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Feasibility Study
Weather Radar for Ice Crystal Detection

RTCA FS-1
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Prepared by: SC-230
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FOREWORD

This report was prepared jointly by EUROCAE Working Group 95 Subgroup "Ice Crystals Long Range Awareness" and RTCA SC-230 'Airborne Weather Detection Systems' and approved by RTCA Program Management Committee (PMC) on May 31, 2017. It was held for joint publication until September 21, 2017.

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- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

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EXECUTIVE SUMMARY

In parallel with the US HIWC and European HAIC projects, the European Organization for Civil Aviation Equipment (EUROCAE) Working Group WG95 (Long Range Awareness subgroup), in association with the RTCA Special Committee SC-230, was tasked with demonstrating the maturity and the feasibility of using an X-band radar system for long-range detection of ice crystal conditions.

This feasibility study document details the context of the study and a description of the intended function (situational display of regions ahead of the aircraft that present potential hazards to the aircraft due to ice crystals). Its goals are:

- To determine if a radar ice crystal awareness function is possible using an airborne X-band weather radar system
- To assess the feasibility of such a function
- To provide guidance on the design and validation of long-range ice crystal awareness functions for X-band radar technology.

Aircraft manufacturers have expressed the following operational goals for a long-range ice crystal detection function:

- Detection out to a range of at least 80 nm
- Discriminante between moderate and heavy ice crystal concentrations.

Based on the reflectivity and temperature data currently available to airborne weather radar systems, these systems do not have sufficient performance to meet the operational targets defined by the aircraft manufacturers. However, initial weather radar flight test data has indicated that incorporating other information available to the radar may allow the system to meet the desired operational goals. In particular, the results of a prototype evaluation conducted during the 2016 HAIC flight test campaign suggest that the use of additional information can increase performance when compared to using reflectivity and temperature alone.

This document also provides recommendations going forward. The main foreseen activities are:

Analyze and gather more data to further evaluate the ice crystals awareness function

Create atmospheric models related to ice crystal phenomena. These models can be used in the development and validation of a radar ice crystal awareness function.

Reach an agreement on whether multiple ice crystal concentration thresholds are needed. In particular, determine whether a moderate threshold should be defined based on engine effects. This may involve collecting more engine data.

Develop an RTCA Minimum Aviation Systems Performance Standard (MASPS), and continue to work with industry partners to continue to evaluate the weather radar's ability to meet the operational goals of this function. There is no expectation of any updates to RTCA/DO-220A.

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GUIDELINES

This document uses a structure similar to a Minimal Operational Performance Standard (MOPS). It will demonstrate the maturity and the feasibility of using airborne weather radar (WXR) for ice crystal awareness. The content has not been written as requirements (no “shall” statements). It considers existing functions and their criticality.

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1. INTRODUCTION/CONTEXT

1.1 Background

The aviation industry has developed a growing concern for the effects of flight through areas with high concentrations of ice crystals. The conditions encountered are often referred to as Ice Crystal Icing (ICI), High Ice Water Content (HIWC), or High-Altitude Ice Crystals (HAIC). Commercial aircraft have experienced in-service events while flying in the vicinity of these atmospheric conditions since at least the early 1990s.

Evidence shows that high concentrations of ice crystals that cause in-service events typically occur in the vicinity of deep convection. Deep convection is defined as convection that reaches the tropopause. High concentrations of ice crystals may also occur at altitudes below the tropopause. Examples of the type of weather systems which can result in an in-service ice crystal icing event are shown in Figure 1-1 and Figure 1-2.

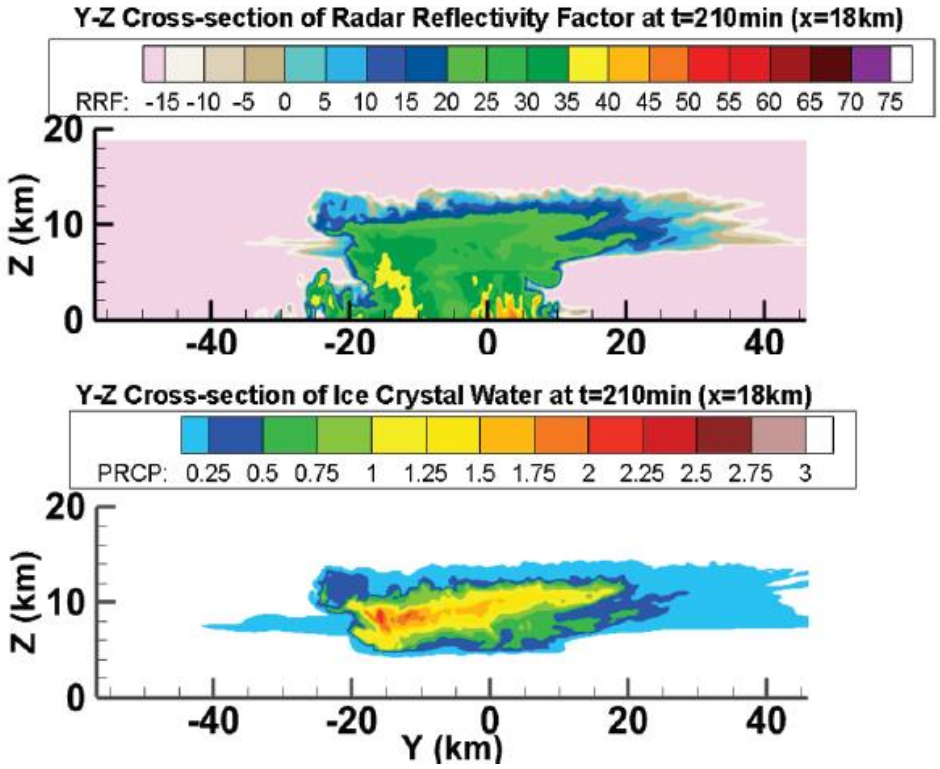


Figure 1-1 – Comparison of Simulated Radar Reflectivity and Ice Water Content[1] for Vertical Cross-section Orthogonal to Line during Mature Phase (*t = 210 min*). Units are dBZ for Radar Reflectivity Factor (top) and *g/m*^{3} for Ice Water Concentration (bottom).

[1] Figure 1-1 extracted from Proctor, F.H. and Switzer G.F., "Numerical Simulation of HIWC Conditions with the Terminal Area Simulation System", AIAA 2016-4203

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