Network Manager
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EUROCONTROL Green Paper on the gains for the European ATM Network of aligned weather impact management

Network Operations Management Division
Contribution to Network Flight Efficiency and Safety Performance

A survey of severe weather risk management in Europe reveals flight efficiency and safety performance gains to be achieved by better alignment of risk management strategies by ANSPs, Aircraft Operators and the Network Manager.

INTRODUCTION

The main purpose of this document is to facilitate the consultation about what policies shall be adopted for the Network Manager role in severe weather risk management in Europe. The paper does not engage with a commitment for action, it rather informs the debate and discussions by outlining the findings and conclusions of an empirical information collection process done in the form of a survey. In this manner, in the paper, there are no recommendations or suggestions but a list of performance impediments to be addressed further in the policy formulation process.

Effective management of severe weather impact on the ATM system and flight operations is of great significance for improving the safety and cost-efficiency of aircraft operations and ATC service provision in Europe, in particular in congested airspaces. Severe weather phenomena disrupt air traffic flows and generate significant delays. If not managed properly, hazards to aviation associated to severe weather can lead to unsafe, high level of workload of pilots and controllers, and ultimately to losses of separation and aircraft accidents.

In 2012 and 2013, on stakeholder request, a dedicated severe weather risk management survey was carried out. The survey scope covered the entire chain of severe weather impact and risk management starting with weather forecasting by meteorological offices, addressing pre-tactical management by FMPs and the Network Manager and concluding with the deployment of tactical measures by ATC and pilots. The survey included analysis of weather related hazards and review of meteorological products, weather impact assessment and decision support tools and ATM procedures related to weather impact management.

The information sources used for the survey are:

- One hundred and twenty four (124) published reports, research papers, magazine articles, advisory materials and websites.
- Twenty five (25) accidents and serious incidents reports
- Six (6) data collection workshops with representatives of five European ANSPs and the FAA. In addition, FMP and operational specialists from further European ANSPs were interviewed in order to collect information on the procedures and practices used to manage severe weather impact on ATS operations.

THE WEATHER HAZARDS

The review of the weather related accidents and serious incidents shows that most fatal and high risk occurrences related to severe weather happen during the approach and landing phases of the flight. The same weather hazards can be encountered during the climb and en-route phases; however the consequences are usually less severe due to availability of more effective mitigation means. During the approach and landing phases of flight the workload in the cockpit is very high and any weather hazard evasive or impact mitigation actions are time critical.

The severe weather related accidents and incidents can be attributed to the following weather related hazards:

- **In-flight icing** that can lead to control difficulties due to degradation of aircraft performance which ultimately could result in loss of control; limited visibility from the cockpit; communication problems; blockage of pitot-tubes and static vents and ice shedding;

- **Severe air turbulence** (convective cloud origin) that can lead to abrupt changes in attitude and altitude with large variations in airspeed; temporary loss of control (there may be periods where effective control of the aircraft is impossible); level busts attributed to abrupt changes in altitude and subsequent loss of separation; loose objects may move around the cabin and cause injuries to passengers and crew and damage to aircraft structure;

- **Hail damage** that can lead to considerable damage to aircraft which may not be immediately apparent to the crew including cracked and glazed windshields and windows which in turn can hinder visibility from the cockpit and ultimately may lead to loss of control and controlled flight into terrain (CFIT);

- **Lightning strike** that can lead to aircraft/airframe damage (mostly affected airframe parts are the radomes, tail fins together with the control mechanisms and surfaces); crew incapacitation due to blindness from the lightning flash; interference and damage to the avionics and the on-board electronic equipment; engine shutdown due to transient airflow disturbance associated with lightning which cause shutdown on engines with close-spaced engine pairs;

- **Low visibility due to fog or precipitation** that can lead to impaired visibility from cockpit which affect take-off and landing operations; aquaplaning; runway incursion and excursion; CFIT

- **Strong low level/surface winds,** applicable to aircraft at low altitude (approach, landing and climb phases of flight) can be particularly dangerous as any loss of control may occur sufficiently close to terrain to make recovery difficult or impossible. Such surface air movements include but are not limited to: windshear related to thunderstorms and extreme down-bursts (microbursts) which occur below the base of cumulonimbus and towering cumulus clouds which may lead to loss of control.

Further high risk situations may be created by the flight crew actions to avoid a severe weather encounter or mitigate its impact on the flight. Such situations include: loss of separation (which ultimately could result in mid-air collision) and CFIT.

THE RISKS

The severe weather impact can be associated to two different, yet interdependent, risks, notably **FLIGHT SAFETY RISK** and **FLIGHT EFFICIENCY RISK**.

THE FLIGHT SAFETY RISK

is the ultimate driver for the existence of the severe weather impact management. Flight Safety Risk can have different sources and manifestations:

In-flight Safety Risk (impact on flight crew):

- **Hazard Encounter Risk** – this risk is originating from the probability of a flight being exposed to severe weather and from the possible effects of this encounter. For example, possible effects of a flight being exposed to severe turbulence are level bust, aircraft damage, aircraft power loss, passenger injuries, crew incapacitation and loss of control in flight.

- **Knock-on Flight Safety Risk** – this risk, the crew is exposed to, is originating from the "side" effects of the prevention and mitigation measures, undertaken to reduce the hazard encounter risk. For example, prolonged deviation to an alternate airport may contribute to a situation of fuel shortage. Another example is crew preoccupation and distraction which contribute to a less efficient threat and error management.

ATCO Excessive Overload Risk:

Similarly to the knock-on flight safety risk the ATCO excessive overload risk is a by-product of the measures undertaken to prevent or mitigate the hazard encounter risk. The difference is that the effect is on ATC and not directly on flight crew. It is important to note that ATC sectors may or may not be overloaded (current traffic demand exceeding declared sector capacity) but the ATCO can have an excessive subjective workload.

THE FLIGHT EFFICIENCY RISK

is associated to the likelihood and potential extent of incurred flight delays or even cancellations made due to severe weather risk management.

THE CONCEPTUAL MODEL

The collection and analysis of the survey data was supported by the establishment of a conceptual model for severe weather risk management in ATM. The model identifies the risks associated to severe weather impact on flight operations and describes the generic risk management functions.

Hazard Encounter Risk is at the core of the model as it is the original reason for the existence of the array of activities associated to severe weather risk management. Therefore, decomposing the activities, starting with those associated to hazard encounter risk management is considered a truly systematic approach to revealing the reasons for the existence of certain activities.

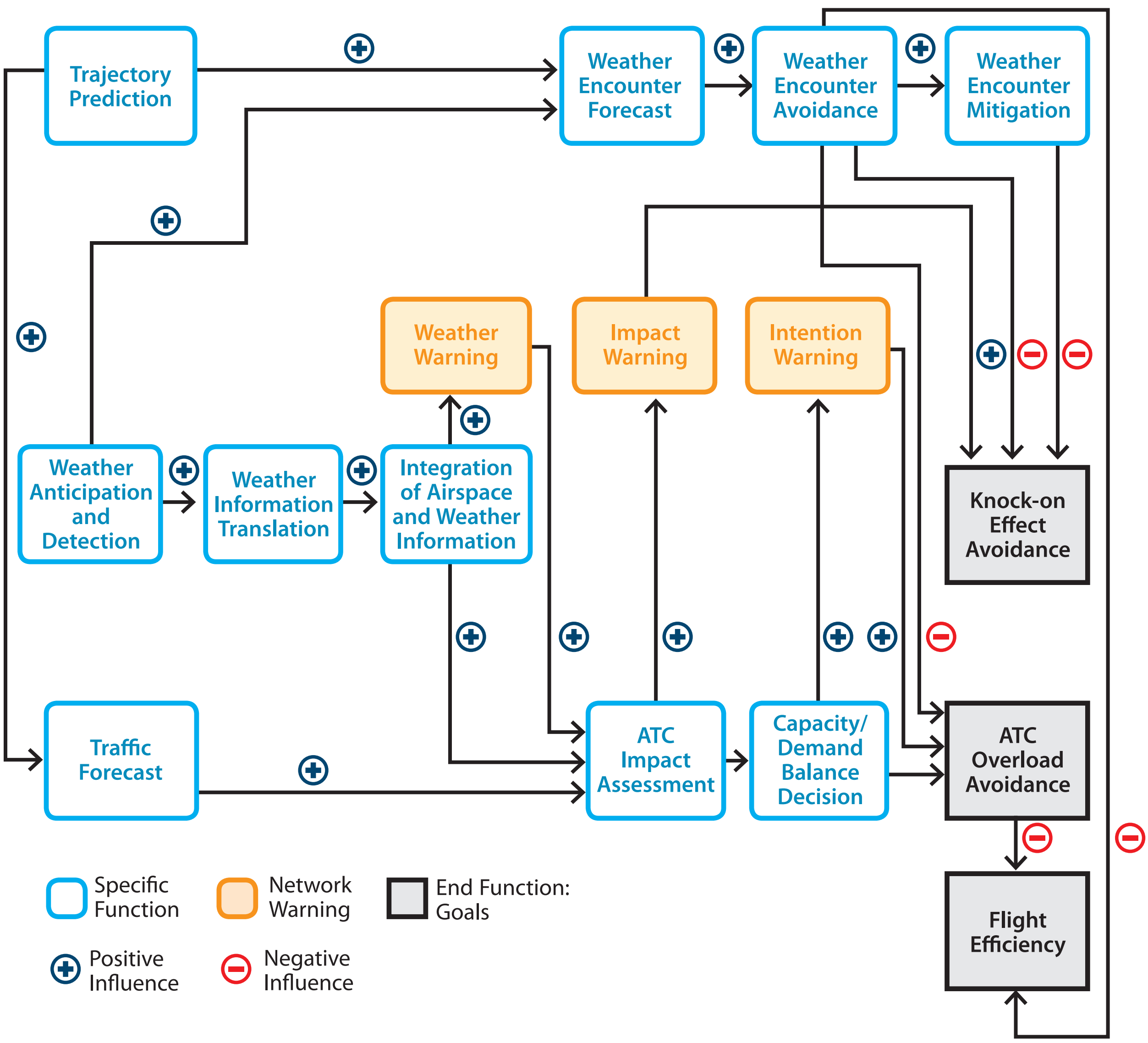


Figure 1: Hazard encounter risk management model

The description of the generic risk management functions of risk prevention and risk mitigation and is done by means of a number of **specific functions:**

- **Flight Trajectory Prediction** – 4D prediction of the future position of the aircraft.
- **Traffic Forecast** – flights expected to be within a given airspace volume within a given time interval; enhanced traffic forecast may include flight trajectories within the given airspace.
- **Weather Anticipation** – foreseeing the presence of a weather phenomenon that may endanger the safety of flights within a given airspace volume within a given time interval.
- **Weather Detection** – determining the location of hazardous weather phenomenon, for example by means of weather radar products;
- **Weather Network Warning** – notification by an ATC unit to the Network (the Network Manager and/or adjacent ATC units) of expected severe weather within its area of responsibility.
- **Weather Translation** – use of models, algorithms and tools to convert the weather forecast and current weather report products and other inputs (ATC system parameters) in aviation constraints and threshold events;
- **Integration of Weather and Airspace Information** – a technical function for an integrated display of forecasted/reported severe weather phenomena and affected airspace structures.
- **ATC Impact Assessment** – assessing the impact of severe weather on the ability of the ATC system to ensure safe and efficient handling of forecasted traffic (the assessment could be supported by tool(s) for integrated processing of weather, airspace and traffic information).
- **Impact Network Warning** – notification by an ATC unit to the Network of expected impact (e.g. affected traffic flow, unavailability of an ATC sector's airspace or flight level layer, or of a runway on an airport for a given period of time) of severe weather within its area of responsibility; it may be combined with either Weather Network Warning or Intent Network Warning.
- **Capacity & Demand Balancing Decision** – decision at Network and/or local ATC unit level for the implementation of measures (e.g. flow regulation) for mitigation of severe weather impact on ATC operations.
- **Intent Network Warning** – notification by an ATC unit to the Network about planned measures (e.g. flow regulation) for mitigation of severe weather impact on ATC operations.
- **ATCO Overload Prevention** – implementation by an ATC unit of the planned or other appropriate measures for mitigation of severe weather impact on ATC operations.
- **Flight Efficiency Effect Management** – actions taken to minimise the adverse impact of weather hazard encounter prevention and of mitigation measures on flight efficiency.
- **Knock-on Effect Management** – actions taken by the flight crew (with or without coordination with AOC) and ATC to mitigate the Knock-on Flight Safety Risk.
- **Weather Encounter Forecast** – flight crew (AO) using the planed trajectory and weather data to determine the likelihood of severe weather encounter.
- **Weather Encounter Avoidance** – actions taken by the flight crew (with or without coordination with AOC) to prevent weather hazard encounter.
- **Weather Encounter Mitigation** – actions taken by the flight crew (with or without coordination with AOC) to mitigate the effects of encountered weather hazard.

THE FINDINGS

The dedicated meetings with the ANSPs and interviews with relevant specialists provided for the accumulation of sufficient information to build a credible outline of the current severe weather risk management practices in Europe. The findings hereafter are formulated as generic statements, applicable to the ATS provided by the European ANSPs.

A. Standards and/or regulations and/or national requirements to be complied with by the ANSP in management of severe weather impact on ATC and flight operations

ICAO standards and recommended practices concerning the provision of ATS in adverse weather conditions (e.g. low visibility) and provision of meteorological information to flight crews are followed in all States. In some States controllers are required to pass available information about hazardous weather phenomena (e.g. severe turbulence) to concerned flights. Specific national rules related to severe weather risk management are rather an exception.

B. MET products and data made available, and actually used by responsible ANSP actors

In all ATC centres operational staff is provided with the aerodrome forecasts (TAFs) for the area of interest and in most the en-route centres controllers have access to the upper wind forecasts. In some centres operational staff can consult further weather forecast products, such as GAFOR, GAMET and general regional forecasts, accessible on the intranet or internet. Few ANSPs receive enhanced forecast products (exceeding ICAO Annex 3 requirements) which enable an improved ATS provision in adverse weather conditions and more efficient decision making by the responsible actors – OPS/TWR SUP and FMP.

Current weather reports (i.e. METAR, SPECI) and ATIS are available to the operational staff in all surveyed ATC units.

In the vast majority of ATC units controllers have access to weather radar information at their working positions either integrated with the operational (radar and flight plan) data or on a separate display. This enables controllers to provide information about location of hazardous areas (e.g. CBs) or avoidance advice on pilot request.

In difference to the weather radar data, satellite weather data are not commonly available at the operational working positions. In some ATC centres satellite weather maps and animation products (showing the direction of movement of detected weather) are available at the OPS SUP and FMP positions.

Pilot reports are important source of information about weather hazards, in particular regarding the severity of impact and current location of hazardous weather. However this information is not always pro-actively sought by controllers (or shared by the flight crew). Upon reception of a pilot report, controllers pass the information to other flights in the affected area and in some cases (e.g. severe turbulence, windshear) to the MET office in line with requirements of ICAO Annex 11 and 3.

Often, OPS/TWR Supervisor has access to more MET data products and more detailed meteorological information than sector controllers. Such information may include enhanced forecasts of aerodrome conditions, weather radar products, possibility to consult the MET office providing meteorological services to the ANSP, etc.

The meteorological information is usually accessible at the operational positions by means of a separate information display system. In some centres, weather radar data and data from the weather channel of ATC radars can be displayed in the main radar situation display window. In one ATC units a MET portal is currently being developed with the aim to provide all operational users with customised meteorological information.

The meetings with ANSPs revealed several potential areas for improvement of the MET products to support safe, more efficient and expeditious ATS provision:

- Improved weather radar data presentation - as an overlay on the actual airspace structure, including also possibility to display a vertical plan view allowing for estimation of affected altitudes and flight levels.
- Better predictability of severe weather.
- Improved estimation of phenomenon probability allowing for a shift to a more pre-tactical management of severe weather impact in the long term, thus reducing the impact of unwanted diversions.

C. MET data flow in the ATC unit

In the majority of ATC units controllers are briefed about hazardous weather at shift start and position handover. However, in some centres there is no dedicated weather briefing; according to the local regulations controllers are responsible to brief all elements of the air situation at the start of their duty. In some centres, the OPS SUP is provided with the capability to insert and send weather related information to all CWP to be observed on a separate display.

In most ANSPs, OPS SUP would contact the FMP and inform them about expected weather impact and need of flow measures. However, in a few cases weather briefing and decision on implementation of flow measures is a collaborative process.

In general, ANSPs do not use dedicated tools for exchange and dissemination of meteorological information – MET data are distributed on the local area network (LAN). The meteorological information is displayed at the operational positions either on a dedicated display and/or on a multi-purpose display.
A good practice identified by the survey is that airport ATC units inform the airport operators about expected disturbances of traffic flow due to severe weather and related traffic management decisions (e.g. use of holding patterns) and restrictions.

D. Procedures, guidance and practices for management of severe weather impact

With a very few exceptions ANSPs do not have dedicated severe weather risk management procedure, but follow applicable generic procedures as per the applicable operational manuals and existing guidance material.

Tactical ATCO procedures include:

- Defensive controlling techniques (at sector level).
- Use of increased separation minima.
- Use of holding patterns.
- Suspension or limited use of parallel headings.
- Tactical flight re-routing.
- Coordination of changes to flight trajectories with adjacent sectors.
- Facilitation of diversion to alternate airport.
- Passing of pilot reports about significant weather (e.g. severe turbulence) to concerned flights and to the MET office, as appropriate.
- No proactive provision of avoidance advice (e.g. vectoring around CB), but provision of information upon request about the weather observed on the CWP displays and the avoiding actions implemented/reported by other crews.

The OPS/TWR SUP procedures include:

- Sectorisation management.
- Monitoring of current and predicted weather conditions and sector loads and assessment of the need to implement sector protective measures.
- Additional controller at sector position.
- Implementation of flow measures (e.g. reduces rates).
- Coordination with adjacent units and implementation of traffic restrictions at the Transfer of Control (ToC) points and/or affected airports.
- Taking decision on the use of and changes to holdings and STARs depending on the location and evolution of the weather phenomenon.
- Implementation of increased minimum departure intervals (MDI), increased separation on approach, traffic prioritisation and reduced arrival rate.

- Implementation of low visibility operations (LVO).
- Regulating departures at closely situated airports.
- Low visibility operations.
- Suspension of RVSM operations.

The FMP procedures include:

- Assessment of potential impact of severe weather using available weather forecasts, predicted traffic data and their expertise.
- Coordination of possible traffic flow measures with OPS/TWR SUP and NM.
- Monitoring traffic counts / sector occupancies and notifying the OPS/TWR SUP of expected capacity issues.

E. Decision making loop and responsibilities

In the majority of States decision for the implementation of traffic flow measures is taken by the OPS/TWR SUP. The OPS/TWR SUP may or may not consult the FMP. In some ATC units the decision for implementation of flow regulations is the result of a collaborative process with the participation of the OPS SUP, team supervisors (e.g. ACC, APP), FMP and operational experts, as applicable.

In most ANSPs there is guidance for the OPS/TWR SUP on capacity reduction, acceptance rates and other sector protection parameters to be implemented depending on the type and severity of impact of weather hazards. Values are recommended and the OPS/TWR SUP has to exercise his/her judgment when making decision.

In general, implementation of traffic flow measures is postponed as much as possible until sufficient confidence is build that ATC services will be adversely affected. Due to the specific European environment (size of airspace and closely situated airports) implementation of traffic flow measures 1 to 2 hours in advance often proves to be effective. In case decision for implementation of flow regulation at an airport is based on the weather forecast, the respective traffic regulation is issued typically 3 to 4 hours in advance.

Some ANSP representatives indicated that the EU imposed ANSP performance management and indicators are not conducive to making decision at corporate level for the implementation of pre-tactical severe weather risk management.

In general, a dedicated risk assessment of severe weather impact is not required and not performed at tactical level. The following examples of good practices are worth a wider dissemination:

- In one ANSP at pre-tactical level the FMP manager carries out risk assessment, determines the mitigation strategy, files a dedicated template and distributes it to the concerned actors. The possible mitigation strategies have been described in detail and include sets of measures and related implementation scenarios. The strategies are implemented at tactical level by the FMP controllers. FMP controllers have received appropriate training and are all ACC supervisors.

- In another ANSP the morning briefing of the ACC, APP, TWR supervisors and FMP staff include assessment of the situations and decision on the use of particular sectorisation schemes and/or implementation of flow regulations, if needed. The latter may be taken or postponed for a later moment depending on the forecasts, current weather reports and the development of the situation.

F. Tools and models for weather translation, ATC impact assessment and decision support:

With a few exceptions operational staff responsible for severe weather risk management use standard (ICAO Annex 3) weather forecasts and reports, weather radar data and some other meteorological products. A tool for integrated display of the available meteorological and airspace data and assessment of the impact on the ATC elements (sectors, traffic flows, etc) is not yet in operational use. Such tools are under development in few ATC centres.

G. Notification of severe weather impact and coordination of measures (to be) taken

Internally, within the ATC unit: Avoidance routes and/or holdings are coordinated between ACC sectors and with TMA / TWR sectors.

With adjacent ATC units: In general, a dedicated notification procedure related to severe weather impact does not exist. However unusual and emergency situations and traffic restrictions on entry points are communicated by the OPS SUP. In some cases coordination with airport ATC units is triggered by pilot reports of areas avoided due to weather (CBs).

With airport operators: OPS/TWR SUP passes information about traffic flow measures affecting airport operation.

With aircraft operators: In general not performed. In one case, the FMP sends on D-1 a brief on expected ATC capacity for the next day to a list of aircraft operators. With the Network Manager: Carried out in line with the established procedures and agreements.

H. Incident and accidents in which weather was reported to be a factor

Severe weather contribution to incidents can be considered limited. The typical descriptions of such incidents are:

- Separation infringement caused by unexpected deviation of a flight from its planned route due to avoiding action without previously notifying the sector controller.
- Separation infringement on final approach due to variation in wind direction and speed.
- Most often weather appears as factor in ATC incident reports related to sector overload.

I. ATC contribution to severe weather risk

One report was received about several flights asked to plan their flight trajectory through airspace affected by CB activity due to ATC restriction, notably implementation of level cap to protect upper sectors. Following coordination safe trajectories were agreed.

J. Potential improvements suggested by ANSPs during the data collection workshops

- Improved traffic predictions and weather forecast; however the existence of limiting factors for predictability improvement is recognised.
- Improved management of resources to the limit possible, including monitoring quality of meteorological service and implementing improvement measures.
- Improved presentation of the weather information: vertical extent, reliable presentation of weather behind weather radar return layer (presentation in depth), precision and granularity.
- Improved impact assessment and decision support tools, including workload and complexity modelling, as well as tagging of flights to be acted upon.
- Optimisation at network level as opposed to optimisation at 'local" level (optimal operation of network components does not mean optimal operation of the network); such process should be supported by incentives; potential incentives to consider might be "network delay attribution" and "missed opportunity to reduce the network delay".
- Improved strategic and tactical management of potential diversions to alternate aerodromes at local and network level, taking into account recent trends in aircraft operating policies to minimise reserve fuel carried and the capacity of airports

ANALYSIS

filed as alternate by the flights affected by adverse weather at the destination airports.

- Further optimisation of the performance scheme to ensure that service providers implementing measures to optimise/improve network performance are not unduly penalised; however it should be recognised that there is a limit to what can be done in severe weather scenarios.

- Optimisation of traffic flow measures, and respectively of ATC network, as a central service.

- Change in methods used for flight efficiency calculation (last filed route) may motivate wider implementation of severe weather risk management procedure.

For the purpose of analysing the survey findings the survey scope is divided into two separate groups:

- En-route and TMA ATC severe weather impact management;
- Airport ATC severe weather impact management.

This grouping is considered appropriate due to the commonality of the hazard encounter preventive and mitigation approaches. It is to be noted that the Airport ATC severe weather impact management often affects the terminal operations (e.g. use of holding patterns, increase separation on approach, etc).

The survey determined that for the en-route and TMA ATC the most relevant weather hazards are: severe turbulence, lightning and in-flight icing. Typically, these hazards are associated with the existence and the development of convective weather.

By applying the conceptual model to the survey findings it was possible to identify and analyse a spectrum of available and used strategies for en-route and TMA ATC severe weather impact management. The strategies are differentiated depending on the degree of accomplished notification and communication regarding the forecasted/actual weather, its potential/actual impact on ATC operations and the application of flow measures:

Strategy A is characterised by: lack of communication at network level (with other ATC units or the Network Manager) about the forecasted/reported severe weather and related impact; traffic flow measures or STAM are not implemented; severe weather risk is managed locally at tactical ATC level.

Strategy B is characterised by: systematic communication at network level (with other ATC units or the Network Manager) about the forecasted/reported severe weather and the related impact; traffic flow measures or STAM are not implemented; severe weather risk is managed locally at tactical ATC level.

Strategy C is characterised by: lack of communication at network level (with other ATC units or the Network Manager) about the forecasted/reported severe weather and related impact; implementation of traffic flow measures or STAM in addition to tactical ATC mitigation measures.

Strategy D is characterised by: systematic communication at network level (with other ATC units or the Network Manager) about the forecasted/reported severe weather and related impact; implementation of traffic flow measures or STAM in addition to tactical ATC mitigation measures.

According to the above definitions traffic flow regulations or STAM are not used in strategies A and B. The survey identified that in such situations successful management of weather hazard encounter risk depends on the correct and timely pilot decision for and execution of in-flight weather avoidance. Thus, the avoidance flight trajectory ❷ is a deviation from the flight planned trajectory ❶ (see Figure 2). In the worst case, identified by the survey, the trajectory of the avoiding flight penetrates the adjacent sector's (Y) airspace without prior coordination. In case Strategy A is applied, both affected ATC sectors (X and Y) are not protected against ATCO excessive overload risk. In case Strategy B is applied, sector X is not protected but the protection of sector Y is possible.

The time needed by the aircraft to travel the additional distance on the avoidance flight trajectory ❷ constitutes an "in-flight avoidance" delay. This delay affects the flight efficiency but is not captured and monitored through the delay indicators established in the context of the European ATM performance scheme. **Figure 2** illustrates graphically strategies A and B.

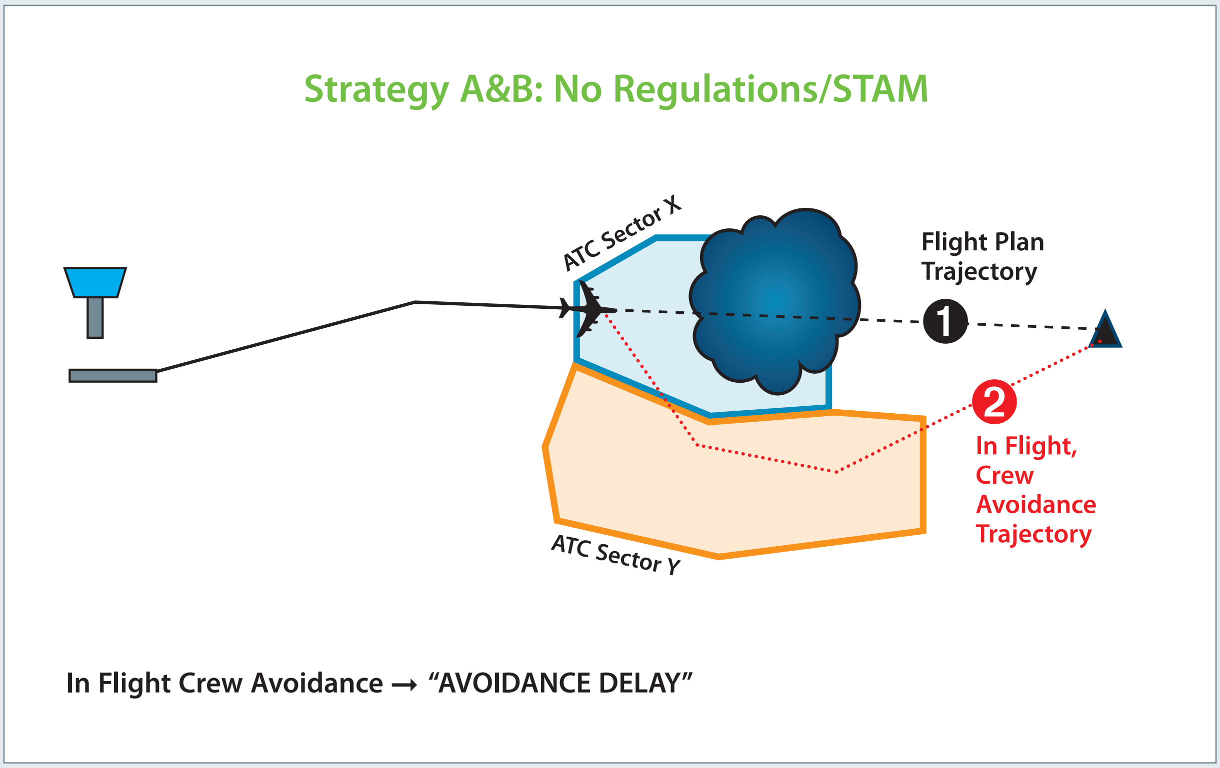


Figure 2: Strategies A & B – In-flight crew avoidance

On the other hand, in line with the provided strategy definitions, traffic flow regulation or STAM are used in strategies C and D. The entry of the flights, affected by the traffic measures, into the weather impacted sectors is either delayed by forced holding on the ground at the airport of departure or, in rare cases, avoided by re-routing before departure. The application of traffic flow measures generally causes "capacity" delay that is captured and monitored through the delay indicators established in the context of the European ATM performance scheme.

Figure 3 illustrates graphically strategies C and D for flights affected by traffic flow regulation measures or STAM.

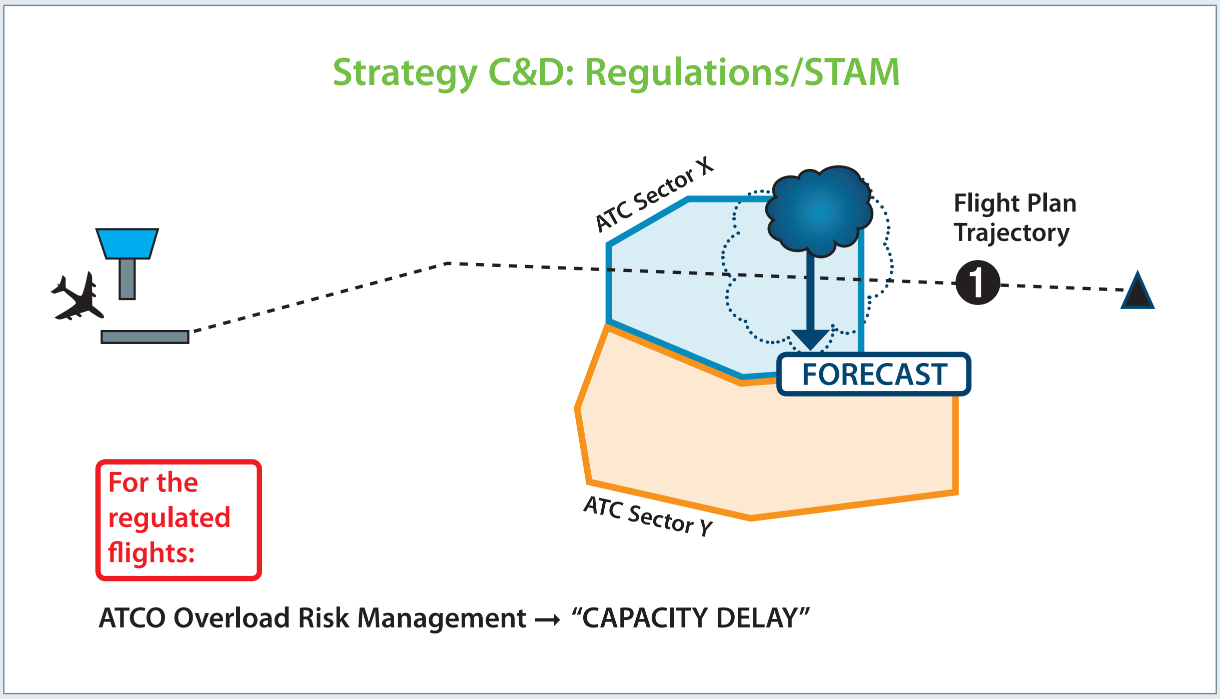


Figure 3: Strategies C & D – Flow regulation & STAM

In strategies C and D the trajectories of flights not affected by flow measures or STAM are similar to Strategy A or B in-flight avoidance trajectory and, consequently, such flights incur similar "in-flight avoidance" delay.

Figure 4 illustrates graphically strategies C and D for flights not affected by flow regulation measures or STAM. In Strategy C the lack of communication about the impact on Sector X, can result in Sector Y overload, in particular when more than one unplanned and unknown flight enters its airspace.

A summary of the ATCO excessive overload risk analysis for all the strategies is on **Figure 5.**

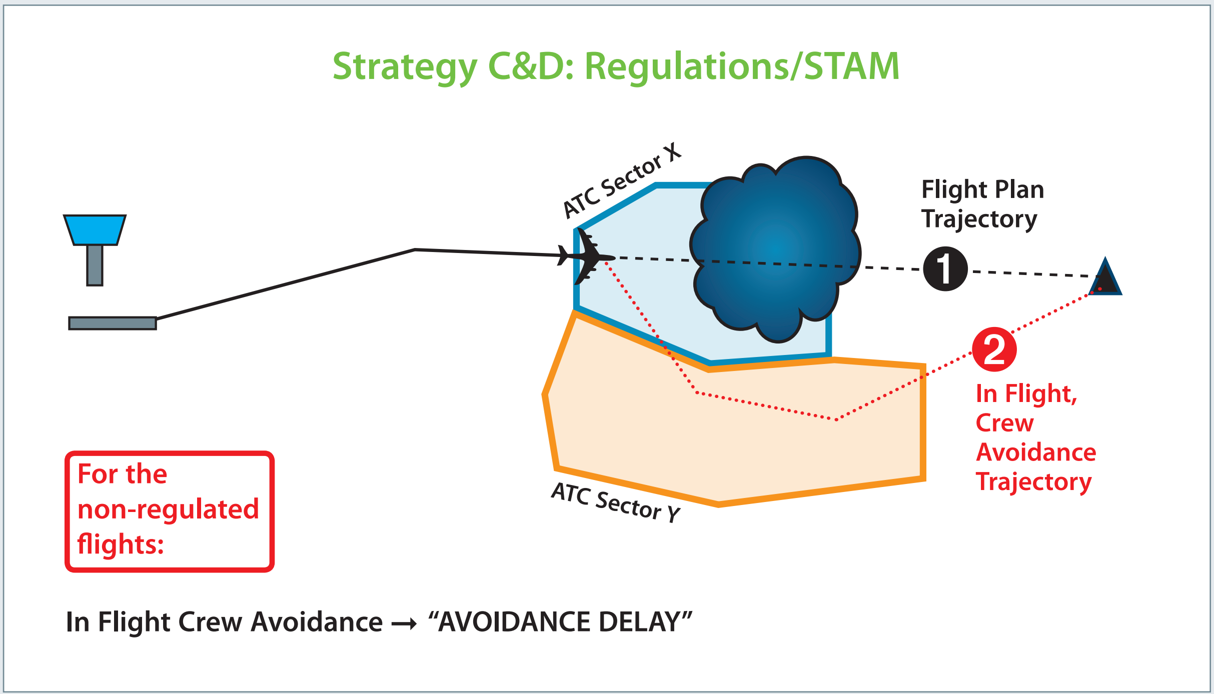
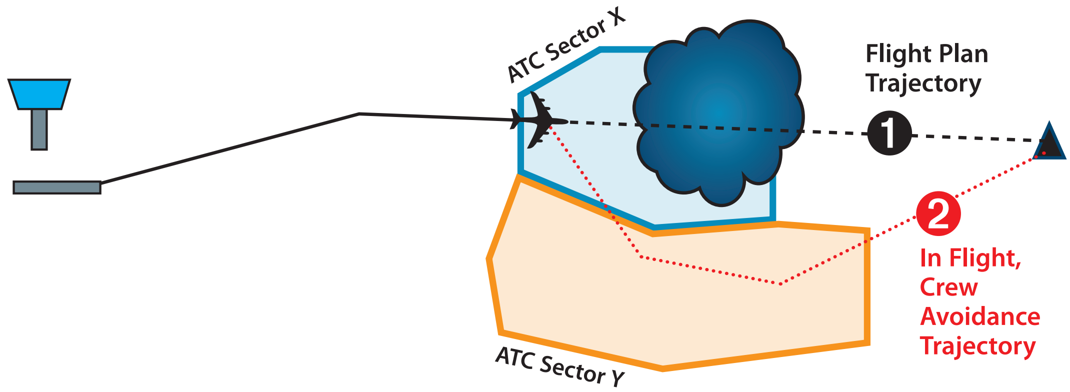


Figure 4: Strategies C & D – Flights not affected by flow measure



Sector X Strategy			Sector X Risk Impact	Sector Y Risk Impact
	A	▪ No Impact/WX Comm. ▪ No Regulations/STAM	Overload	Overload
	B	▪ Impact/WX Comm. ▪ No Regulations/STAM	Overload	None
	C	▪ No Impact/WX Comm. ▪ Regulations/STAM	None	Overload
	D	▪ Impact/WX Comm. ▪ Regulations/STAM	None	None

Figure 5: All strategies – ATCO excessive overload risk

In Europe, currently, a strategy for optimisation of in-flight avoidance is not applied. Such a strategy would reduce the in-flight "avoidance delay" of airborne flights affected by severe weather and therefore would minimise the impact on the flight efficiency.

The review of the existing literature and the findings from a dedicated visit revealed that FAA is using **Strategy E** (an upgrade of Strategy D) that can be characterised by: systematic communication at network level about the forecasted/reported severe weather and related impact; implementation of traffic flow measures or STAM. Additionally, based on a collaborative decision making process, the in-flight weather avoidance by affected flights may be optimised.

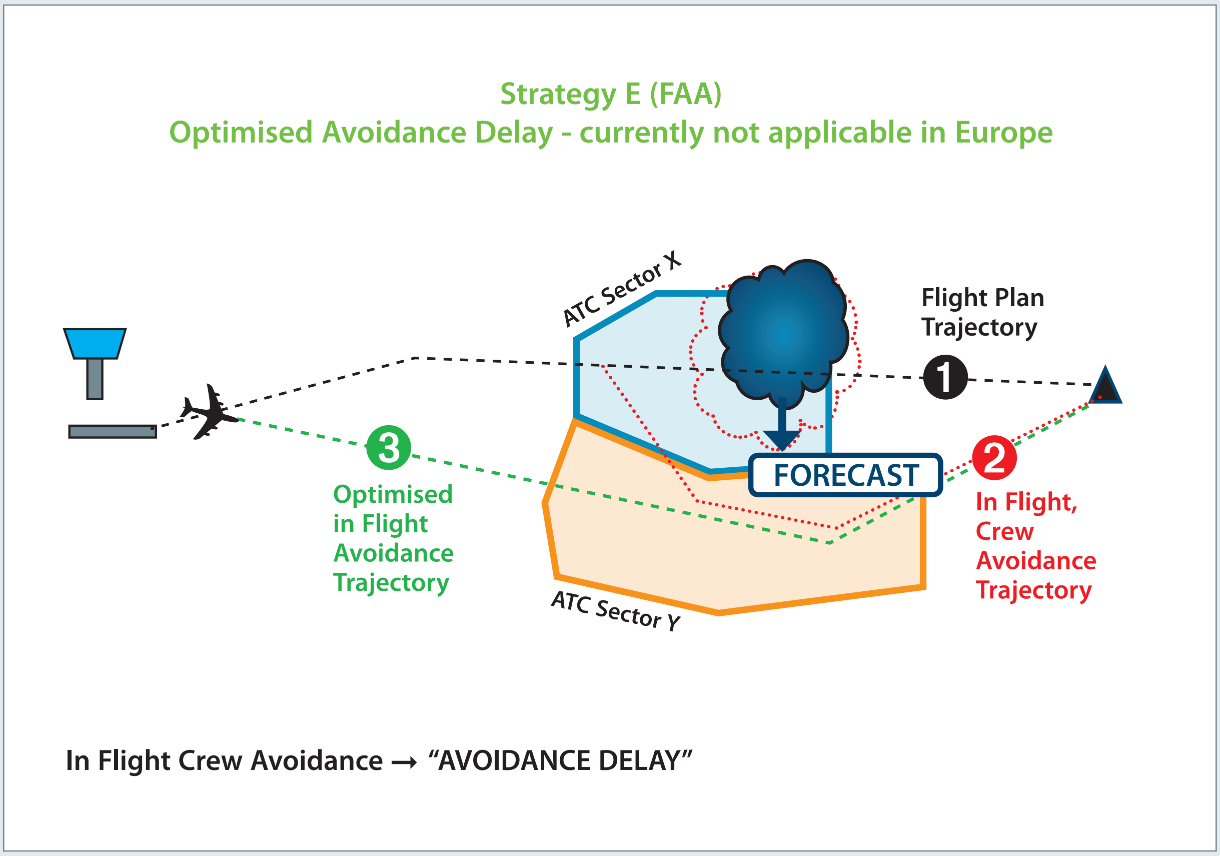


Figure 6: Strategy E– In-flight avoidance delay optimisation

ATCO excessive overload risk is one of the two main risk components of Flight Safety Risk, together with In-Flight Safety Risk. The survey findings and the analysis of the strategies discussed above enabled the development of a risk summary table (**see Figure 7**) that presents the effect of applying different Strategies on the formulated risks.

The weather encounter risk is reliably reduced only by Strategy E because this is the only strategy removing the need for ad-hoc in-flight severe weather avoidance by pilot and hence significantly reducing the likelihood of pilot acting on limited or insufficient weather information available in-flight (the limitations of on-board weather radars has been well documented in the literature).

Additionally, in strategies C, D and E (use of flow measures and STAM) the ATCO overload risk in the severe weather impacted sector will be strongly dependant on the efficiency of a number of elements of the weather management chain and their characteristics, in particular:

- Availability and accuracy of weather anticipation and detection;
- Credibility and reliably of weather data translation into operationally meaningful terms (constraints, threshold events) and calculating associated probabilities;
- Sound impact assessment (including integration of weather, airspace and traffic data);
- Capacity / demand balancing and decision making.

Strategy			ATCO Overload Risk	WX Encounter Risk	Capacity Delay Risk	Avoidance Delay Risk
Strategy	A	No Impact/WX Comm. No Regulations/STAM	↑	!	↓	↑
	B	Impact/WX Comm. No Regulations/STAM	↑	!	↓	↑
	C	No Impact/WX Comm. Regulations/STAM	↑	!	↑	!
	D	Impact/WX Comm. Regulations/STAM	↓	!	↑	!
	E	Strategy D and Optimised avoidance	↓	↓	↑	↓

↑ Major risk increase ↓ Marginal risk ! Risk reduction

Figure 7: Risk summary table – Impact of mitigation strategies

ANALYSIS (CONT'D)

The survey determined that for the Airport ATC severe weather management the most relevant hazards are low visibility, strong surface winds, runway contamination, severe turbulence on final approach, lightning and (heavy) precipitation. Alike the en-route and TMA environment, the risks associated with the en-route and TMA ATC severe weather impact management are also valid with the following particularities:

- The affected adjacent ATC sector (Y) is, most of the time, the APP sector, associated with the Terminal airspace.

- The effect on the adjacent APP sector is even stronger compared to the en-route adjacent sector scenario. The reason is that all or significant part of the traffic to/from an airport passes through the associated APP sector. The impact of low visibility operations is very much indicative of this effect. During the survey it was reported that during low visibility operations the workload of the TWR Controller is likely to reduce and the workload of the APP controller likely to increase compared to normal operations, provided that all other conditions are remain equal.

- An additional risk is affected by the applied strategies, notably the knock-on flight safety risk. During the survey it was reported that the provision of weather warning and, even more importantly, forecasted impact warning has a significant effect on the aircraft operator and crew planning. Available forecast weather information is often not sufficient to the flight crew for accurate estimation of expected in-flight delays and for an appropriate reserve fuel planning. Several aircraft emergency events were reported recently following unfold of similar scenarios.

The effect on the flight efficiency risk of the previously described elements of weather management process (availability of correct and appropriate weather information, its reliable interpretation; sound impact assessment and decision making) seems to be higher compared to the effect on flight safety risk. The more efficient is the severe weather impact management process the better will be aircraft operators' awareness of the forecasted severe weather and its impact on planned operations. This would help shift the decision making horizon more towards the pre-tactical phase (before departure) and would reduce the proportion of flights in need to divert to alternate aerodrome. During the survey it was reported that currently a diversion to alternate aerodrome is probably the worst case scenario with respect to the flight efficiency.

THE MAJOR CONCLUSIONS

Sufficiently managed Hazard Encounter Risk and Knock-on Flight Safety Risk. The in-flight Hazard Encounter Risk and Knock-on Flight Safety Risk are consistently managed in accordance with ICAO PANS-ATM and PANS-OPS provisions, aircraft operating procedures and other applicable national regulatory provisions. However, it can be argued within the context of this project that the risk of controllers' excessive workload (associated with the Knock-on Flight Safety Risk) is not sufficiently managed.

Inconsistent pre-tactical and tactical strategies. The severe weather hazard encounter prevention strategies and measures are applied inconsistently at pre-tactical and tactical level. The European ANSPs have developed and deployed different capabilities. In the majority of cases severe weather risk management is not applied at pre-tactical level. Some ANSPs have built the needed capability and competence but the lack of incentives and of an established process to capitalise on the available capabilities prevents the implementation of an enhanced and more effective severe weather risk management. This leads to sub-optimal ATM efficiency and increased air traffic controllers' workload, in particular in the critical time period before the tactical ATC measures take effect.

Non-interoperable pre-tactical and tactical strategies. In the rare cases of application, the risk prevention and mitigation strategies are based on locally developed capabilities, definitions and processes that are specific (not following common definitions, criteria, format, etc) and do not support an efficient communication and collaboration at Network level.

Sub-optimal performance of the European ATM Network. With respect to severe weather risk management the operation of the European ATM Network is suboptimal when applying the following criteria: (1) missed opportunities and (2) use of the available best practices. A risk management approach with adaptive incremental decision making presents a major opportunity for reducing weather related delays. The reasons for the sub-optimal performance can be found in the following groups of impediments:

- **Lack of technical capabilities** – tools to enable improved functioning of the risk management chain;
- **Insufficient competence** (e.g. lack of appropriate training) of involved actors;
- **Lack of procedures** – with few exceptions, operational supervisors are required to exercise their best judgment regarding the need to manage the anticipated impact of severe weather on the ATC operations;
- **Lack of or inefficient incentives** due to institutional and organisational reasons, such as: insufficient incentives for the ANSPs to introduce risk-based severe weather impact management and strategies that are optimised for the efficient operation of the Network; insufficient incentives for the meteorological service providers to go beyond the provisions of ICAO Annex 3 and provide information better supporting risk-based impact assessment and decision making; insufficient incentives for the FMPs to apply strategies at the pre-tactical level.

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