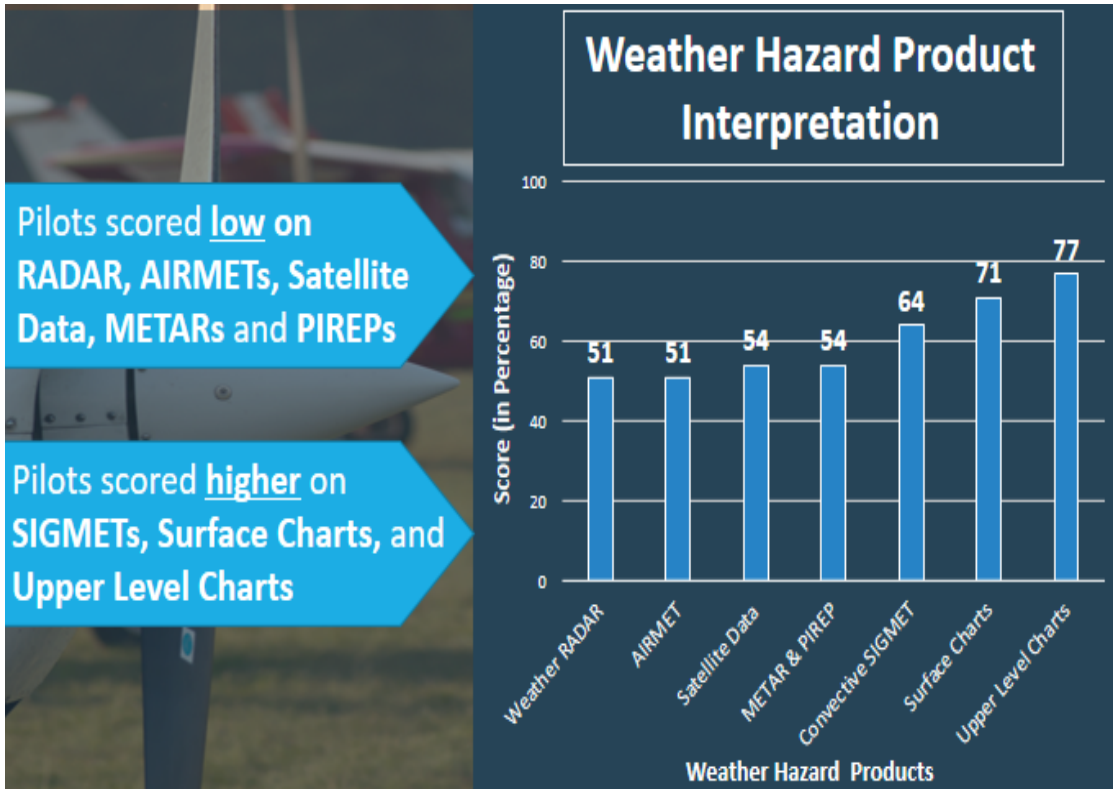
Clouds, Cloud Ceiling, and Visibility (C&V) Technical Exchange

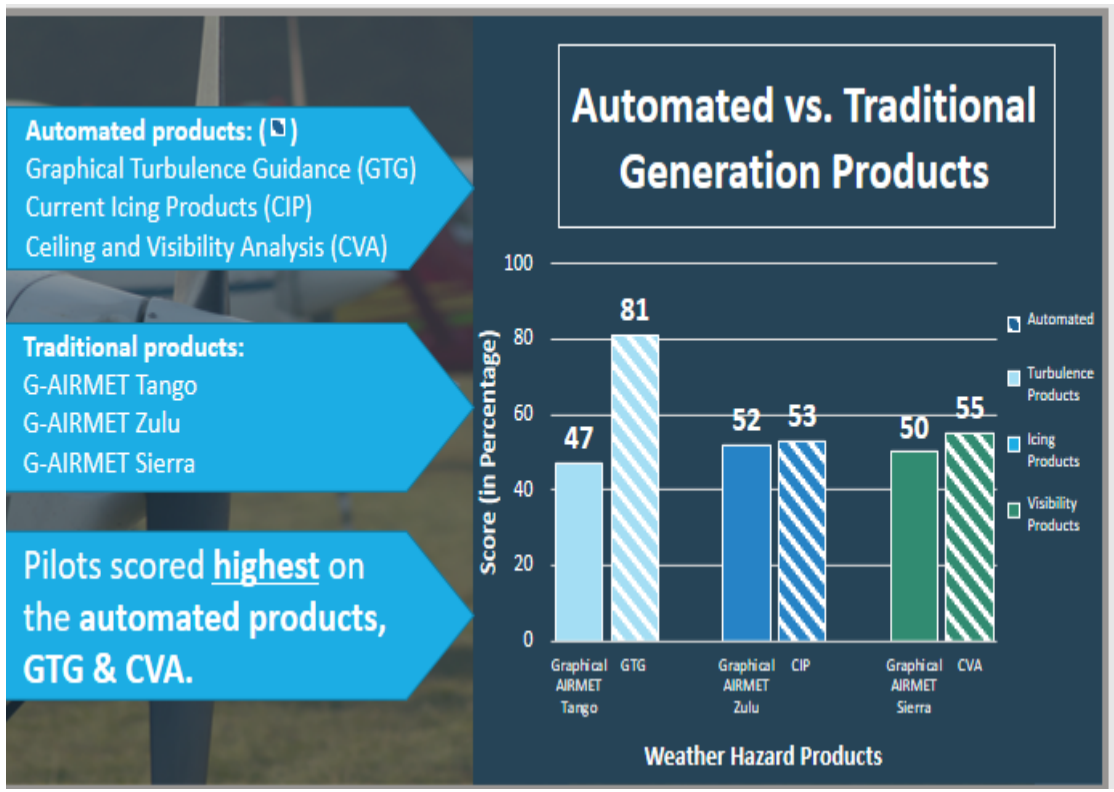
Weather Technology in the Cockpit (WTIC) Related Projects

Program Manager – Gary Pokodner

Gap Analyses – Summary of Findings

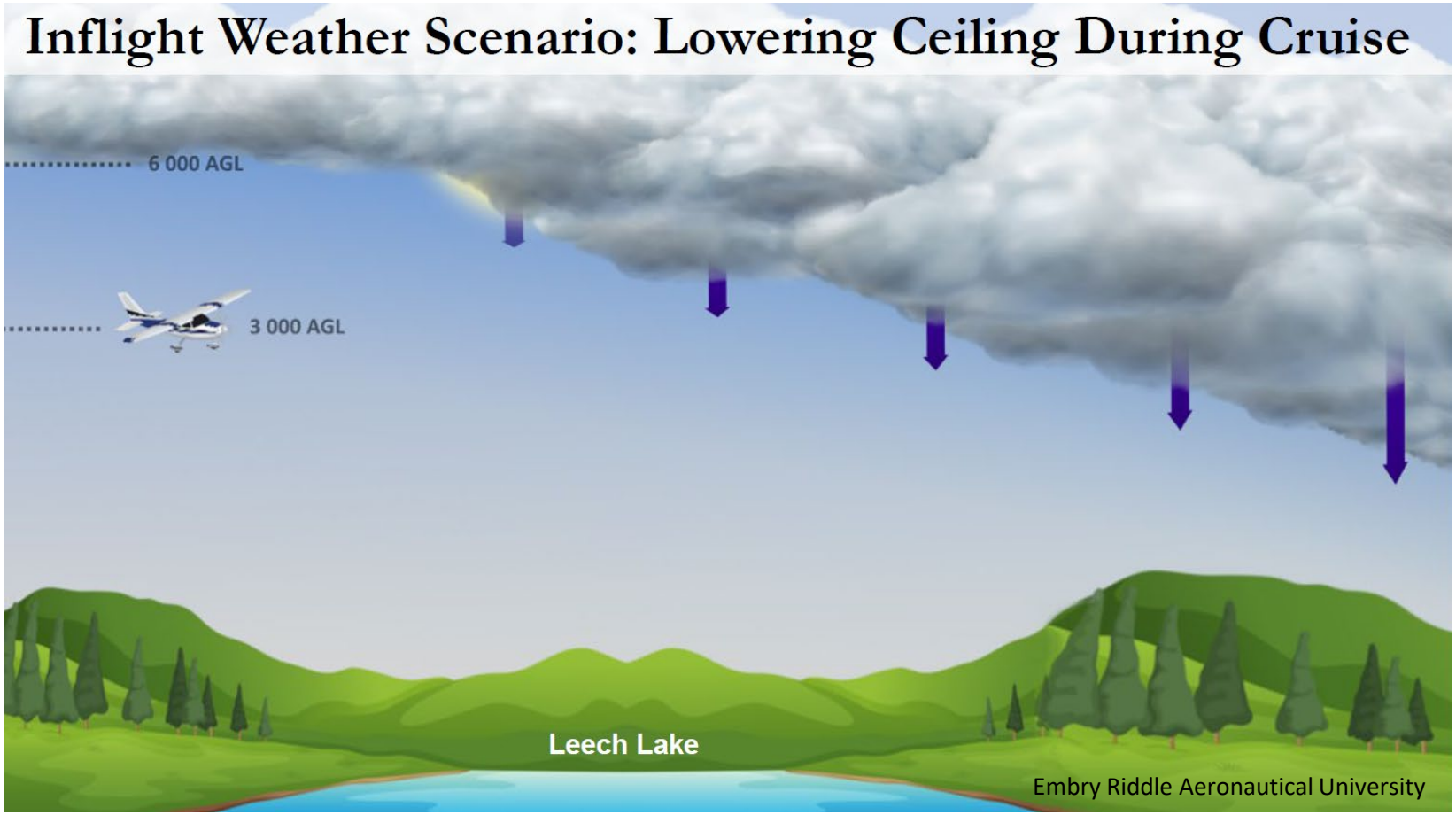
Weather Knowledge Research



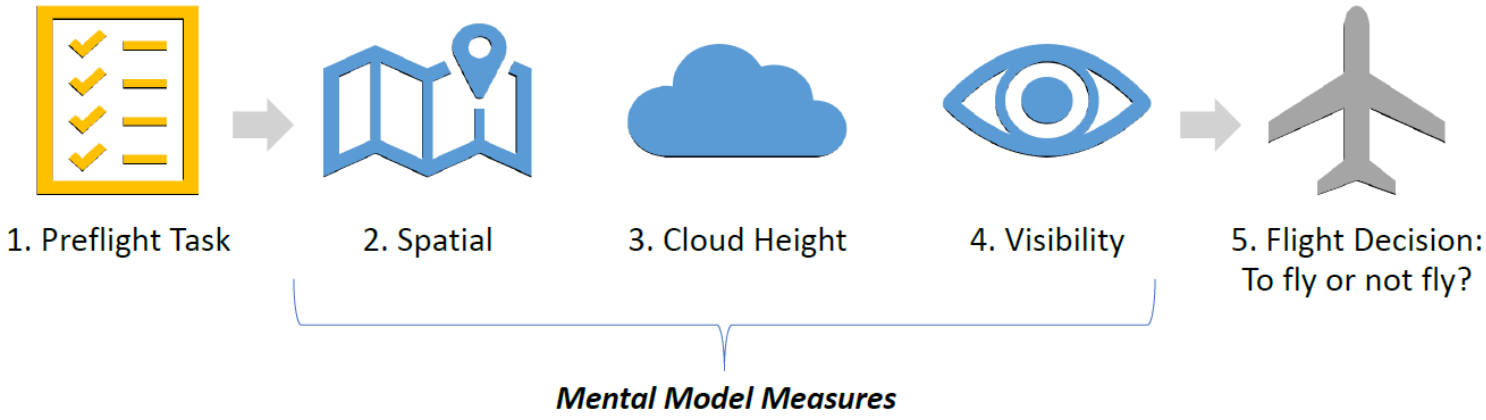


Source: (Blickensderfer et al., 2019)

Gaps in Pilot Weather Knowledge



Gaps in Pilot Weather Knowledge



- **High Fidelity Preflight Scenario**
  - Closely mimic real preflight tasks and processes.
- Pilots developed a weather briefing based on “current” and “forecasted” weather products
- WX data captured from the Aviation Weather Center (AWC, 2017)
  - Slightly modified
- Formatted to match AWC website
- Mockup website created using Wix.com

Gaps in Pilot Weather Knowledge

RESULTS

Frequency of Estimated Ceiling Correct by Region

	Private *n* = 24	Private w/ Instrument *n* = 20	Commercial w/ Instrument *n* = 20	CFI/CFII *n* = 20	Total *n* = 84
	f	*f*	*f*	*f*	***f***
Region 1	8	7	6	6	**27**
Region 2	0	2	8	1	**11**
Region 3	1	5	2	3	**11**
Region 4	1	3	2	5	**11**
Region 5	2	2	4	1	**9**
All regions	0	0	0	0	**0**

Frequency of Estimated Visibility Correct by Region

	Private *n* = 24	Private w/ Instrument *n* = 20	Commercial w/ Instrument *n* = 20	CFI/CFII *n* = 20	Total *n* = 84
	f	*f*	*f*	*f*	***f***
Region 1	21	20	17	20	**78**
Region 2	21	17	12	18	**68**
Region 3	3	4	11	3	**21**
Region 4	4	5	9	6	**24**
Region 5	4	6	7	2	**19**
All Regions	0	1	2	0	**3**

Gaps in Pilot Weather Knowledge

- **SUMMARY**
  - Pilots struggled at depicting weather along the route
  - Held incorrect weather expectations for most of the route and at the destination airport
    - Depicted destination weather as Visual Flight Rules (VFR) whereas conditions were much lower
  - Pilots may not be assessing enough forecast products to gain a better mental model of what weather to expect along the route
    - Relying on observation information (e.g. METARs) for destination instead of the appropriate forecast products

Gap Analyses

Enroute Mental Model

Participants were tasked with identifying weather conditions in each region at the time they expect to pass through each Region.

- Region 1: includes Departure airport
- Region 6: Includes Arrival airport

Gap Analyses

How does a pilot's understanding of the weather change the further they forecast out? (Enroute)

Weather Information Representativeness and Correlations

Assisting Pilots In Identifying Weather Risks Using Cofactors When Flying in Areas Lacking an ASOS/AWOS

ICN

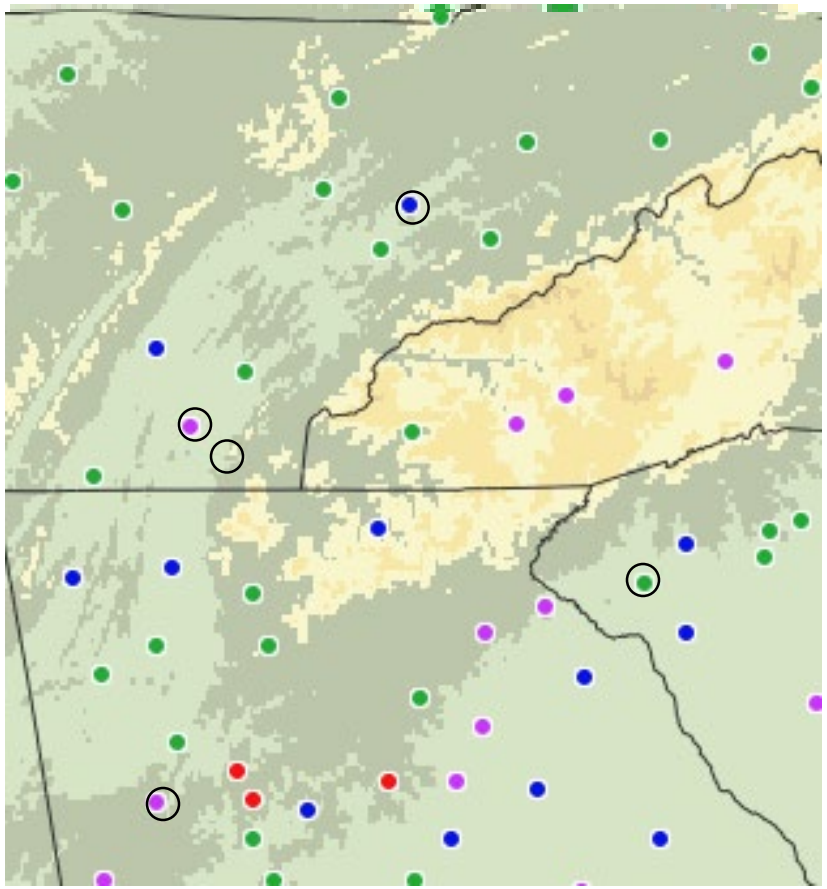
Representativeness Overview

Rotorcraft-specific weather information representativeness from sentinel cases, with growing awareness of other low altitude operations (LAO) and fixed wing considerations

- Representativeness issues
  - ASOS/AWOS altitude bias and valley vs. higher elevation weather
  - ASOS/AWOS data density and mesonet data
  - Terrain resolution and winds
  - Relative humidity representativeness
    - Leveraging ASOS ceiling information
    - Association of obscurations and dew point depression
  - Observed rotorcraft proximity to weather stations and climate zone transitions

Representativeness Overview

- Correlation of Weather Observations
  - The degree we can expect that two locations will have similar weather conditions. This can also be thought of as agreement or association.
  - It is expected that the farther two locations are from each other the higher the probability they will not be correlated.
  - The correlation between locations can be influenced by other factors besides spatial separation (such as topography) and can change in seasonally.
  - This concept of correlation can help establish risk at locations of unknown weather.

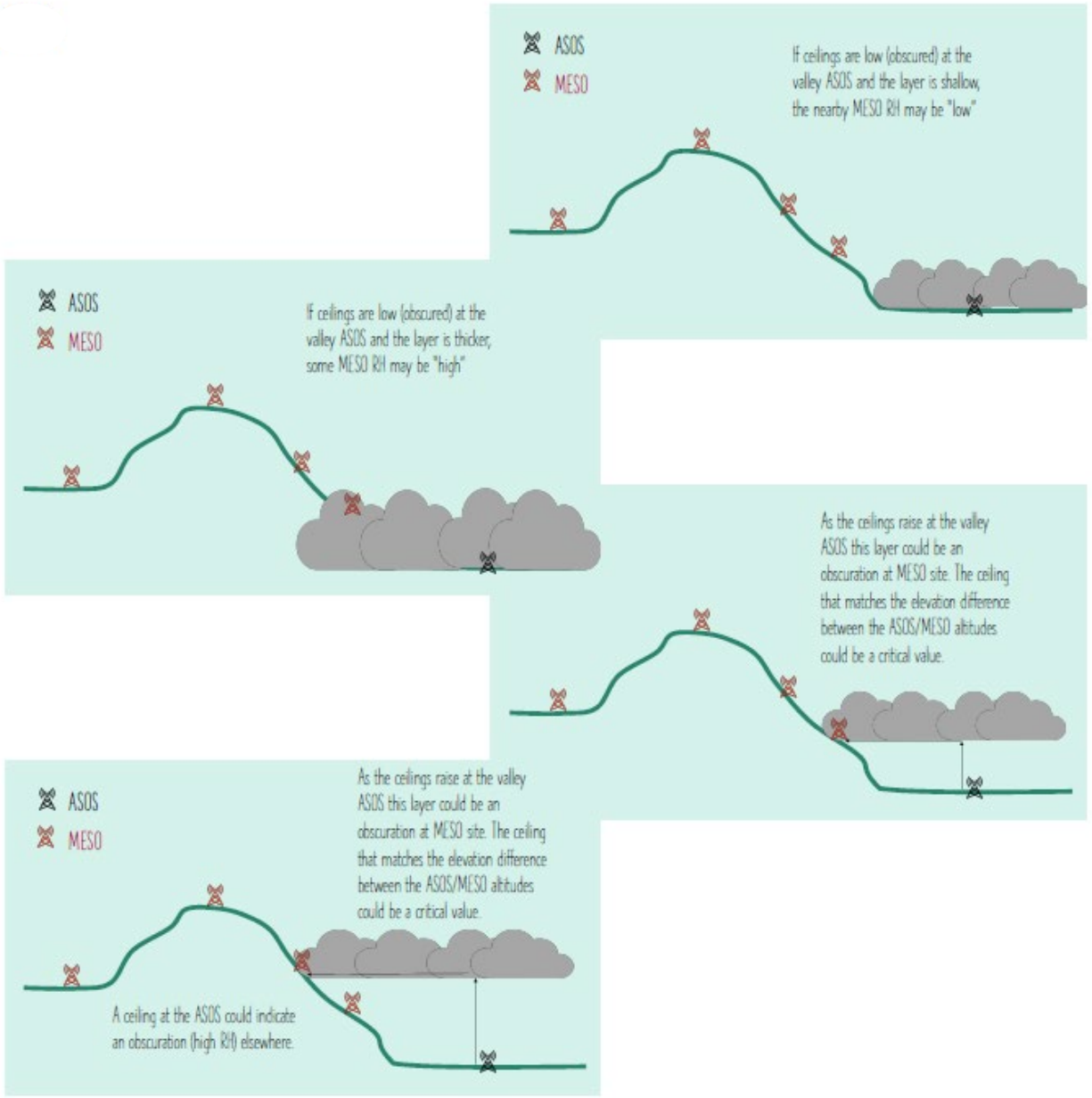


Mesonet RH Representativeness

ASOS/AWOS are typically in the low-lying areas or valleys

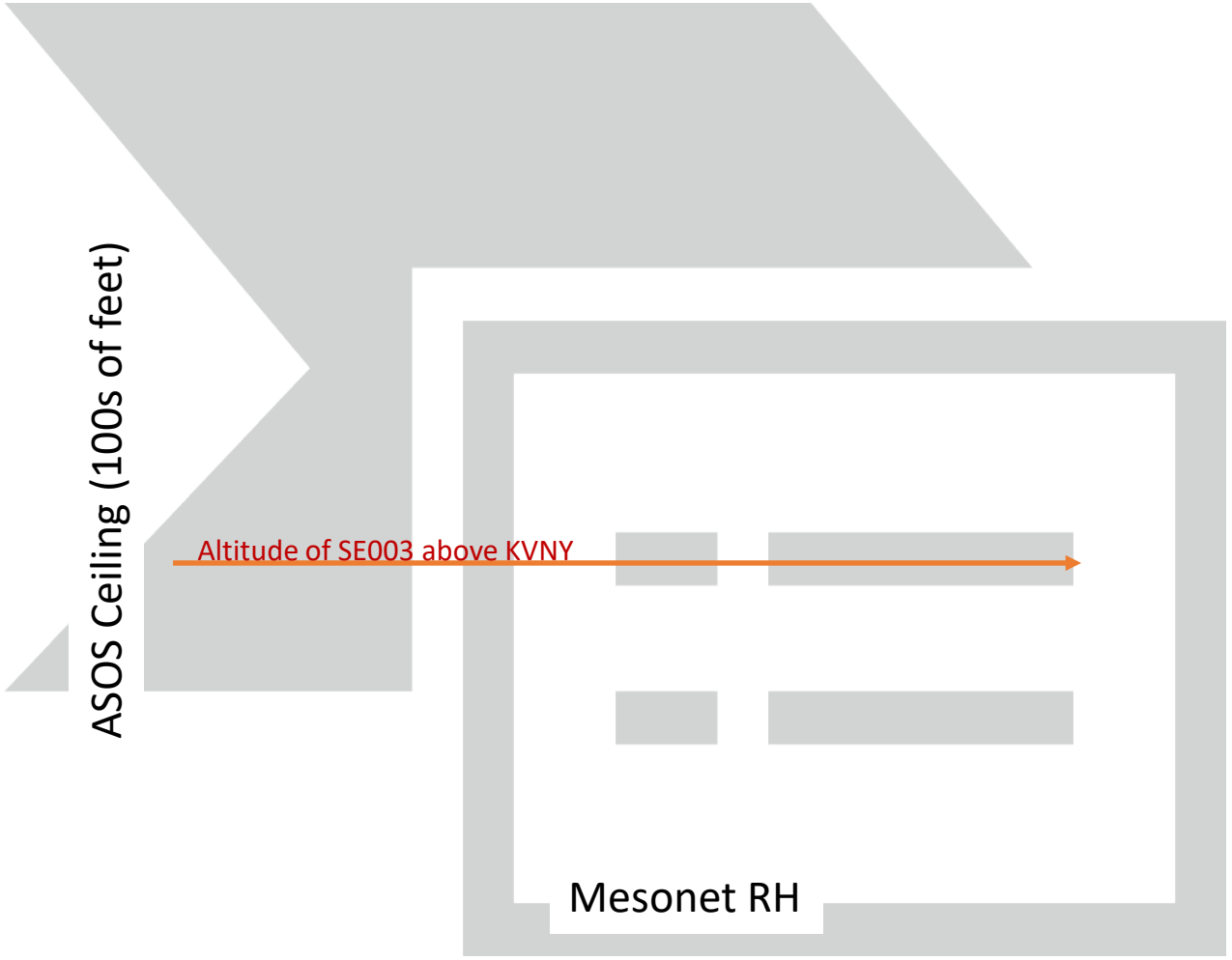
When there are low clouds or obscurations at low altitude mesonet stations at higher altitude be at lower relative humidity.

As cloud layers rise with respect to the valley, mesonet stations at higher altitude may get into “weather” and the relative humidity increases while decreasing at the valley floor.



Mesonet RH Representativeness

- As ceilings rise to near the mesonet station altitude the RH in very small and values are near saturation indicative of the mesonet station being in or near the cloud obscuration.
- The combination of RH information from the mesonet site and the ceiling from the nearby ASOS provide a more confident indication of obscuration at the mesonet site than just using relative humidity alone.



Mesonet RH Representativeness

Note: at some distance away KVNY the ceilings/clouds at KNVY won't be representative of conditions at a mesonet site. This distance may be very different than that for other meteorological variables.

Dew Point Depression and Weather

Calabasas, CA

- Dew point depressions thresholds are shown to have a relatively high number of non-occurrences of fog and mist (false alarms).
- The low-resolution dew point depression based on the temperatures to the nearest whole degree performs more poorly than that based on the higher resolution temperature that can be reported in the hourly METAR. The dew point depression based on the higher resolution temperature provides better resolution to the analysis and is recommended for use.
- Implications for general aviation training.
- This study indicates the importance of exploiting additional information to mesonet relative humidity in the context of providing advisory information pertaining to the potential for obscurations.

WEATHER: FOG TALK
AOPA, MARCH 1, 2021

But the more you fly, the more you'll realize the importance of this term. Think of the dew point as a kind of threshold for fog formation. When the air temperature drops to within 5 or so degrees Fahrenheit (or about 2 degrees Celsius) of the dew point, fog is likely. So, when you hear someone say that there's a close temperature-dew point "spread," you'll know what they mean. And when you hear that the temperature and dew point are "on top of each other," you'll know that the temperature and dew point are the same. At times like that, it's almost guaranteed that fog—or some form of precipitation—is present.

PILOTS HANDBOOK OF AERONAUTICAL KNOWLEDGE

Temperature/Dew Point Relationship

The relationship between dew point and temperature defines the concept of relative humidity. The dew point, given in degrees, is the temperature at which the air can hold no more moisture. When the temperature of the air is reduced to the dew point, the air is completely saturated and moisture begins to condense out of the air in the form of fog, dew, frost, clouds, rain, hail, or snow.

Dew Point Depression and Weather

Calabasas, CA

- How well does dew point depression (DPD) track with “weather” (in this case FG/BR)
  - False alarm rate (FAR)

DPD	NO FG/BR	FG/BR	%FG/BR	RH Range	FAR
0	330	27	7.56	100%	0.92436975
1	1492	2631	63.81	94%	0.36187242
2	8550	5586	39.52	87%-89%	0.60483871
3	21620	1520	6.57	82%-83%	0.93431288
4	21723	28	0.13	76%-79%	0.9987127
5	19733	12	0.06	71%-74%	0.99939225
6	15931	4	0.03	67%-70%	0.99974898
7	14500	4	0.03	62%-65%	0.99972421

KVNY **Low Resolution** Dew Point Depression and Fog or Mist during December, January and February

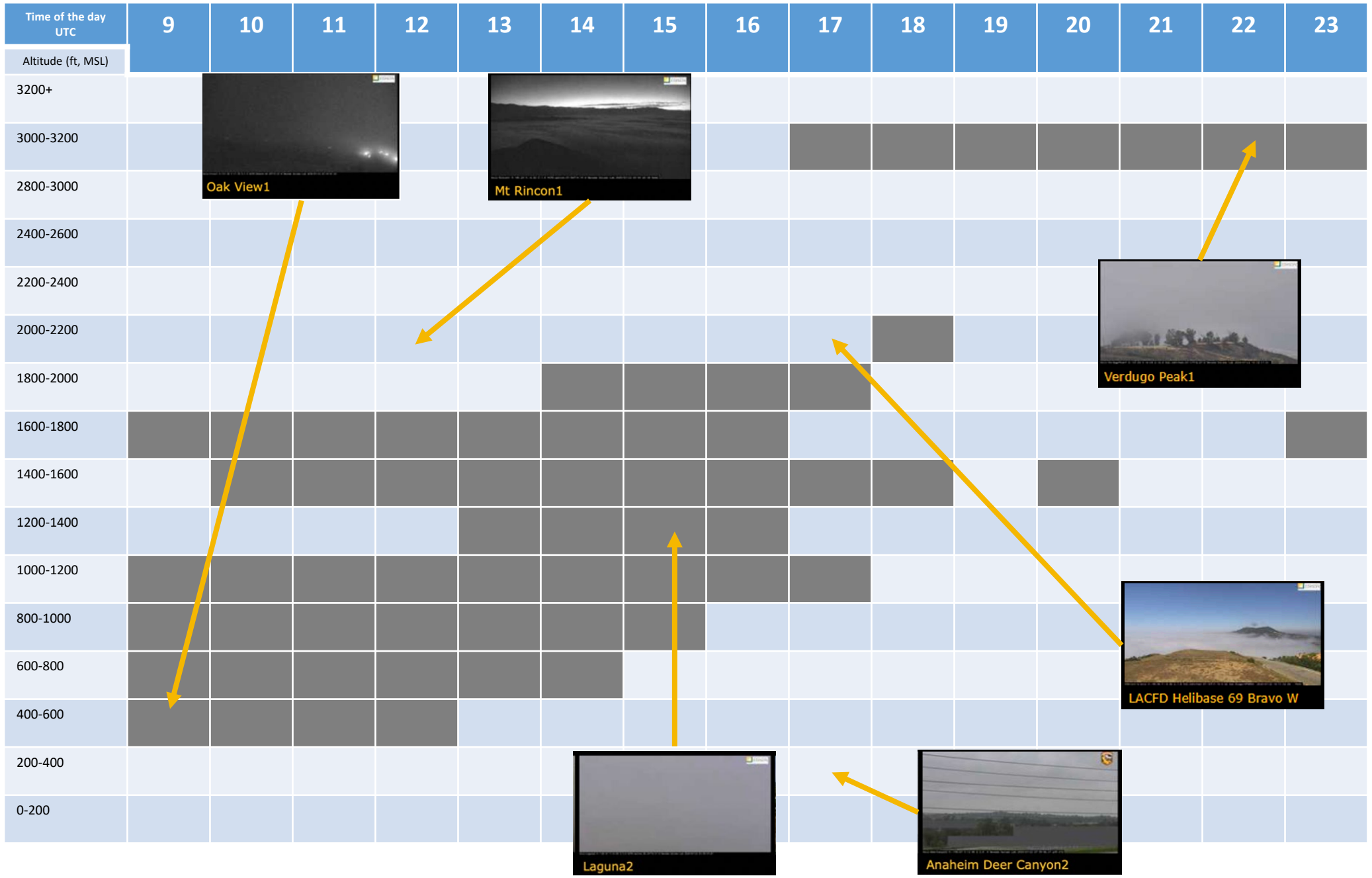
DPD HIRES	NO FG/BR	FG/BR	%FG/BR	RH Range	FAR
0	0	21	100.00	100%	0
1	709	1081	60.39	94%	0.39608939
2	5666	3993	41.34	87%-89%	0.58660317
3	15187	15	0.10	82%-83%	0.99901329
4	11409	11	0.10	76%-79%	0.99903678
5	9076	3	0.03	71%-74%	0.99966957
6	10368	2	0.02	67%-70%	0.99980714
7	9602	0	0.00	62%-65%	1

KVNY **High Resolution** Dew Point Depression and Fog or Mist during December, January and February

Skyreps

Skyrep Prototype Overview

- A Skyrep is a PIREP-like sky condition report
- Use imagery from the ALERTWildfire camera network in real-time; focus on coastal Southern California stratus/fog events
- Post-analysis of the imagery provided estimates of cloud base and height by assessing the vertical continuity of obscurations (SKYREP)
- Comparison to available pilot reports (PIREPs) indicated this prototype has potential to validate PIREP cloud base-top reports
- May provide independent PIREP-like observations of clouds or other obscurations where camera observations are of sufficient density
- SKYREPs could provide cloud base/top information for day and night operations, including regions where few PIREPs are available

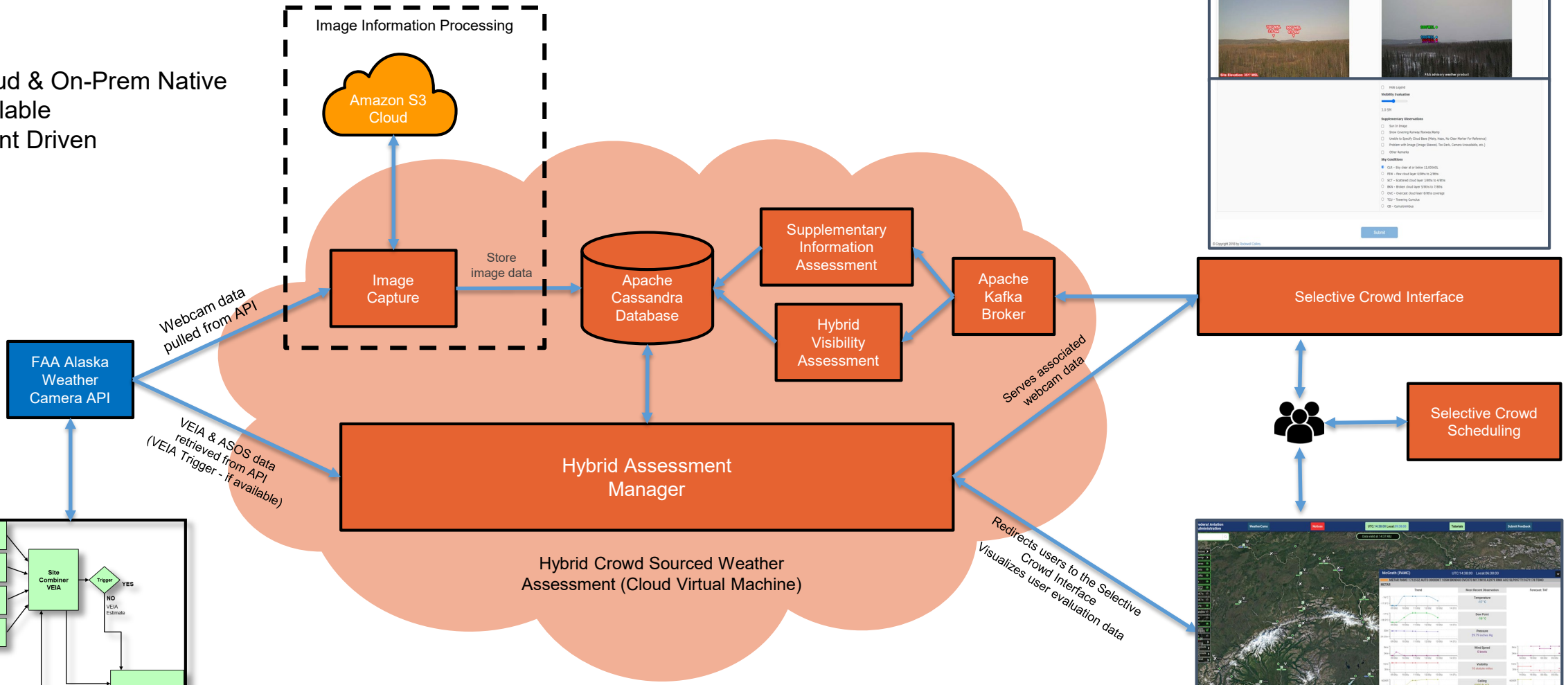


July 22, 2020 ”June Gloom” Fog/Stratus Event

Hybrid Visibility – Crowd Sourcing and Edge Detection

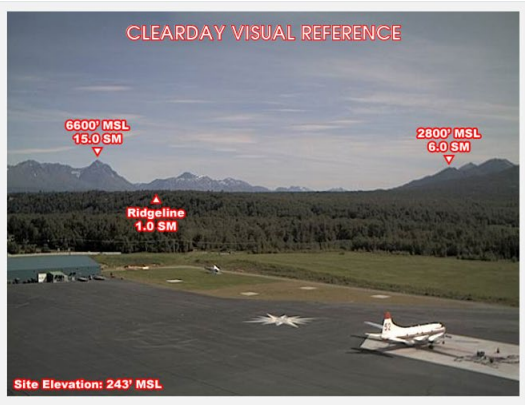
Hybrid Evaluation Prototype Architecture

- Cloud & On-Prem Native
- Scalable
- Event Driven



VEIA Camera Automated Processing (e.g. MIT/LL)

Visibility in Agreement with ASOS



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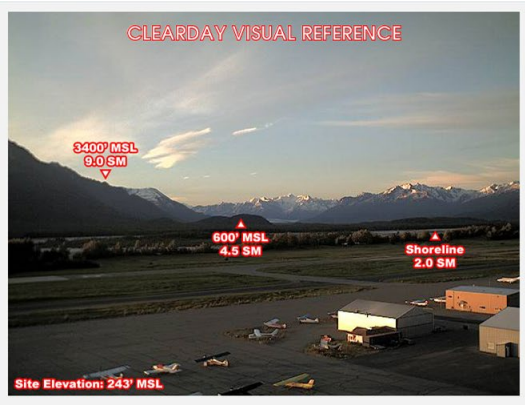

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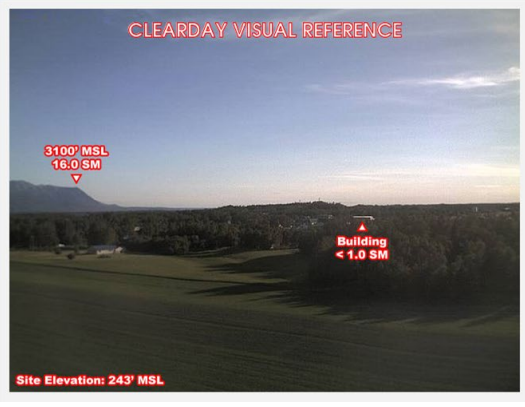

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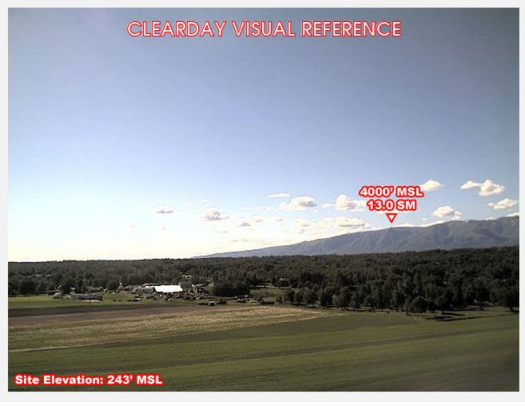

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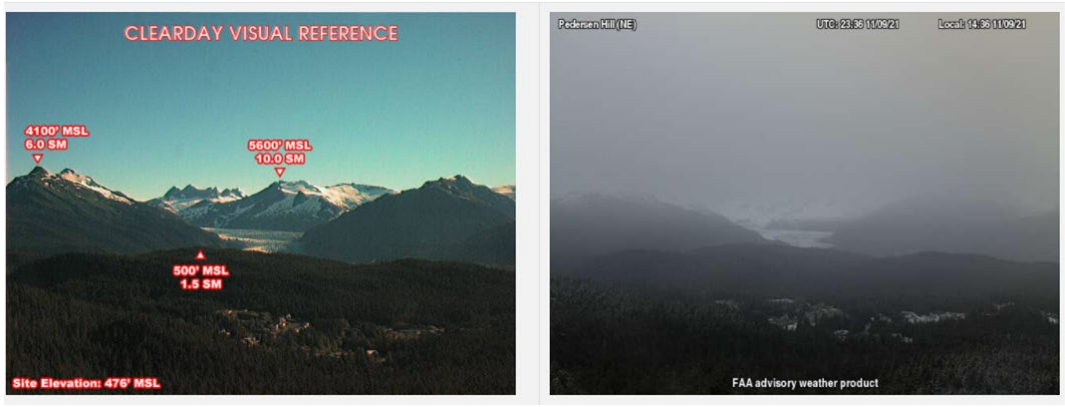
ASOS Visibility:
0.25 (LIFR)

ASOS Ceiling:
200 (LIFR)

Crowd
Visibility(Average):
0.25 (LIFR)

VEIA Visibility:
0.125 (LIFR)

Visibility in Agreement with ASOS



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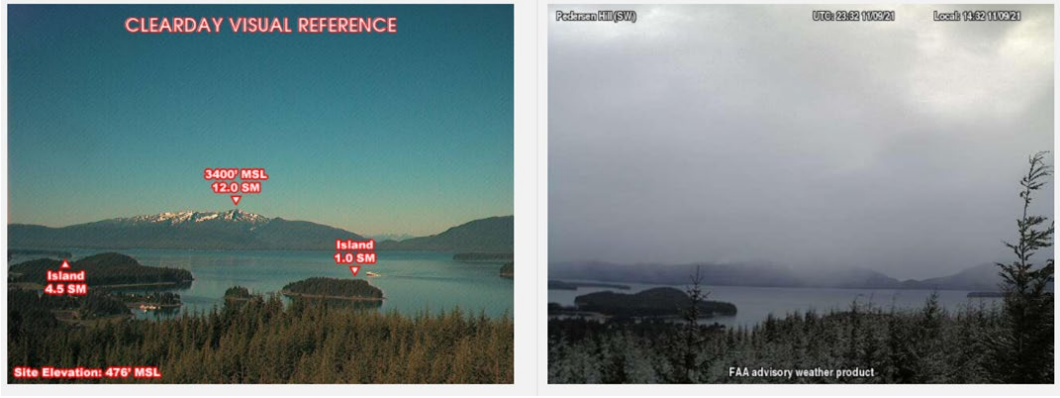
(Crowd Visibility: 5.0 - MVFR/VFR)



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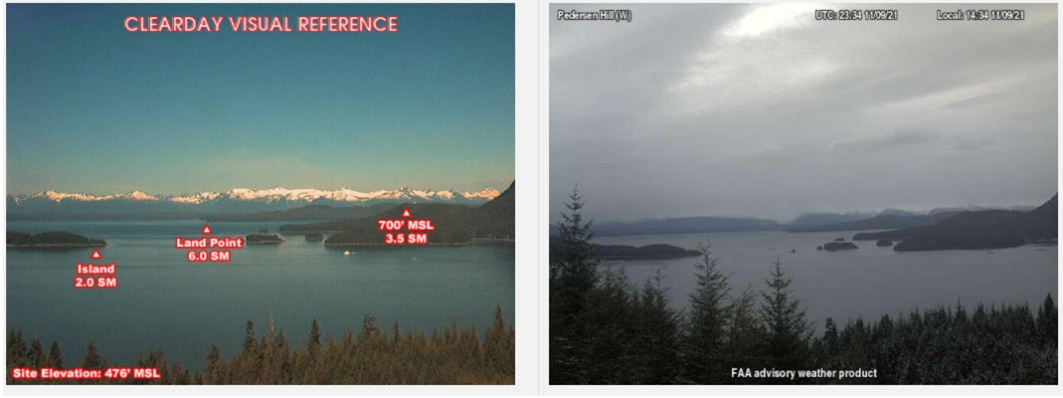

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(Crowd Visibility: 8.5 - VFR)

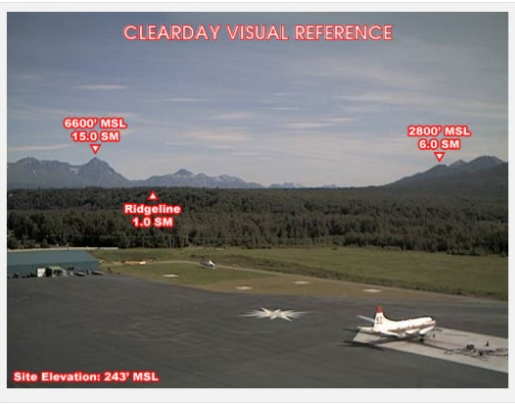
ASOS Visibility: 10.0 (VFR)

ASOS Ceiling: 6000 (VFR)

Crowd Visibility(Average): 7.125 (VFR)

VEIA Visibility: 3.0 (IFR/MVFR)

Visibility in Disagreement with ASOS



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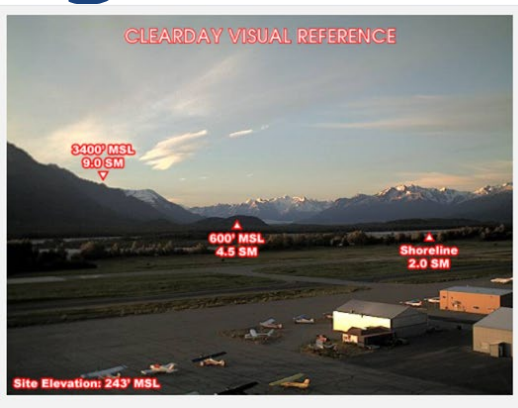

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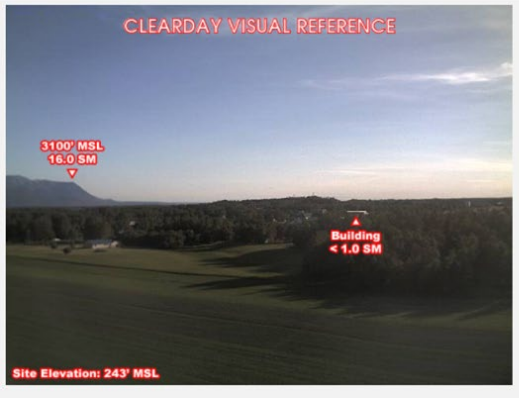

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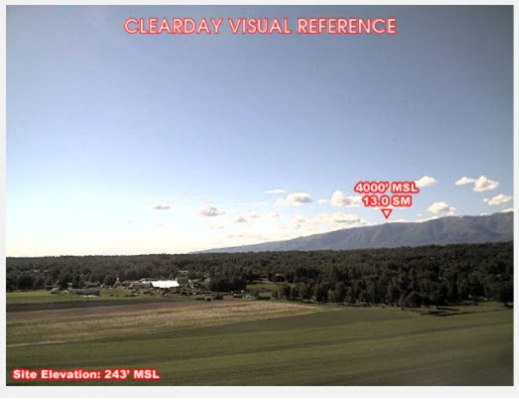

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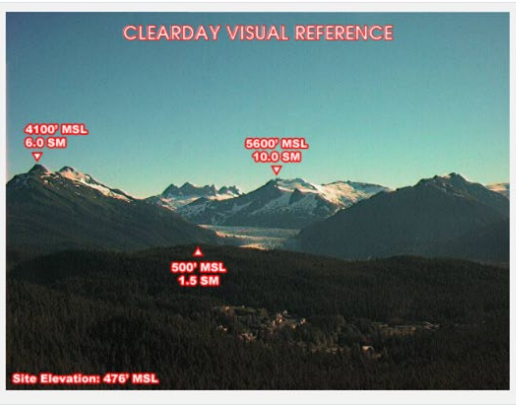
ASOS Visibility:
10.0 (VFR)

ASOS Ceiling:
400 (LIFR)

Crowd
Visibility(Average):
1.25 (IFR)

VEIA Visibility:
4.0 (MVFR)

Visibility in Disagreement with ASOS



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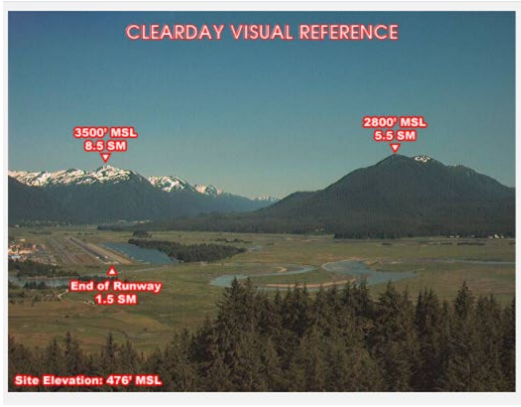

Chip ID: 10018-1635270431
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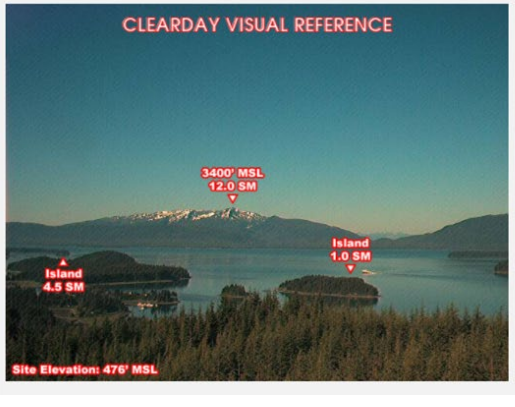
ASOS Visibility: 10.0 (VFR)

ASOS Ceiling: N/A

Crowd Visibility(Average): 0.25 (LIFR)

VEIA Visibility: 0.75 (LIFR)



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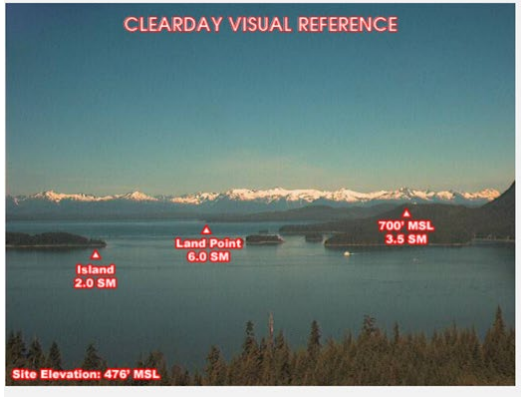

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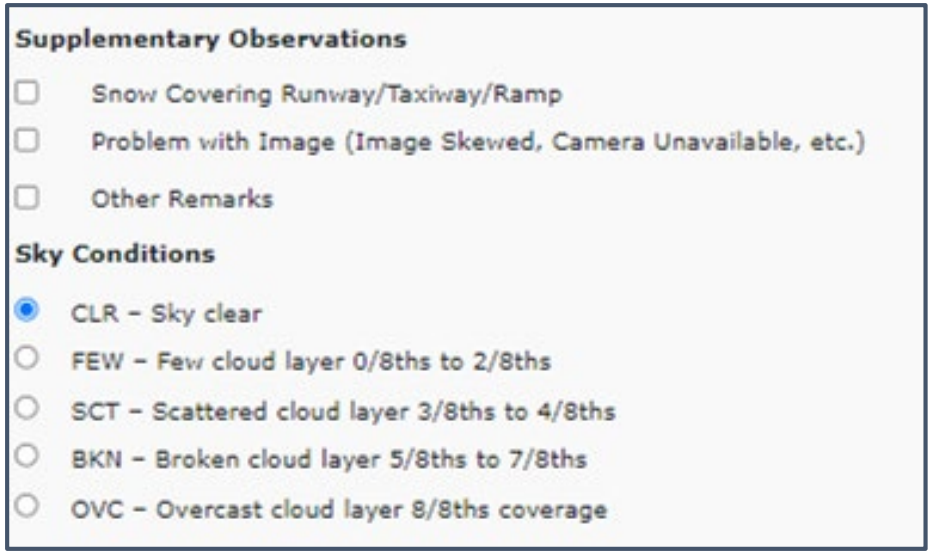
(Crowd Visibility: 0.25 - LIFR)

Aggregate Site Statistics

- ASOS vs crowd differences based on flight rule categories:
  - 0 category difference (same flight rule between crowd and ASOS): 67.05%
  - 1 category difference: 16.47%
  - 2 category difference: 12.79%
  - 3 category difference: 3.68%
- Aggregate statistics based on visibility values produced by the crowd and ASOS:
  - Mean ASOS Assessment: 8.10
  - Median ASOS Assessment: 10.0
  - Mean Crowd Assessment: 6.52
  - Median Crowd Assessment: 7.5

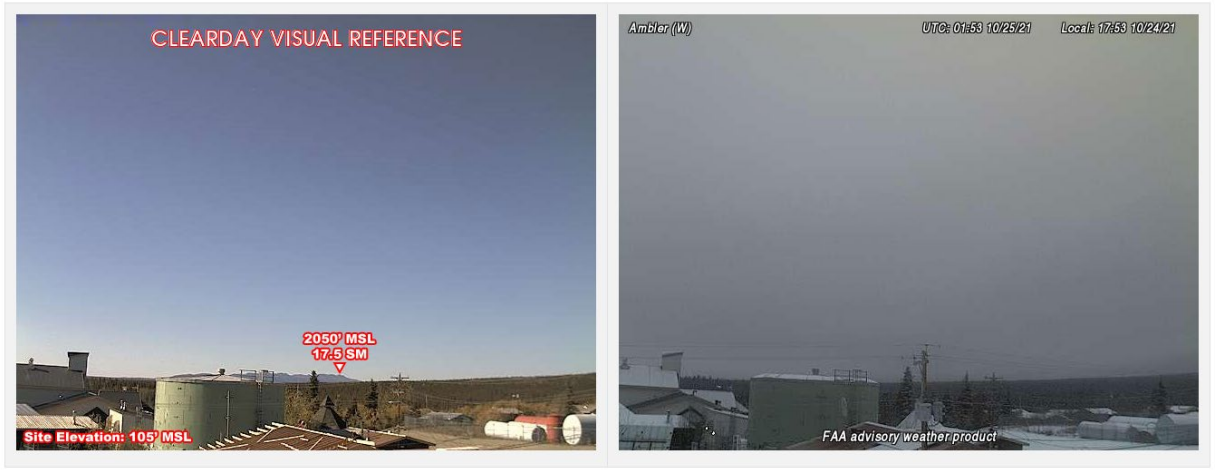
Crowd Sourcing Supplemental Information

Supplemental visibility-related information, in addition to the visibility measure, can be input into the hybrid system to assist pilots and to improve the edge detection's capabilities?

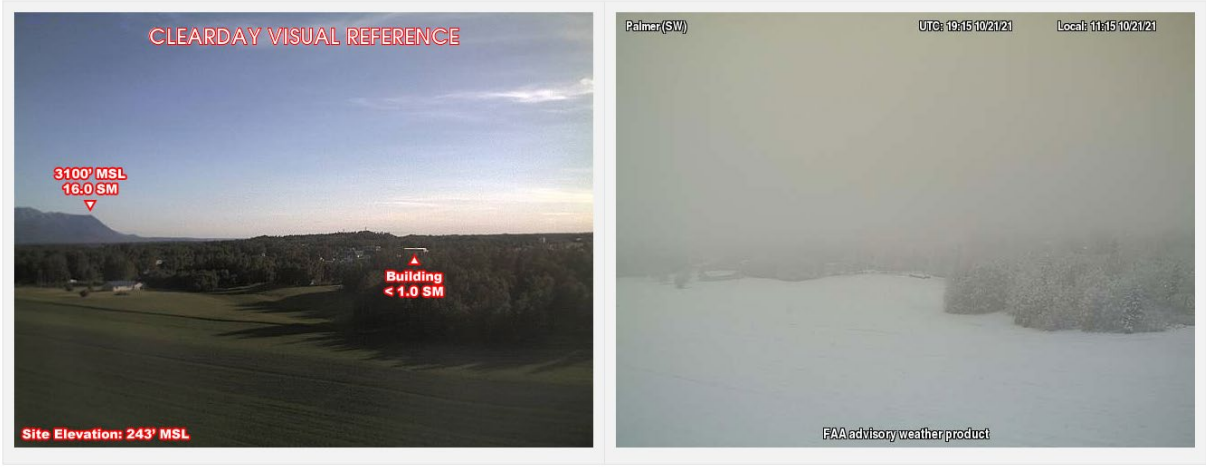


Supplementary Information Collected

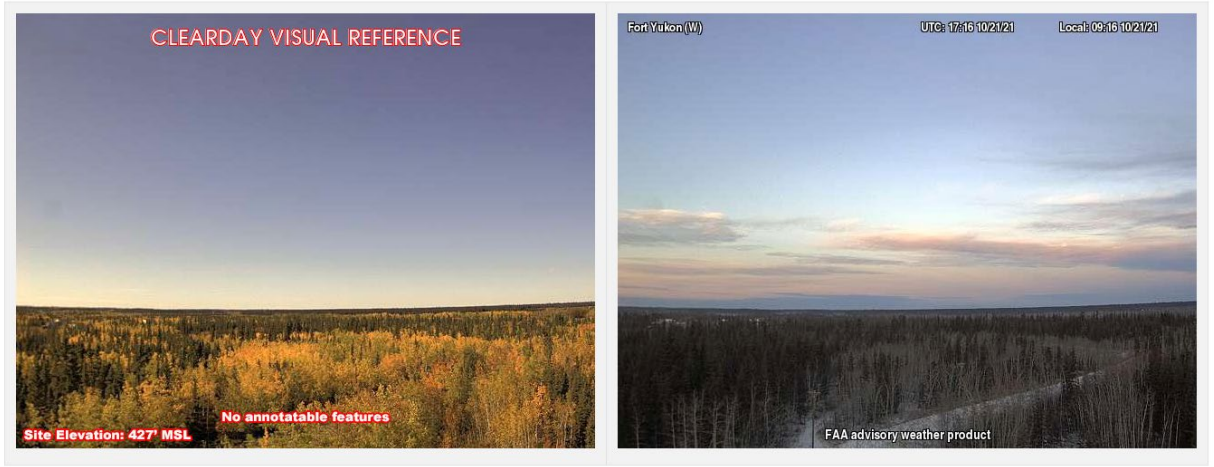
Besides visibility, collect information on potential issues with a camera, cloud cover, snow on runways, and other remarks. Examples of supplementary information are:



Overcast sky cover



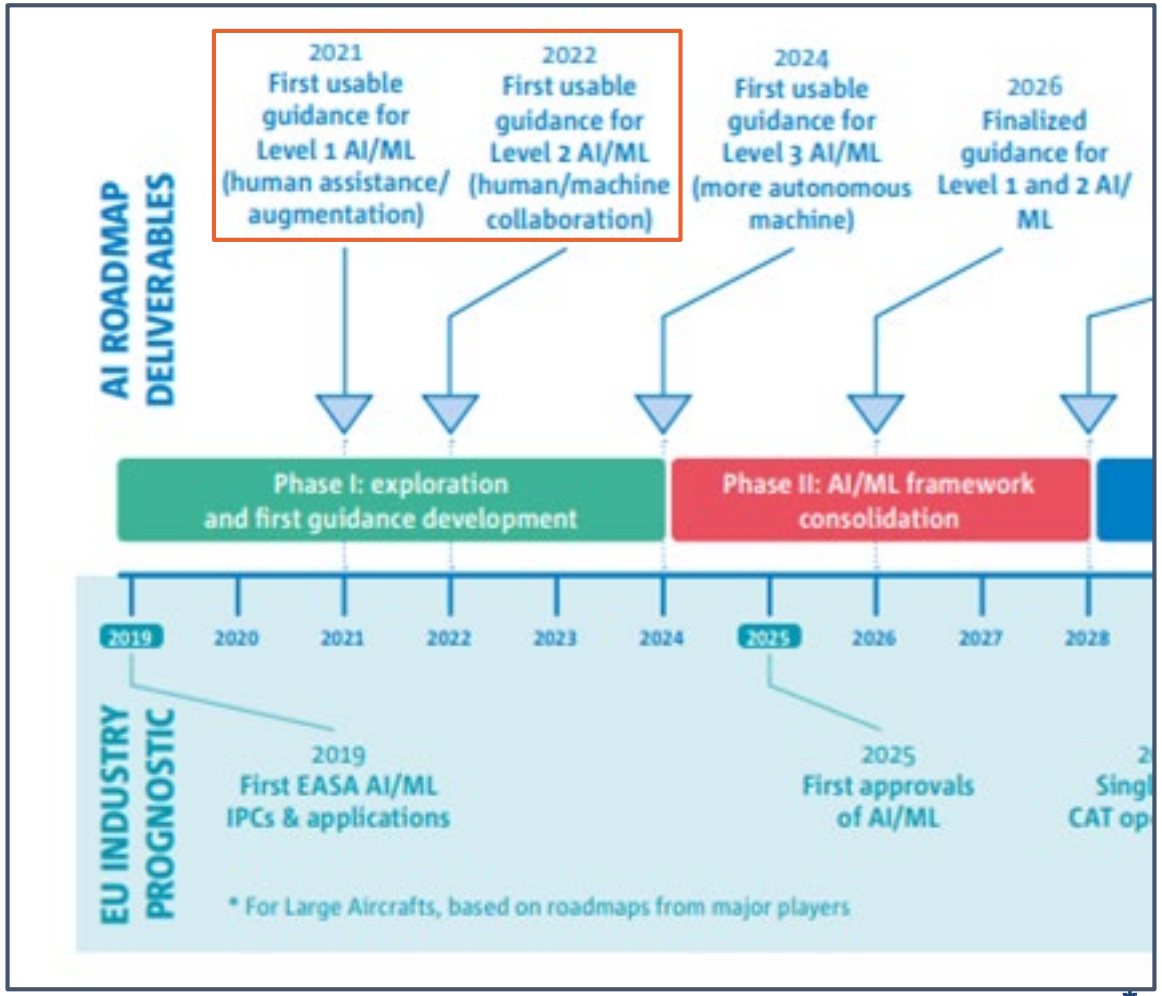
Snow covering runway



Scattered sky cover

Crowdsourcing in Validation Efforts

- Based on documents provided by EASA's AI roadmap and its deliverables, the need for human assistance or collaboration in AI/ML systems is required for certification approval in any productionized environment.
- This crowdsourcing effort is an example and use case of validation for supporting automated systems.
- EASA AI/ML Guidance Reports:
  - EASA Artificial Intelligence Roadmap 1.0
  - EASA Concepts of Design Assurance for Neural Networks (CoDANN)
  - EASA Concepts of Design Assurance for Neural Networks (CoDANN) II
  - AVSI - AFE 87 – Machine Learning
  - EASA Concept Paper First usable guidance for Level 1 machine learning applications



Convergence of Projects – Long Term Plan

Using New and Existing Observations

- Cockpit Automation (**future goal**) - General Overview
  - Use dissimilar observations and crowd sourcing algorithms for a quality metric
  - Use strengths of each observation source to enhance confidence/quality
  - Use historical data to identify trends, such as decorrelation, to support notification issuance for atypical Wx conditions and rapidly changing Wx
  - Voice recognition to request weather information
  - Goal is to automate advisory responses to weather questions to cross check pilot assessments of weather conditions
  - Include design elements to aide in building pilot confidence – understand automation, monitor quality of input data
  - Format outputs to support various air and ground use