User needs for a prototype of probabilistic winter precipitation forecast

D4.2 - UNPWPF

PNOWWA

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Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Herbert Pümpel	Austro Control Strategic Development WP 6 leader	13.1.2017
Rudolf Kaltenböck	WP 4,6 leader	24.5.2018
Heikki Juntti	WP5 leader	24.5.2018

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Elena Saltikoff / FMI	Science and WP Manager	23.1.2017
Harri Haukka / FMI	Project Manager	23.1.2017

Approved for submission to the SJU By — Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date
Ari-Matti Harri / FMI	Project Coordinator	23.1.2017
Herbert Pümpel / AUC	WP 6 leader	13.1.2017
Martin Hagen / DLR	WP 3 leader	23.1.2017

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

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user needs (Appendix) Heikki Juntti

Harri Haukka

PNOWWA

PROBABILISTIC NOWCASTING OF WINTER WEATHER FOR AIRPORTS

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Abstract

User Needs were sought to be obtained from a wide range of aviation stakeholders mainly at airports, ranging from major hubs to smaller regional European airports. These were selected to represent different (and challenging) topographic regions, ranging from Nordic maritime to high Alpine environments to determine the limits of applicability as well as the capabilities of the proposed Now-casting system. Apart from web-based surveys, direct contact was established to a number of representatives of user groups and their views and operational concepts established and compared, leading to the interesting result that any such Now-casting system will have to be highly flexible, scalable and adaptable to meet genuinely diverse user needs

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Abbreviations

ACG	Aviation capital group
AUA	Austrian Airlines
AUC	Austro Control
APCH	(Aviation control) approach
ATM	Air Traffic Management
EDDM	Munich airport
EFHK	Helsinki airport
EFRO	Rovaniemi airport
FMI	Finnish Meteorological Institute
GANP	Global Air Navigation Plan
ICAO	International Civil Aviation Organization
INN	Innsbruck Airport
LOWW	Vienna Airport
LOWI	Innsbruck Airport
LSGG	Geneva Airport
LSZH	Zurich Airport
LVP	Low Visibility Procedure
MET	Meteorological
NM	Network Manager
OUE	Operative User Environment
PNOWWA	Probabilistic Nowcasting of Winter Weather for Airports
REA	Research Executive Agency
RVR	Runway Visual Range
RWY	Runway
SES	Single European Skies
SJU	SESAR Joint Undertaking
TWR	(Aviation control) tower
VIE	Vienna International Airport
VIS	Visibility
WMO	World Meteorological Organization
4D trajectory	Route of aircraft in space and time

Executive Summary

User needs were mapped with the PNOWWA user survey, including an online survey, face-to-face interviews and an interactive workshop. Survey revealed relevant threshold values e.g. for snow depth accretion over a given period. These relevant thresholds or equivalent decision criteria were discussed in face-to-face meetings with different end users at Vienna (LOWW), Innsbruck (LOWI), Zurich (LSZH), Geneva (LSGG), Rovaniemi (EFRO) and Helsinki Vantaa (EFHK) airports. The selection of these airports was based on the wide range of traffic density, climatological and topographic types, and different operational concepts.

The survey revealed that the threshold values depend on the user application area. They are often but not always related to ICAO regulations. Additionally, threshold values are strongly dependent on the clearing capability related to the runway and taxiway surface area to be maintained in operations in the different weather.

1 Introduction

The PNOWWA project will produce methods for the probabilistic short-term forecasting of winter weather and enable the assessment of the uncertainty from the end points (airports) of 4D trajectories. 4D trajectory management, also sometimes called “Gate to Gate concept” is an essential building block of the ICAO and SES concepts (GANP, ATM Master Plan) to meet future growth in air traffic; probabilistic forecasts will be used in ATM applications to support operational planning in surface management and ATM decision making, thereby increasing airport capacity in critical weather situations, shortening delays and promoting safety. PNOWWA will demonstrate very short-term (0-3h, "Now-cast") probabilistic winter weather forecasts at 15min time resolution based on the extrapolation of the movement of weather radar echoes and improve predictability of changes in snowfall intensity caused by underlying terrain (such as mountains and seas). Research demonstrations are conducted both offline and online at the Operative User Environment (OUE) site representing influence of the underlying terrain to forecast accuracy. An extensive user consultation will analyse needs to ensure products are suitable to be integrated in various applications on the ATM side. The adjustment to user needs will cover the most relevant parameters (visibility, intensity and snow depth) and operationally important thresholds of the selected parameters (e.g. heavy snowfall).

1.1 Selection of airports

The selection of airports in Europe was to some extent determined by the objective of establishing a wide range of traffic density, climatological and topographic types, and different operational concepts.

The Nordic airports of Oslo - Gardermoen, Helsinki and Rovaniemi were contacted, in central Europe Frankfurt (via the German Met Service), Vienna, Salzburg and Innsbruck in Austria, as well as Zurich and Geneva in Switzerland. In most of these airports interview partners were selected from at least the Air Traffic Management and the airport operators, in Vienna a wider range of users including airlines took part in a dedicated workshop.

The airports of Rovaniemi and Oslo were selected for their high likelihood of experiencing significant snowfall during the limited observing and test period, Innsbruck and Salzburg for their challenging location in terms of orographically enhanced snowfall and difficult radar coverage in steep alpine topography.

The Swiss Airports of Zurich and Geneva both are experiencing infrequent significant snow events, which again forms a particular challenge to operators, having to maintain equipment and operator competence in the light of infrequent strong snowfall events. The comparison between the two airports also is interesting as the airport in Geneva only has one runway, whereas in Zurich a multi-runway environment requires a different operational concept for snow clearing and de-icing.

2 Methods for mapping the user needs

In order to quantify and objectify user needs, the PNOWWA user survey, which included an online survey, interviews and an interactive workshop, tried to establish relevant threshold values e.g. for snow depth accretion over a given period. The relevant thresholds or equivalent decision criteria were discussed in face-to-face meetings with different end users at Vienna (LOWW), Innsbruck (LOWI), Zurich (LSZH), Geneva (LSGG), Rovaniemi (EFRO) and Helsinki Vantaa (EFHK) airports. Written feedback of varying detail was received from Oslo-Gardermoen, Munich, Istanbul, and Salzburg.

Most interviewees saw value in receiving a calibrated probability that snowfall (or freezing rain) will exceed a given threshold value during the following 15 minute period. Decisions depending on such a threshold vary considerably between single runway and multiple runway airports.

The threshold values depend on the user application area. They are often but not always related to ICAO regulations, and to established clearing capabilities and friction coefficients. Additionally, they are strongly dependent on the clearing capability related to the runway and taxiway surface area to be maintained in operations in the different weather.

Airport operators and their relevant departments (or sub-contractors) are maintaining close liaison with the ATM units (typically the TWR control) to develop clearing strategies that allow continued safe operations with a minimum loss of capacity.

A significant part of the airports under consideration are affected also by the Low Visibility Procedures often occurring with moderate or heavy snowfall, in the case of Innsbruck the case of low ceiling and visibility associated with snow or high humidity being the critical element limiting operability of the airport under these conditions. Further work may be required to establish robust statistical relationships between predicted snowfall rates and associated LVP conditions, as the will depend on multiple parameters, such as temperature, relative humidity and environmental conditions. Such a Now-cast of associated probabilities of LVP conditions could form part of a later implementation or industrial research project as a follow-up to PNOWWA.

Oslo, as one of the most snow-prone airports, is operating a highly sophisticated and effective information system, where updated information is even delivered to the snow-clearing flotilla of trucks. Thresholds for actions are dependent on type of snow/slush, temperature and the use of forecast probability depends on the traffic load. Whenever heavy traffic is current, clearing action becomes re-active, i.e. immediate actions is taken with the onset of the critical weather phenomenon, whereas during off-peak hours, the decision is taking into account the forecast evolution of the situations. The responsible managers take a very professional and open-minded attitude towards new products and systems, and welcome probabilistic information in principle, while warning that a poorly calibrated probability product could have a very negative effect on the future trust of the operators in the system providing the information.

In the case of Geneva, the lack of rapid exits (taxiways) adds to the susceptibility to LVP conditions, reducing the runway capacity by 50%.

In case of significant snowfall, a complete clearing cycle takes approximately 20 minutes, during which take-off and landing operations in the single runway have to be suspended, reducing the airport capacity by 33%. Good predictions of such conditions will help to minimize the significant impact on operations, where both military airspace and high mountains (Mont Blanc, among others…) in the vicinity of LSGG severely limit holding capacity for approaching aircraft

For Zurich, the aim is to maintain at least one runway open even under heavy snowfall, with extra consideration given to the type and intensity of weather elements requiring aircraft de-icing before take-off. It seems that ATM is typically able to adapt to these situation, while the airport operators are occasionally struggling to maintain operability under the above-mentioned conditions.

As a limiting factor LSZH ATM see the thickness of snow on the runway rather than the measured breaking action.

In the case of the inner alpine airport of Innsbruck (Single Runway, narrow valley, high minima due to special procedure involving a short final in Visual conditions), snow clearing is reactive, i.e. starts with the onset of snowfall, and is normally capable of maintaining operability albeit with reduced capacity. This is only an issue on days with heavy charter traffic, otherwise brief holding periods are manageable. On heavy traffic days, however, holding space in high mountain areas and in the vicinity of the major hub of Munich (EDDM) becomes limited, and stress levels for ATM can be considerable. One to two-day forecasts of significant snow events are thus required to plan such days well ahead, and communicate with ATM and the NM.

For most of the airports listed above it is thus obvious that the introduction of objective criteria such as the likelihood of exceeding a threshold of snowfall would help to maintain operational planning and execution, but the exact limits and thresholds may need to be established or revisited for a newly developed probabilistic Now-casting system. Thresholds used successfully at other airports may form a basis for the studies, but are likely to need adaptation to the local conditions and operating procedures.

For Vienna (LOWW), the availability of two runways allows continued clearing operations on alternate runways, and again, close coordination between Airport and ATM as well as users is the key to mitigate delays and problems associated with snow fall, freezing rain and LVP, which all appear equally high on the list of problem cases for the airport, which particularly during the rush hours in the morning and evening are very difficult to overcome. Currently, deterministic forecasts of snow accumulation are provided by the AMSP Austro Control, with a set of thresholds given in the chapter 3 to this document.

2.1 Uptake of probabilistic forecasting by the different user groups

While probabilistic methods have been accepted widely in the commercial and risk management professional communities as a means to quantify and compare strategic, financial and operational risks, many frontline operators having to make rapid and tactical decisions are only slowly warming to the concept of probability-based decision support information. In particular, when it comes to decision regarding de-icing and application of de-icing fluid in large quantities on runways and movement surfaces, with far-reaching financial and operational consequences in the case of inappropriate action, winter operations practitioners generally prefer a clear yes/no information, even if they accept that this information may be incorrect. For moderate or intense snowfall, they will often make a snap decision only after seeing the intensity of the event unfolding in front of their eyes. The decision to start snow clearing is frequently taken after snow cover becomes visible on the movement surfaces, and the operation is then carried out always in full configuration of the flotilla of vehicles, irrespective of momentary intensity. (Mostly) Deterministic forecasts of anticipated intensity or changes thereof are providing valuable additional information on the recommended further course of action.

For a more general acceptance and use of probabilistic information the experiment will be a valuable pioneering enterprise, in particular where the overall benefits and reduction of de-icing agents applied can be demonstrated. The widespread application of a “just culture” should also help to reduce the sometimes present fear of decision makers to be accused of taking the wrong decision based on deterministic information only without a clear indication of the characteristics and limitations of the forecast system. The general recognition that atmospheric processes will always contain a stochastic element will also help to overcome the unavoidable discrepancies between information coming from different sources, such as a national/local MET service provider, that coming from the network Manager (NM) and possibly private enterprise provides supplying ground-side operators, e.g. those clearing parking surfaces or access roads to the airport.

2.2 User groups

The following groups have agreed to participate in the demonstration

LOWW:

MET, ATM (TWR) and RWY maintenance
De-icing possible – contact via workshop VIE and direct e-mail contact not answered
AUA flight planning not answered (only AUA pilot representative and direct contact person to ACG)
APCH: demonstrator will provided

LOWI:

ATM
RWY-maintenance, de-icing – direct contact will follow when demo-product is available

EFHK:

RWY maintenance, de-icing management, ATM tower
Finnair interested to join that type of development later. Now informed only that issue is important to them.

EFRO:

RWY maintenance

3 Parameters and their thresholds

3.1 Selected Parameters offered to Users as Options

For runway maintenance and snow clearing purposes, the likelihood of occurrence of different classes of snow/slush/wet snow accumulation over a given period were offered to users as possible criteria in their decision-making process. These parameters including the discrimination between dry snow, wet snow and slush was intended to give the widest possible range of criteria, and the temporal resolution of 15 min the minimum period that could be realistically be predicted.

During the face-to-face interviews we found that the overwhelming majority of users currently used fewer thresholds, less time-steps and granularity, and the less discrimination between different types of contamination (dry/wet/slush), but some used temperature as additional criteria.

3.2 Additional Criteria for De-Icing Weather and ATM-TWR requirements concerning LVP

Recognizing the fact that the necessity to de-ice aircraft prior to departure during wintery precipitation and due to frost or rime accumulation has a significant impact on total airport throughput, additional criteria for the requirements of aircraft de-icing ere offered to users, given in the lower part of the following Table 1.

Standard De-Icing Weather classes from o to 3 are offered again in terms of probability of occurrence during the given 15-min time intervals, with additional information on new accretion of contaminants through snow, slush or freezing precipitation.

Finally, the probability of LVP-conditions are provided to the TWR-control of ATM as they are typically related to wintery weather conditions and have a significant impact on airport throughput

Runway maintenance	**accumulation % dry snow**	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	less than 1 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	1-2 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	2-4 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	over 4 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	accumulation % wet snow	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	less than 0.5 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	0.5-1 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	1-1.5 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	over 1.5 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	accumulation % slush	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	less than 0.3 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	0.3-0.5 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	0.5-1 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	over 1 cm/h	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	prob of freezing rain	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	prob	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	prob of freezing of runway for the cooling of air after the precipitation of wet snow, slush or water	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	prob	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
De-icing	**DIW class**	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	3	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	2	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	1	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	0	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
	prob of freezing of runway for the cooling of air after the precipitation of wet snow, slush or water	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min
	prob	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%
Tower	**LVP casued by precipitation**	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	105-120 min	105-120 min	105-120 min	105-120 min
	prob	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%	?%

Table 1: Example of probability forecast of relevant winter weather for airports

3.3 Thresholds for Vienna

In extended consultations with the winter maintenance department of Vienna Internal Airport (VIE) the following set of thresholds is used to determine an overall risk in terms of risk management. The snow depth thresholds are 0,1, 0.5, 1 and 2 cm accretion, and the probability categories were set at 0 o 20%, 20 – 50%, 50 – 90% and 90 – 100%. The resulting Risk Categories are color-coded and given below in Table 2.

At the same time, a probability of LVP conditions is provided to ATM (LVP (standby) starts with 600 (1200) m RVR and 200 (300) ft ceiling)

Table 2: Risk Categories for VIE Airport given sets of accretion depth and probabilities Airline users

Probability of occurence \ predicted snow accumulation in cm	0.1	0.5	1	2
0.9 – 1	orange	orange	orange	red
0.5 – 0.9	yellow	yellow	orange	orange
0.2 – 0.5	green	yellow	yellow	orange
0 – 0.2	green	yellow	yellow	orange

Further explanation for Tab.2 is given in Tab.3.

Table 3: Risk Matrix from WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services in 2015 as source for Table 2.

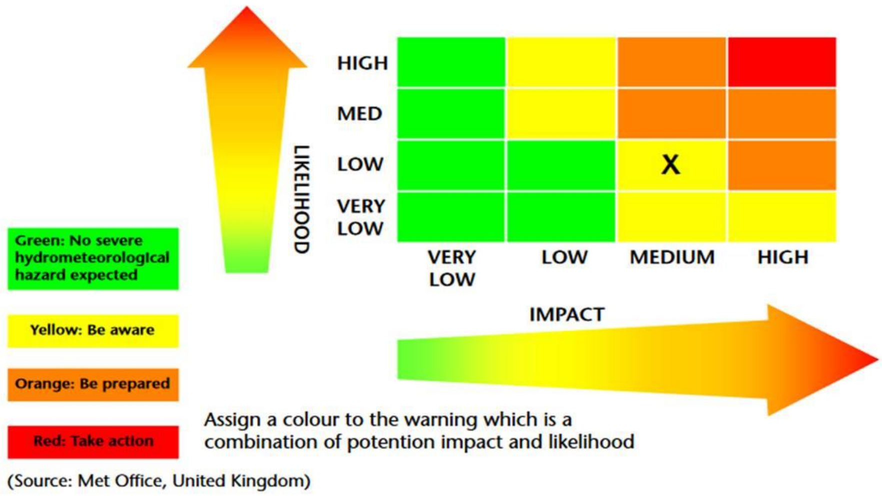

Figure 2. Risk matrix

3.4 Thresholds for Innsbruck

Due to the specific orographic difficulties of the airport with a partially visual approach procedure, LVP conditions and ceiling heights (depending on aircraft type, runway conditions, wind and crew training) are the prime concern to ATM, with visibility of interest below 1500m, 3000m and 5000m and staggered ceiling thresholds below 1500 ft. Contamination thresholds are less critical, as any accumulation needs to trigger full-scale clearing response due to the single-runway operation.

Freezing rain is rare (VIE), and extremely rare (INN), but very important to be warned about well ahead of occurrence, moderate fzra is automatically in the "red" category, and preventive application of de-icing fluid is the rule.

Summary for VIE, INN with respect to 15 min intervals:

user1	**Weather**	**thresholds**			
Maintenance	dry snow	over 10 mm/15min	5-10 mm/15min	1-5 mm/h/15 min	less than 1 mm/15 min
	wet snow	over 5 mm/15min	3-5 mm/15min	1-2 mm/15min	less than 1 mm/15min
	freezing RA	%			
	freezing after cooling	not forecasted			

user2	**Weather**	**thresholds**		
De-icing management, airlines	dry snow	VIS less than 2 km	VIS 2-12 km	VIS over 12 km
	wet snow	VIS less than 2 km	VIS 2-12 km	VIS over 12 km
	freezing RA	%		
	freezing after cooling	not forecasted		
	frost forming	%		

user3	**Weather**	**Thresholds VIE**	**Thresholds INN**
Tower	dry snow	VIS less than 600 m RVR	VIS less than 3000/5000 m
	wet snow	VIS less than 600 m RVR	VIS less than 3000/5000 m
	freezing RA	%	
	freezing after cooling	not forecasted	
	frost forming	%	

3.5 Thresholds for Rovaniemi

user1	Weather	Thresholds			
Maintenance	dry snow	over 8 mm/15min	5-8 mm/15min	1-4 mm/h/15 min	less than 1 mm/15 min
	wet snow	over 5 mm/15min	3-5 mm/15min	1-2 mm/15min	less than 1 mm/15min
	freezing RA	%			
	freezing after cooling	%			

3.6 Thresholds for Helsinki

user1	weather	thresholds			
Maintenance	dry snow	over 8 mm/15min	5-8 mm/15min	1-4 mm/h/15 min	less than 1 mm/15 min
	wet snow	over 5 mm/15min	3-5 mm/15min	1-2 mm/15min	less than 1 mm/15min
	freezing RA	%			
	freezing after cooling	%			

user2	weather	thresholds		
De-icing management (FINAVIA), Swisspro, Finnair	dry snow	VIS less than 2 km	VIS 2-12 km	VIS over 12 km
	wet snow	VIS less than 2 km	VIS 2-12 km	VIS over 12 km
	freezing RA	yes or no?		
	freezing after cooling	yes or no?		
	frost forming	%		

user3	weather	thresholds
Tower	dry snow	VIS less than 600 m (RVR 1000m)
	wet snow	VIS less than 600 m (RVR 1000m)
	freezing RA	yes or no?
	freezing after cooling	yes or no?
	frost forming	%

3.7 User needs not included in prototype

In the Tower –product it was taken into account only the influence of snow and sleet to visibility. Effects of fog, mist or drifting snow was not forecasted in prototype. That was because project concentrated to research the possibilities to use weather radar as a source of information to probabilistic winter weather nowcast.

Runway conditions are also strongly affected by frost formation during moist air and cool surface conditions, but that was also outsourced from that research. FMI has also tools for that type of nowcasting and by blending of numerical model information and radar information it would be possible to tackle also those conditions.

4 Conclusions

The requirements collected in this task was forwarded for the Research demonstration development team, and executed to scientific demonstration of PNOWWA.

The diversity of requirements from different user groups underlines the benefits of a wide survey and personal discussions with the end users. During workshops at airports it raised also discussions how ATM will use probabilistic meteorological information in their procedures. That is area needing more co-operation in future.

After the first demonstration phase some users suggested to use exceedance probabilities instead of group probabilities in the product. They also wished the products for LVP conditions that take into accounts also fog situations.

During both demonstrations users used also additional information than PNOWWA to get a better overall situational picture of the weather. They felt that table type product as used in demonstration isn’t sufficient to human users; humans like to have graphically visualized products. It can be concluded that table type information is as best in machine-to-machine type solutions.

Some of the collected requirements are such, that they couldn’t been fulfilled within the scope of this project. Even that information is valuable, and the requirements were saved for possible follow-up projects.

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Appendix – reconciliation of user needs after the project

This appendix covers additional information about user needs, collected during and after the two PNOWWA winter demonstration campaigns in winter 2017 and 2017/2018. The deliverable D4.2 was the basis for the user specific demonstration product, which was originally closed in the beginning of 2017, before first demonstration campaign started.

To reopen the document in 2018 after the project phase, gives us the opportunity to add additional requirements gathered from stakeholder feedback. The weather radar based winter nowcasting product of PNOWWA focuses on short range precipitation forecast, only. The principle of this method is not able to cover all meteorological winter parameters of aeronautical interest, even when the collected radar data resolve precipitation systems in high temporal and spatial resolution, including important mesoscale subscale structures responsible for aeronautical hazards.

Following, the user needs are summarized and separated in two classes.

User needs – included in PNOWWA product

Next, the user needs included in the weather radar based PNOWWA product are listed:

- tailored product to runway maintenance, de-icing agents, tower and approach air traffic controller and airliner
- online service, automatic updated every 15 minutes
- nowcasting (short range forecast) up to 3 hours
- probabilities of weather categories defined by users
- different classes/amounts of forecasted snow accumulation (based on stakeholder impacts and actions)
    - 1st demonstration phase: most probable (e.g. <1, 1-5, 5-10, >10mm of snow within 15 minutes)
    - in 2nd demonstrator it was changed to exceedance of probability (e.g. <1, >1, >5, <10mm of snow within 15 minutes) due to feedback of user consultations
- discrimination between wet and dry snow
- probability of freezing rain
- de-icing weather type
- decrease of visibility caused by snow

- probability of freezing of wet runways was originally not planned, but included in PNOWWA demonstrator

Additional user needs - not included in PNOWWA

Not all of the user needs, collected at the beginning of the project, were included in the PNOWWA prototype, which was based mainly on weather radar data. One example is the extended lead time for tactical planning mostly stated by airliners and … in the online survey (see Dxx). This extended lead time was beyond the project as the focus was short-range forecasts and numerical weather prediction model data would have extensively to exploited. By the other hand, user feedback from airport operation during demonstration phases showed importance of definition of proper probability thresholds, visualization of the product or including other weather phenomena than winter weather alone.

Relevant user needs not addressed in PNOWWA are listed below:

- seamless prediction (extend forecast time range from 0-3 hours up to24 hours or longer for tactical planning)
- considering all visibility reduction (fog, mist, blowing-drifting snow etc.)
- include cloud ceiling information especially for low visibility procedures in air traffic management
- layout of forecast product for manual use is essential (e.g. visualization, mobile app, etc.)
- procedures for probability necessary (e.g. routing of airplanes, handle low probability values)
- all weather application – integrate summer weather such as deep convection and autumn / fog and low stratus

Future air traffic management solutions related to probabilistic weather forecasting should addressed this issues in both cases, for manual and automatic generated products and interpretations.