

H175 De-icing Flight Test Campaign – Focus on Flight Test Instrumentation

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Abstract:

Among flight test campaigns required for certifications, the flights in icing conditions are challenging both for the aircraft system but also from the Flight Test Instrumentation (FTI) perspective. It requires a specific organization, scheduling, resources with expertise and particular means of measurement when it comes to instrument the aircraft for campaigns in icing areas.

Such data must be collected in given icing conditions to be considered as valid data from the certification authorities. It might take time to meet such conditions, thus one possibility to increase these statistics is to run parallel campaigns in several locations. The benefits are there, but come at the cost of some points to be particularly aware of to ensure that both field tests run smoothly.

The instrumentation required to perform those acquisitions has its own complexity and specificities. The choice of the various parts (icing measurement probes, video system, weather station) shows a major importance to withstand the harsh icing environment.

Key words: Flight Test Campaign, Instrumentation, Icing Probes, Video, Weather

De-icing Flight Test Campaigns from FTI perspective

In the frame of the H175 helicopter certification in icing conditions, specific Flight Test Instrumentation installations have been designed and integrated to ensure two campaigns in parallel. The flight tests took place in Canada (London/Ontario) from October, 2023 to April, 2024 and in Norway (Trondheim/Alta) from February, 2024 to April, 2024. Two aircraft were fully instrumented to perform those campaigns in good conditions.

The management of two campaigns simultaneously brings additional challenges, as well as important added-values. The number of measurements increase, thanks to various icing conditions in different locations, which is a major argument to undertake those challenges. As the instrumentation is quite specific, it is important to ensure the availability of the required equipment but also spare parts to face any potential issue with a high reactivity. The resources are shared on two foreign locations in different time zones, increasing the difficulty to communicate between the teams and the third support team located in the main site in France. All the teams must be somehow composed by people experimented with such

types of campaigns, to not miss a chance to perform proper flight tests and adequate measurements.

The parallel campaigns allowed a clear speed up in the certification process, ensuring the availability of all required data by the certification authorities in one go, to justify the sustainability of the aircraft and its de-icing system in such a harsh environment. Good preparation ahead of those campaigns is mandatory in order to obtain the required results from the various flight tests sessions. Ensuring a sufficient number of well-trained resources, as well as equipment availability along with enough spare parts, comes as a prerequisite in addition to a proper schedule organization upfront and during the campaigns.

FTI Overall Architecture

Nowadays, most of the flight test installations are based on a network architecture. This implies as basic components several network switches to ensure the interconnection between data acquisition units, recorders, data displays, control units... When it comes to such de-icing campaigns instrumentation, a huge amount of equipment is added as an extension to the existing typical instrumentation system. An additional network switch is used as gateway

between the existing system and the de-icing specific system, collecting data from the cameras via video encoders, from the de-icing probes via a given computer and feeding dedicated data displays to show the weather data and icing-related measurements.

All in all, it gathers more than 500 analog parameters, as well as 16 video cameras installed inside and outside of the aircraft collected by 4 video encoders, along with 30 ARINC429 lines to store various information coming from the aircraft and several Ethernet busses to exchange data between the equipment.

FTI Specificities for De-icing

De-icing flight test campaigns require some specificities in terms of instrumentation. As a non-exhaustive list but still covering the main components: the icing measurement probes, the video system and the weather station; all considered in the harsh environment of icing conditions.

- **Icing Measurement Probes:** this type of probe is fully specific to this kind of measurement; therefore, they are not often used and the list of suppliers is quite reduced. This implies a strong link with the chosen supplier, in terms of communication, training, implementation but also regarding support during the campaign and potential on-site maintenance. The technology integrated into the means of measurement itself is crucial and might evolve from one campaign to the next one; so obsolescence might appear, which can be seen as an opportunity to improve the efficiency of data collection. Mainly three distinct criteria must be measured:

- Water concentration, via a “King Probe”, range [0,05; 3,00] g.m⁻³;
- Small water drops, via a “Cloud Droplet Probe” (CDP), range [2; 50] μm;
- Big water drops, via “Scattering Spectrometer Probe” (SSP) or “Cloud Imaging Probe” (CIP), range [1; 950] μm;

Those measurements are processed together with the True Air Speed data (TAS) of the aircraft taken from a static pitot probe. All those probes can be considered separately, but as an alternative, new technologies propose one single system called Cloud

Combining Probe (CCP). Working with a dedicated embedded computer, those data can be processed in real-time and provide final parameters useful for the validation and certification process. In addition, it helps defining directly whether the droplets present in the clouds respond to the requirements for such data, or if the particles cannot be used in the frame of certification.

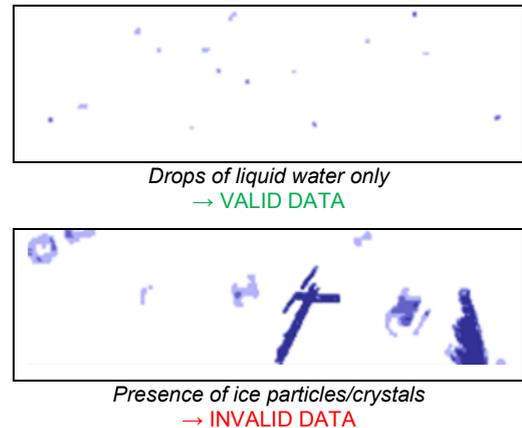


Fig. 1. Icing particles going through the CIP to define the validity of the data for two different kinds of clouds.[1]

The fact that data processing starts in real-time during data collection reduces the time needed for post-processing, improving the overall efficiency regarding the high amount of data to consider other than the icing particles themselves. This however requires the presence of an additional computer linked to the probes. This brings up a new challenge regarding its integration in the FTI system, but it allows timestamping the data coming from the probes via Network Time Protocol (NTP) and aligning them with other acquired data;

- **Video System:** The video system plays a key role in such testing campaigns. Having a literal view on the icing conditions outside helps during interpretation of the measured data, the evaluation of ice quantity all over the campaign by the aircraft and to prepare the crew for the different flight testing phases to perform.
- *SDI cameras* have been designed specifically to withstand icing conditions by adding a self-heating resistors ring around the lens. One of the main points of interest is to verify the icing accretion and good operation of the de-icing system from the helicopter on the

blades. The pictures taken by the cameras must offer a clear view of the accumulation of the ice without any blurring due to the rotation of the blades. This is ensured thanks to a second key feature of the cameras, allowing to trigger the picture on an external synchronization signal coming from the rotor blades. Other cameras are oriented towards so-called icing indicators, which are installed all over the aircraft at strategic locations with graduations allowing the measurement of ice aggregation. Keeping the same customized model of camera for all shots helps the interchangeability, the mechanical and the electrical integration in the aircraft;



Fig. 2. Camera clearly showing ice accretion on rear rotor blades in 26 seconds thanks to the synchronization of picture capture on the blade frequency.

- *Video encoders* are used to capture the SDI stream from the cameras and compress them with the best possible ratio (H.265 compression algorithm). This is a trade-off between the quality of the resulting compressed videos and the data rate transferred to the rest of the FTI architecture. Each video encoder collects up to 4 video cameras and outputs a single Ethernet stream, sent in parallel to the recorder and data display.

The video system represents a significant data rate transferred over the FTI installation. The calculation of each rate and support by the various equipment receiving the stream must

be planned upfront to setup the system accordingly.

- **Weather station:** weather data provides important information used to identify cloud type and location, as potential sources of valid data. It guides the crew to navigate to the interesting locations and hopefully quickly meet the right icing conditions. Such a system [2] can be connected to the IRIDIUM satellite constellation to provide weather data to experts on ground, in the air or at sea. By processing such data in real-time and combining these with the GPS location of the aircraft, the experts can communicate with the crew to provide them a cartography of the real-time weather conditions. Finding right away adequate icing conditions drastically improves the time required to collect the required parameters with the right quality.

Those specificities about the FTI system increased the integration efforts in more typical FTI architectures, both regarding software and hardware in a general way. However, those technologies and technical choices made it possible to cover all necessary measurement points required by the certification authorities in a limited time range. Appropriate icing conditions being available only in a narrow time window during the year, usually in quite remote locations, it would otherwise have been necessary to wait for one additional year to be able to complete the missing points and complete the flight test campaigns.

- **Harsh environment:** everything has to function properly notwithstanding the harsh environment naturally imposed by the icing conditions. More than ever, the sensors, harnesses and various parts of the instrumentation exposed to the icing conditions must be protected. Damages can appear fast and a high level of repair, maintenance and reactivity become a key success factor. Issues and side effects can appear in unexpected areas. Due to the high responsiveness required during campaigns while facing damaged parts, it is not always possible to wait for repair before flying again and adaptability must be accounted for upfront. As an example, if the static pitot probe from the CCP is damaged during a campaign and becomes inoperative, the data analysis team must be trained to use the static pitot

data acquired from the aircraft and apply the proper formula, to finally calculate the resulting correct icing measurements without this being done automatically by the dedicated computer.

Summary

In addition to the typical harsh environmental conditions met during deicing campaigns which put a heavy stress on the instrumentation, especially as it needs to maintain the highest standards from a metrological perspective, the real challenge behind the H175 deicing campaign was to manage and follow two campaigns happening simultaneously in different locations and timezones.

First, the management of equipment inventories requires an important level of organization and

coordination (ensuring spare parts, facing obsolescence).

Second, the management of the teams requires dedicated attention, regarding the availability of a relevant group of specialists, but also from a communication and planning point of view.

Last but not least, the technical challenges are highly present: from the integration of new probes to the complexity of a customized video system, over the necessary evolution of the network architecture... and all that under time constraints and particularly challenging environmental conditions! But in the end, the resulting benefits in terms of lead time of the certification process proved the challenge to be worth the effort!

References

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