maneuvering speed = ___________*

T-storms forecast? Yes ☐ No ☐
Convective SIGMETS? Yes ☐ No ☐

* V_A *decreases as weight decreases*

Ceiling and Visibility Analysis

Personal IFR Approach Minimums:
Ceiling = __________
Visibility = _________

Planned altitude = _____________
- Lowest en route ceiling = ______
} __________ ground clearance

Planned altitude = _____________
- Highest en route obstacle =_____
} __________ clearance

Planned altitude = _____________
- Highest en route terrain =______
} __________ clearance

Cloud bases = _______ Cloud tops = ________

Alternate required ? Yes ☐ No ☐
Over mountainous terrain ? Yes ☐ No ☐
Over large bodies of water ? Yes ☐ No ☐

Departure visibility = ________________
Lowest en route visibility = ___________
Destination visibility = _______________

Performance Analysis

Density altitude = _____________
Freezing level = ______________

Takeoff distance = ____________
Runway length = _____________

Landing distance = ____________
Runway length = _____________

Cruise performance = _________

Fuel available = ____gal____hrs
Fuel required = ____gal____hrs
Fuel reserve = ____gal____hrs

Note: It is good practice to add a 50% to 100% safety margin to the "book numbers" you derive from charts in the approved flight manual (AFM).

Appendix 8
Estimating In-flight Visibility & Cloud Clearance

There are a number of ways to develop your skill in estimating your in-flight visibility and cloud clearance. These techniques will help you establish a continuous weather assessment habit. It will also help you calibrate your perceptions and learn when to trust what you see.

✓ Listen to the ATIS or ASOS/AWOS as you pass near an airport. First try to evaluate the basic weather conditions based on what you see. Then listen to the ATIS or ASOS/AWOS and compare the official report to your own evaluation of conditions, as well as with any previous reports you have seen from this location.

✓ Use the length of a runway you pass in flight to estimate distances.

  - A runway that is 5,300 feet long is about a mile. Look to see how far ahead you can see, and estimate the number of runways that it would take to cover that distance.

  - A 2,600 foot runway would be about a half mile, and so on. In this case, visibility is less than 3 miles if you cannot see 6 runway lengths ahead.

✓ If you know your aircraft's groundspeed, you can estimate distance. Look to the most distant point you can see ahead and then time how long it takes to reach it.

  - If, for example, your ground speed is 105 knots, that's about 120 mph and you'll cover about 2 miles per minute. If you reach the point in less than 90 seconds, the in-flight visibility is less than 3 miles!

  - A simple variation on this technique it to use GPS or DME while flying directly to or from a waypoint or VOR. Just look at the beginning and ending mileage on the GPS or DME to see how far you've flown to reach the farthest point you can see.

✓ If you need to know the lateral distance to a cloud, start timing when the cloud is ahead of you and at about a 45° angle (halfway between your 10 and 11 o'clock or between your 1 and 2 o'clock positions). Stop timing when the cloud is off your wingtip. The distance you've traveled forward will now be equal to the distance between you and the cloud. If you were traveling at 120 mph, it will take you about 11 seconds to travel 2000 feet. If the cloud took less than 11 seconds to arrive off your wingtip, you are now less than 2000 feet horizontally from that cloud.

(*courtesy of Max Trescott, SJ Flight*)

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Appendix D

EHEST Leaflet HE 12 Helicopter Performance

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EHEST
Component of ESSI
European Helicopter Safety Team

Helicopter Performance

FOR HELICOPTER PILOTS

TRAINING LEAFLET

HE 12

CONTENT

INTRODUCTION

This leaflet was developed by the European Helicopter Safety Implementation Team (EHSIT), a component of the European Helicopter Safety Team (EHEST). The EHSIT is tasked to process the Implementation Recommendations (IRs) identified from the analysis of accidents performed by the European Helicopter Safety Analysis Team (EHSAT) [1]

Data from the European Safety Analysis Team (EHSAT) accident review confirms that a continuing significant number of helicopter accidents are performance related. The accident circumstances usually show that the pilot had not ensured there was sufficient power available for the intended manoeuvre, in the prevailing conditions.

The aim of this leaflet is to examine the factors affecting aircraft performance and provide guidance to help pilots ensure that a proposed operation can be safely accomplished.

ACKNOWLEDGEMENT

EHEST wishes to acknowledge the cooperation of the New Zealand Civil Aviation Safety Authority in the production of the leaflet. Some changes have been incorporated to reflect EASA terminology and regulations.

[1] Refer to the EHEST Analysis reports of 2006-2010 and 2000-2005 European Helicopter Accidents

DEFINITIONS

AGL	Above Ground Level
AMSL	Above mean sea level
CG	Center of Gravity
DA	Density Altitude
IGE	In Ground Effect
HTAWS	Helicopter Terrain Awareness Warning System
OAT	Outside Air Temperature
OGE	Out of Ground Effect
POM	Pilot's Operating Handbook
RFM	Rotorcraft Flight Manual
ISA	**International Standard Atmosphere.** An International Standard Atmosphere has been established to enable comparison of aircraft performance, calibration of altimeters, and other practical uses. In the ISA, a particular pressure and temperature distribution with height is assumed. At sea level the pressure is taken to be 1013.2 hPa, and the temperature 15°C. ISA also assumes dry air
PA	**Pressure Altitude** In ISA, any pressure level has a standard corresponding altitude called the pressure altitude, based on a lapse rate of approximately one hPa per 30 feet at lower levels. Pressure altitude is the height that will register on a sensitive altimeter whenever its sub-scale is set to 1013.2 hPa. At any ISA pressure level, there is also a corresponding temperature called the ISA temperature. In ISA, temperature falls off with height at a rate of 1.98°C per 1000 feet up to 36,090 feet, above which it is assumed to be constant (see Figure 1). Warm air is less dense than cold air. Thus, when the temperature at a given altitude is higher than the standard atmospheric temperature, the air at that altitude will be less dense.

Helicopters have the unique ability to take-off and land almost anywhere. It is the responsibility of the pilot to determine if a safe take-off and landing is possible and the availability of sufficient power. Unfortunately, a significant number of helicopter accidents are performance related, with the majority of these accidents occurring during the take-off or landing phases of flight. Many of these accidents occurred when the helicopters were being operated from sites that were elevated, out of wind, restricted by terrain, sloping, or had rough surfaces. Often the helicopters were being operated at high all up mass, in high ambient temperatures and high density altitude These accidents may have been prevented had the pilots been fully aware of the prevailing conditions, and determined the performance capabilities of their helicopter before commencing flight. Such accident prevention relies on thorough pre-flight preparation, of which Flight Manual performance chart calculations are an integral part. Because the ambient conditions at the intended point of operation can be quite different from those planned for, calculated values must always be validated by an actual power check at the operating site. This leaflet provides an overview on the major factors that influence performance and provide tools and checklists to the pilot to safely plan and perform a flight.

1. EXAMPLES OF PERFORMANCE RELATED TOPICS

1.1 Example of a performance related accident

The following examples illustrates how a series of events can compound to result in an accident in which a lack of performance becomes a key causal factor.

1.1.1 Synopsis

A passenger who wished to be flown to a hut in the mountains, approached a friend who was the owner of a single piston-engined helicopter, advising him that the hut was at an elevation of 1450 feet above mean sea level. The pilot assigned to the flight flew the helicopter to the airport where the passenger waited. The pilot assessed the weight of the passenger, pack, helicopter, and fuel and considered them to be within the limit of the helicopter to operate at the elevation of the hut. Some items from the passenger's pack were stowed under the seat, and the pack was placed at his feet. The pilot did an *in-ground-effect* hover check, and found that there was a sufficient power margin for the hover. The passenger guided the pilot to the hut, which turned out to be at a much greater elevation than expected. The pilot did not perform an in-flight power check and elected to land on a nearby site.

He approached the landing site obliquely to allow for an escape route, and flew the helicopter in a shallow approach. At about 15 feet above the landing site, the pilot noticed the rpm was decaying to the bottom of the normal range and opened the throttle fully. No more power was available, and believing a landing was inevitable, the pilot tried to control the flight path by increasing collective pitch. He could not arrest the helicopter forward motion by applying full aft cyclic, and the helicopter began to rotate, touching down heavily. The helicopter then pitched slowly onto its nose and fell onto its right side.

1.1.2 Analysis

Overall, this flight was unlikely to be successfully carried out, although there were numerous opportunities for the pilot to have rectified the situation along the way.

The passenger had misled the pilot about the correct site elevation, and used a map, which showed the heights in metres and not feet. The altitude of the hut was 1,450 metres AMSL (4,750 feet), not 1,450 feet as the passenger reported. Another significant factor was the helicopter mass and balance. Using the weights the pilot estimated, the actual helicopter take-off mass was over the maximum permitted for the aircraft. Moreover, by placing the pack at the passenger's feet, the helicopter was probably loaded outside its forward CG limits. This would have added to the difficulties of using cyclic to arrest the helicopter forward motion. Lack of a power margin was inevitable given the helicopter mass and the density altitude at the landing site, but the pilot did not recognise the shortfall in power. Had the pilot carried out a performance calculation prior to flight which could have been confirmed with an in-flight power check, he would have realized that he had insufficient power to land at that density altitude. A no-go situation would then have been evident. After recognising that there was insufficient power available, the pilot should have used the correct go around technique.

On final approach to the landing site and when he recognized he had insufficient power he should have accelerated the helicopter towards to a pre identified escape route to avoid ground contact.

1.2 Example of a performance chart use for a landing in a mountainous area

The following example illustrates how proper planning and a correct use of performance charts can help to prevent an accident.

1.2.1 Synopsis

During a mountain training course, my instructor ask me to land on a pass in a mountain area. The first step of this mountain training flight was to set our altimeter at 1013 HPa. With this altimeter setting and with the outside temperature, I first check the HOGE performance chart of my helicopter at the estimated altitude of the landing site, with the actual weight of my helicopter, that includes crew, equipment on board (including a survival bag) and the remaining fuel.

Then I performed an orbit at about 500Ft above the landing site altitude, to check the ground and flight hazards and to find the lift side of the mountain.

After estimating the wind, I carry out 2 recon low passes, on two different axes with a front wind, in order to confirm the wind, check the available power and the security on the landing site.

After choosing the approach direction, I inform the instructor about the type of approach I'll intend to perform (high bank to keep the pass with the background, the touch down area, the type of take-off, and the clear way in case of aborting take-off).

I executed the approach according of my decision and we landed on the pass. We checked the power during a short hovering before landing the helicopter.

1.2.2 Analysis

Regardless the full recon procedure using to land in a mountainous area, the most important here is the use of the appropriate performance chart, with the right altimeter setting and to check then during a recon low pass that the performances of the engine are in accordance with the performance chart.

2. PILOT IN COMMAND RESPONSIBILITY

Annex IV 1.c. to Regulation (EC) No 216/2008 and Annex VIII Part NCO.GEN.105 states that *"....The pilot in command must be responsible for the operation and safety of the aircraft and for the safety of all crew members, passengers and cargo on board"*. Additionally the Annex IV 2.a.3. to Regulation (EC) No 216/2008 specifies:

- (iv) the mass of the aircraft and centre of gravity location are such that the flight can be conducted within limits prescribed in the airworthiness documentation;
- (v) all cabin baggage, hold luggage and cargo is properly loaded and secured; and
- (vi) the aircraft operating limitations as specified in point 4 will not be exceeded at any time during the flight.

Additionally the paragraph 4 of the same Annex states:

- 4.a. An aircraft must be operated in accordance with its airworthiness documentation and all related operating procedures and limitations as expressed in its approved flight manual or equivalent documentation, as the case may be. The flight manual or equivalent documentation must be available to the crew and kept up to date for each aircraft.
- 4.c. A flight must not be commenced or continued unless the aircraft's scheduled performance, considering all factors which significantly affect its performance level, allows all phases of flight to be executed within the applicable distances/areas and obstacle clearances at the planned operating mass. Performance factors which significantly affect take-off, en-route and approach/landing are, particularly:
    - (i) operational procedures;
    - (ii) pressure altitude of the aerodrome;
    - (iii) temperature;
    - (iv) wind;
    - (v) size, slope and condition of the take-off/landing area; and
    - (vi) the condition of the airframe, the power plant or the systems, taking into account possible deterioration.
- 4.c.1. Such factors must be taken into account directly as operational parameters or indirectly by means of allowances or margins, which may be provided in the scheduling of performance data, as appropriate to the type of operation.

2.1 How to Comply

Compliance with these rules can be achieved by using the performance data graphs contained in the RFM. Use the graph and trace the applicable data to determine the performance capabilities for the given conditions – and then confirm those values with the applicable in-flight power check applicable for helicopter type. Flight Manuals have graphs for determining density altitude, IGE and OGE hover ceilings, take-off distances, and rate-of-climb performance. It should be noted that different helicopter types have considerable variation in the standard of information presented in these graphs. The use of these graphs is discussed, with worked examples, later in this booklet.

3. PERFORMANCE FACTORS

In this section we discuss how various physical and environmental factors can adversely affect helicopter performance. We have tried to avoid using rule-of-thumb performance methods, because there are differences between helicopter types. – the application of a simplified rule could be either misleading if not unsafe. Instead, we have given a number of performance examples from a range of helicopter types to illustrate how each performance factor affects performance capability. Refer to your RFM or operating procedures, or ask your chief pilot or instructor for the specific performance information that applies to your helicopter. Please note that the performance values derived for the following examples may be significantly better than what the helicopter can actually achieve. All examples have been derived from RFM performance graphs only, and they would normally be validated by an actual power check, if applicable, under the ambient conditions existing at the point of intended operation. Some RFM contain performance charts that have minor variations (e.g., generator on/off, sand filter fitted, bleed air on/off, etc.). You must use the correct variant so that accurate performance data is obtained.

3.1 Mass

What can be seen is that the greater the gross mass of the helicopter the greater the lift (rotor thrust) required for hovering or climbing. The available lift is proportional to the collective setting and the associated rotor blade angle of attack. The power available determines the maximum collective pitch setting that can be maintained at the optimum rotor rpm. The heavier the helicopter the greater the power required to hover (and for flight in general), and the smaller the margin between the power required and the power available. The higher the gross mass the lower the hover ceiling, and therefore the more restricted the helicopter will be in where it can operate. This can be seen from the following example.

Effect of increasing mass on IGE hover ceiling example: Schweizer 269C
Temperature: +27°C at sea level
QNH: 1013 hPa

Gross mass	Gross mass 725 kg	Gross mass 910 kg
Hover ceiling	11,350 feet P alt.	5,400 feet P alt.

Pilots must ensure that they always use an established method to accurately determine the gross mass of the helicopter prior to flight.

3.2 Air Density

As air density affects engine (particularly normally aspirated piston engines) and aerodynamic performance (rotor thrust and tail rotor thrust).

The density is influenced by:

- Pressure;
- Temperature;
- Humidity

Density Altitude: Density Altitude represents the combined effect of pressure altitude and temperature. DA is defined as the height in the standard atmosphere that has a density corresponding to the density at the particular location (on the ground or in the air) at which the density altitude is being measured.

A graph (See Figure 1) provided in the RFM allows us to calculate DA easily. To use the graph we must be flying at a PA (i.e. with 1013 set on our altimeter subscale). Entering the graph with our altitude and OAT we can calculate our DA. When conditions are standard (ISA), DA = PA.

As a DA increases the helicopter performances decreases and vice versa.

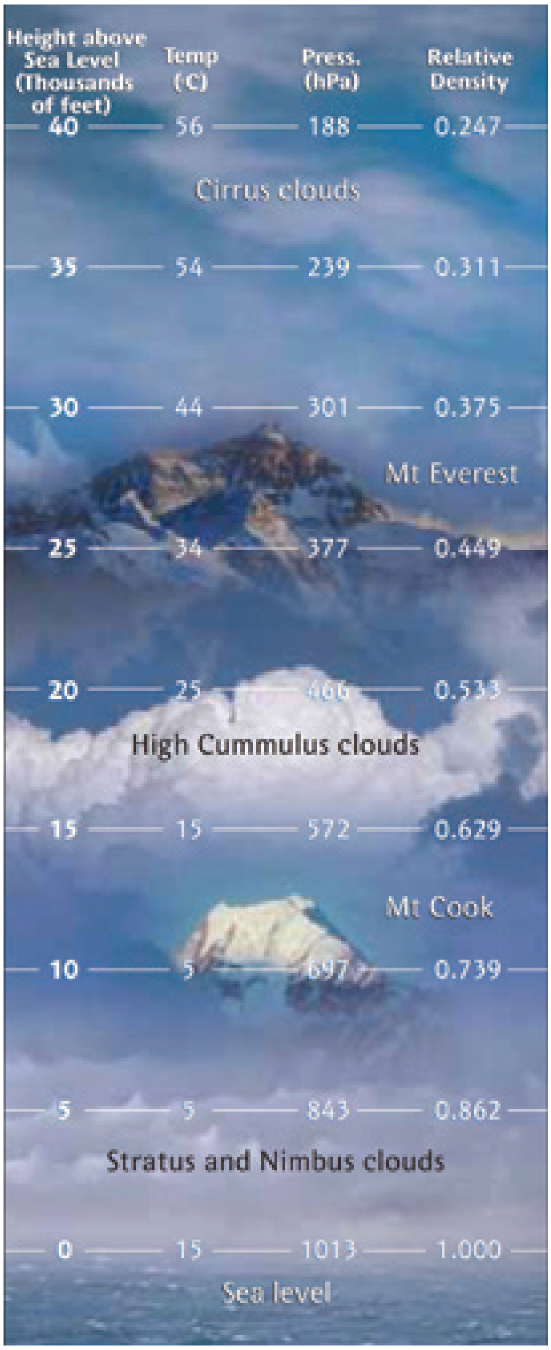
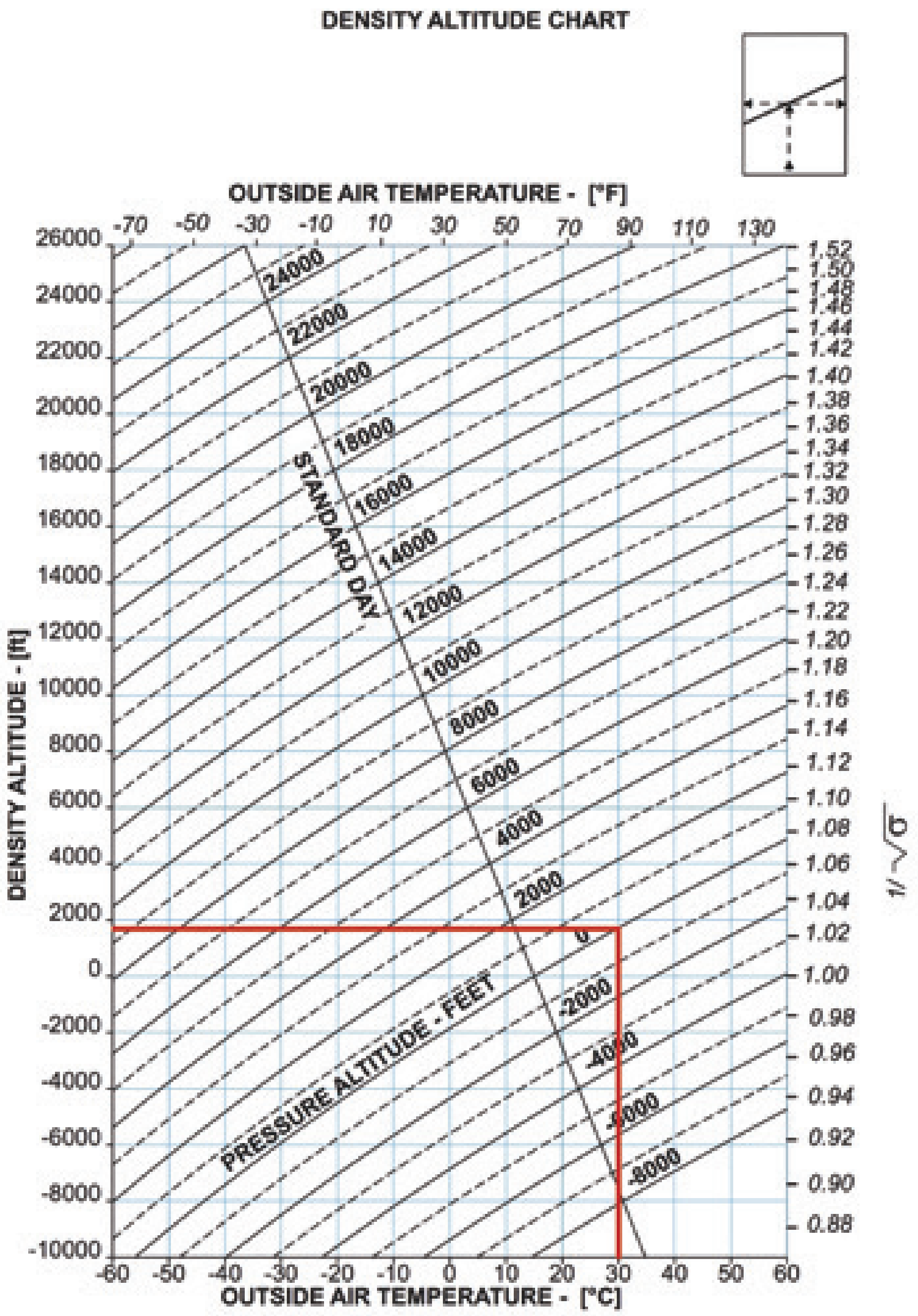


Figure (1)

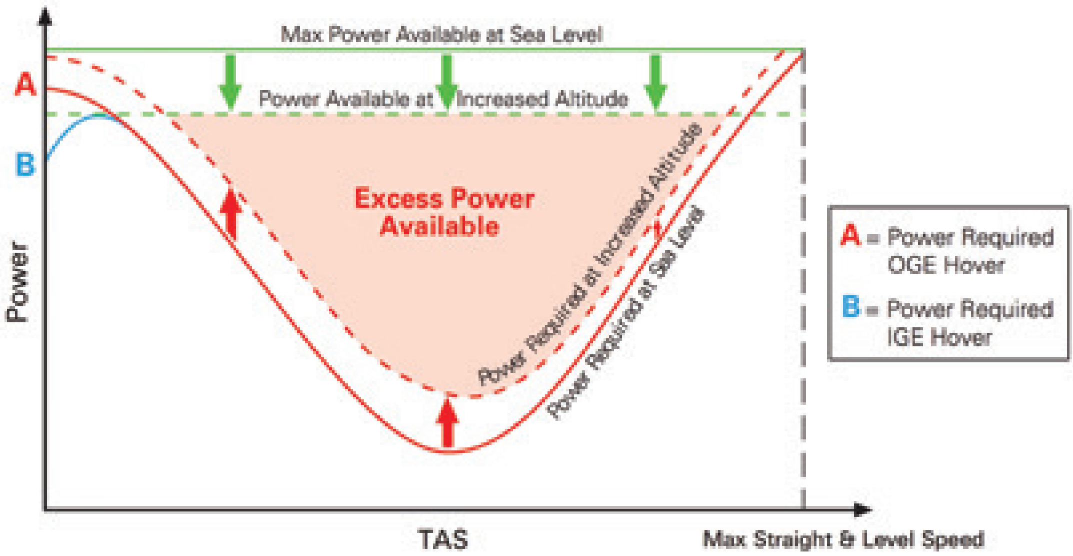
E.g.: Temperature: 30°C; PA: = 0 Ft; DA: = 1800 Ft

DA, therefore, provides a basis for relating air density to ISA, so that comparative helicopter performance can be readily determined. Operating in high density condition can be perilous, so your performance calculations have to be continuously accurate.



The margin between available power and the power required to hover at high gross mass and high density altitudes is often small for helicopters (see Figure 2).

The Figure below shows the effect of the power when the Air Density increases



In practical terms for the pilot, an increase in density altitude has a number of effects on helicopter performance:

Reduced hover ceiling – means the choice of take-off and landing sites available to the pilot becomes limited.

Reduced operating margins – means reduced payloads.

Reduced rate-of-climb performance – means obstacle clearance can be adversely affected.

3.2.1 Take-Off

For any given mass, the higher the density altitude at the departure point, the more the power required to hover, because of reduced rotor efficiency. With engine performance already reduced, the amount of excess power available to hover can be small. Under certain conditions, a helicopter may not have sufficient power available to take off in such a way that satisfactory obstacle clearance can be assured.

3.2.2 Landing

Given that a normal landing is preceded by a hover, the limited power available at high density altitudes can be just as much of a problem when landing. If the landing site has a high density altitude, sufficient power may not be available to hover at your operating mass and a loss of directional stability may be experienced due to lack of tail rotor authority.

In this case, if we reach the maximum power a subsequent increase in collective will cause a droop in rotor RPM as a result of Overpitching. In this condition the efficiency of the main and tail rotors will decay producing an increase in the rate of descend and a loss of yaw directional control. Recovery from such a condition will be difficult if not catastrophic.

Alternative landing techniques should be considered that do not require a hover (e.g. running landing or no hover landing).

3.3 Wind

Headwind components provide a benefit in terms of improved rotor efficiency and therefore performance, conversely being out of headwind reduces rotor efficiency and helicopter performances.

Knowing which direction the wind is coming from is very important – especially in light wind conditions. Some RFM performance graphs (i.e., Bell 206B3) have a critical wind azimuth area, in which adequate control of the helicopter is not assured when the wind is from anywhere within the specified azimuth area – consequently hover ceiling will be reduced.

3.4 Ground Effect

While in ground effect the power required is less than required while hovering out of ground effect-

OGE hover ceiling is considerably lower than IGE hover ceiling.

Most helicopter Flight Manuals provide performance graphs to calculate IGE hover ceiling. Remember that an IGE hover is based on hovering over a flat and relatively smooth surface.

The hover-ceiling charts (HIGE, HOGE) are used to determine the helicopter performance capabilities.

3.5 Slope and surface

Hovering above sloping ground will require more power than that needed to hover over a flat surface.

Any surface that absorbs or disrupts the downwash from the rotor blades (i.e. surface with long grass, uneven surface, rough water, rocky river beds etc.) will reduce the benefits of ground effect, which will require more power to maintain hover and consequently will reduce the IGE ceiling.

3.6 Other Factors

3.6.1 Overpitching (Low Rotor RPM)

As previously mentioned (3.2.2) Overpitching is a dangerous situation; at high collective pitch settings the power system may no longer provide enough power to overcome the rotor drag and then produce the required lift. The result is a reduction in rotor RPM, lift, and centrifugal force, which in turn reduces the effective lifting area of the rotor disc.

An adequate planning, an attentive smooth pilotage and a power check at the operating site, will help preventing this condition. If you encounter it, a quick RPM recovery action must be initiated by the pilot slightly lowering the collective and adopt an attitude that will minimize the consequence of a possible hard landing

Remember, if you are close to the ground, there may be insufficient height to recover.

3.6.2 Rotor condition

Deposits on the main or tail rotor blades can disrupt the laminar airflow and significantly reduce the lift production.

3.6.3 Loss of Tail Rotor Effectiveness (LTE)

As already described in the "HE1 – Safety Considerations", the LTE is generally encountered at low forward airspeed, normally less than 30kt, where:

- the tail fin has low aerodynamic efficiency;
- the airflow and downwash generated by the main rotor interferes with the airflow entering the tail rotor;
- a high power setting requires a yaw pedal position which is close to its full travel;
- an adverse wind condition increases the tail rotor thrust requirement;
- turbulent wind conditions require large and rapid collective and yaw inputs.

Recovery actions will vary according to the circumstances, if height permits, attaining forward airspeed without increasing power (if possible reducing power) will normally resolve the situation. Therefore, as these actions may involve a considerable loss of altitude, it is recommended that pilots identify a clear escape route.

3.6.4 Retreating Blade Stall

High DA, high AUW, turbulent air and rough /abrupt or excessive control movements can aggravate retreating blade stall.

Indications can be a pitch up tendency followed by a roll to the retreating side. Recovery action will depend on the in-flight conditions however it will normally be to reduce speed, reduce collective lever, reduce manoeuvre or a combination of these actions together.

3.6.5 Contingencies

Even after having worked out your helicopter take-off, landing or lifting performance, it is prudent to add a contingency to allow for other factors that you may have overlooked. For example, the engine may not be performing as well as expected, you might encounter an unexpected lull or shift in the wind, the air temperature at the landing site might be higher than anticipated because of surface heating.

Most performance-related accidents can be prevented, provided that the pilot maintains a good situational awareness, knows the performance limitations of the helicopter, and apply basic performance calculations; if necessary the results may be validated with a power check at the actual landing or T/O site.

4. FLIGHT PREPARATION

Most performance-related accidents can be prevented, provided that the pilot maintains a good situational awareness, knows the performance limitations of the helicopter, and apply basic performance calculations; if necessary the results may be validated with a power check at the actual landing or T/O site.

4.1 Performance Calculation

Talking about performance the first step for a safe flight preparation is to determine the performance of our helicopter. In the RFM are made available tables and graphs that help the pilot in this duty.

4.2 Power Check

Conditions at take-off and landing sites may differ from what has been used for RFM performance calculations. In order to take this into account, and to confirm the amount of power available, the pilot should make an operational assessment by carrying out a power check, in accordance with the RFM, before committing to a take-off or a landing.

The power check shall be carried out in accordance with the information provided by Manufacturer.

5. THREAT ASSESSMENT

Pre–flight planning shall include performances calculations for all phases of flight.

5.1 Hazards

For all helicopters but especially for single engine helicopters, there may be hazards associated to insufficient performance calculation, following are reported some examples (not exhaustive list):

A. Presence of obstacle;
B. Weather;
C. Wrong or no calculation of performance;
D. Engine power check;
E. Wrong or no calculation of mass and balance;
F. Use of wrong or no use of performance chart;
G. Difference in the elevation of the landing site;
H. Routine / Complacency (Internal Pressure);
I. Economical pressure (External pressure);
J. Change in helicopter configuration;
K. Different performance due to optional equipment;
L. Other.

The above hazards can have different impact if we consider different types of operations (i.e. Corporate, Private, Training, Pleasure flights etc.)

In case of lack or wrong performance calculations we remove barriers and we face with this type of Risk assessment MATRIX:

RISK PROBABILITY	RISK SEVERITY				
	Negligible (A)	Minor (B)	Major (C)	Hazardous (D)	Catastrophic (E)
Frequent (5)	5 A	5 B	5 C	5 D	5 E
Occasional (4)	4 A	4 B	4 C	4 D	4 E
Remote (3)	3 A	3 B	3 C	3 D	3 E
Improbable (2)	2 A	2 B	2 C	2 D	2 E
Extremely Improbable (1)	1 A	1 B	1 C	1 D	1 E

For the criteria used in the Risk Matrix refers to “HE5 Risk Management in training”

5.2 Mitigation

Possible mitigating measure that can be adopted may be:

5.2.1 Obstacles

This types of flight, most of the time, are conducted in areas where the environment is known or protected in terms of obstacles (See “HE 3 Off Airfield Landing Operations”). In case of doubt an accurate analysis of the charts or the availability on board of terrain avoidance systems (HTAWS) may prevent the risk of ground contact. If is not possible to consult charts or the helicopter is not equipped with this devices, the presence of ground personnel, in conjunction with a RECCE, may help the pilot to prevent an accident.

If necessary change the take-off path to clear obstacles or decrease the mass to have additional margin.

If it not safe **REJECT TAKE OFF**

While en-route, for single engine helicopter is important to identify an escape route or identify a suitable landing place in case of engine failure.

During landing we may face with different landing site condition or the information in our hand ore not correct. In this case do not execute a rush approach, execute an accurate RECCE or collect information from ground personnel and select the most appropriate approach path. If necessary verify on the WAT chart the capability to land of the helicopter.

If It is not safe **GO AROUND**.

5.2.2 Weather:

(From HE2) Ensure you get an aviation weather forecast from an authorised source, heed what it says, (decodes are available on the internet) and make a carefully reasoned GO/NO GO decision.

Do not let self-induced or passenger pressure influence your judgement. The necessity to get home (Homeitis) has been a frequent casual course of accidents. Establish clearly in your mind the en-route conditions, the forecast, and possible diversions in case of deteriorating weather. Have a planned detour route if you are likely to fly over high ground which may be cloud covered. In piston engine helicopters be aware of the conditions that lead to the formation of engine icing, comply with the RFM / Pilot's Operating Handbook (POM) instructions regarding the use of Carb heat or Engine anti-ice and remember to include Carb Air Temp and OAT in your regular instrument scan. In wet weather beware of misting of windshield and windows, especially when carrying passengers with wet clothes and carry a cloth to assist demisting the windshield prior to take-off.

5.2.3 Power Check:

The execution of the power assurance check as described in the RFM by the Manufacturer, provide the actual status of the engine of our helicopter, missing this check or not adequately consider the result of the check may lead the possibility to carry-out a safe operations.

5.2.4 Wrong or no calculation of performance / Wrong or no calculation of mass and balance:

To be certain of the actual mass of the helicopter is the first step to avoid accidents. In case of doubt or if you are not sure of the mass that the passengers are embarking on board the helicopter, do not hesitate to ask for clarification. If necessary, perform a weight check of the material and / or passengers.

5.2.5 Use of wrong or no use of performance chart / Different performance due to optional equipment:

The tables or graphs available in the RFM usually reports the performance in case of installation of particular equipment (i.e. particle separator, Anti Ice etc.). Some supplementary equipment are not computed by Manufacturer with a specific chart, in this case, for each supplementary equipment, a penalty factor is provided in the RFM in order to determine the effect of the performance on the helicopter. Be sure and take your time to identify and **use** the correct chart.

5.2.6 Internal / External pressure:

Sometimes the Routine or the Complacency (Internal pressure – Press On Itis) or the pressure of the Management can push the crew to not consider the actual status of the helicopter and the related performances. We must be aware of the pressure that we are having at the moment (internal or external) and react accordingly.

Although in most cases it is not necessary, sometimes we have to also do an informative action to the Management, so as to inform them about the risks to which you are going to meet, and to the negative effect that might be on the company. The need is to instil a flight safety culture at all levels.

5.2.7 Change in helicopter configuration:

Sometimes there is a need to change the configuration of the helicopter to be adapted at the different operation to be carried out. In this case an effective communication between the Technical and Operational department is deemed necessary. The pilot shall be aware if change in the configuration occurs, and he shall consider the changes in the performance calculation.

With the correct consideration about performance, the Assessment Matrix below now shows that we can operates in the acceptable green area.

RISK PROBABILITY	RISK SEVERITY				
	Negligible (A)	Minor (B)	Major (C)	Hazardous (D)	Catastrophic (E)
Frequent (5)	5 A	5 B	5 C	5 D	5 E
Occasional (4)	4 A	4 B	4 C	4 D	4 E
Remote (3)	3 A	3 B	3 C	3 D	3 E
Improbable (2)	2 A	2 B	2 C	2 D	2 E
Extremely Improbable (1)	1 A	1 B	1 C	1 D	1 E

6. CONCLUSION

Take-off, landing and hovering are all potentially risky phases of helicopter flight. The more that we can do as pilots to minimise these risks – especially when operating at high gross mass, from challenging sites, with high density altitudes – the safer we will be.

Most performance-related accidents can be prevented, provided that the pilot maintains a good awareness of the surrounding conditions, knows the performance limitations of the helicopter, always does a power check before committing to a marginal situation, and is disciplined enough to 'give it away early' if the odds are stacking up against getting the job done safely.

If you ever have any doubts about the ability of your helicopter to perform the task at hand, then the prudent thing to do is to take the time to apply basic performance calculations, and validate these with a power check at the actual site. This takes the **'it'll be alright'** out of the situation.

Always make performance calculations part of your flight preparation.

IMPRINT

EHEST
Component of ESSI
European Helicopter Safety Team

July 2017

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Appendix E

Robinson Safety Notice SN-25

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Safety Notice SN-25

Issued: Dec 1986 Rev: Jul 2012

CARBURETOR ICE

Avoidable accidents have been attributed to engine stoppage due to carburetor ice. When used properly, the carburetor heat and carb heat assist systems on the R22 and R44 will prevent carburetor ice.

Pressure drops and fuel evaporation inside the carburetor cause significant cooling. Therefore, carburetor ice can occur at OATs as high as 30°C (86°F). Even in generally dry air, local conditions such as a nearby body of water can be conducive to carburetor ice. **When in doubt, assume conditions are conducive to carburetor ice and apply carb heat as required.**

For the R22 and R44, carburetor heat may be necessary during takeoff. Unlike airplanes which take off at full throttle, helicopters take off using power as required, making them vulnerable to carburetor ice. Also use full carb heat during run-up to preheat the induction system.

On aircraft equipped with the carb heat assist system, the control knob should be left unlatched unless it is obvious that conditions are not conducive to carburetor ice.

Carburetor heat reduces engine power output for a given manifold pressure. Approximately 1.5 in. Hg additional MAP is required to generate maximum continuous power (MCP) or takeoff power (TOP) with full heat applied. The additional MAP with carb heat does not overstress the engine or helicopter because power limits are still being observed. Since the engine is derated, it will produce TOP at lower altitudes even with full heat. However, avoid using more heat than required at high altitudes as the engine may reach full throttle at less than MCP or TOP.

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