Weather Technology in the Cockpit (WTIC) Program – Applying Cloud Technology and Crowd Sourcing to Enhance Cockpit Weather

Friends and Partners of Aviation Weather Summer Meeting

Date: August 26, 2015

What Is Crowd Sourcing?

- **The term is used for 2 broad concepts**
  1. Crowd as Processor: Enlisting the contributions of a large number of networked participants in solving problems for which human intelligence performs better than automation
     a) **Volunteers** with an interest in the problem being solved
     b) **Inadvertent "Volunteers"** who perform the desired task for their own purposes (e.g., the "CAPTCHA's" used on web sites to verify that they are being accessed by humans)
     c) **Persons paid** a small amount per decision to perform the task (e.g., the Amazon Mechanical Turk web service)
  2. Crowd as Sensor: Gathering anonymous data from a large number of networked platforms for (e.g., inferring city traffic congestion from cell phone tracking data)
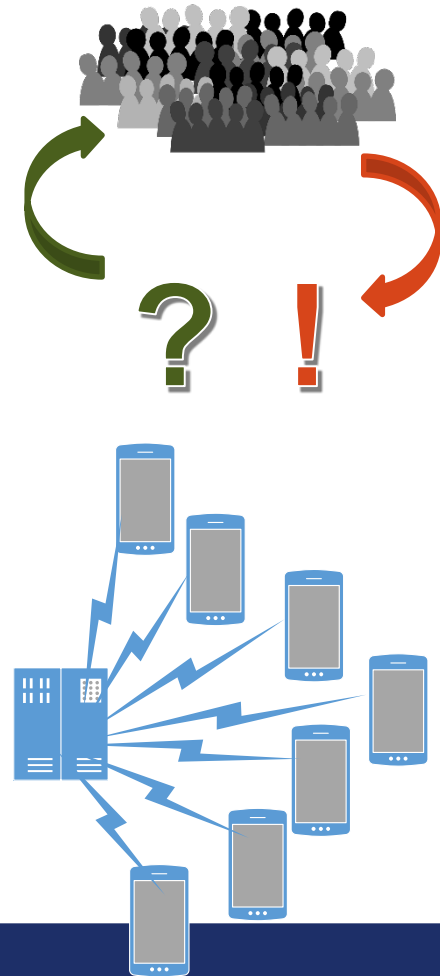
What is Cloud Computing

- **Cloud computing is a resource sharing strategy**
  - Infrastructure, a group of servers and software networks, is provided as a utility
  - Services are built on top of this network
  - Structured so that services are not dependent upon the structure of the network
  - End users see only the service interface with no insight into the underlying structure

- **Buy just the service needed**

- **Data safely stored across multiple sites and servers**

- **Supports "big data" applications**
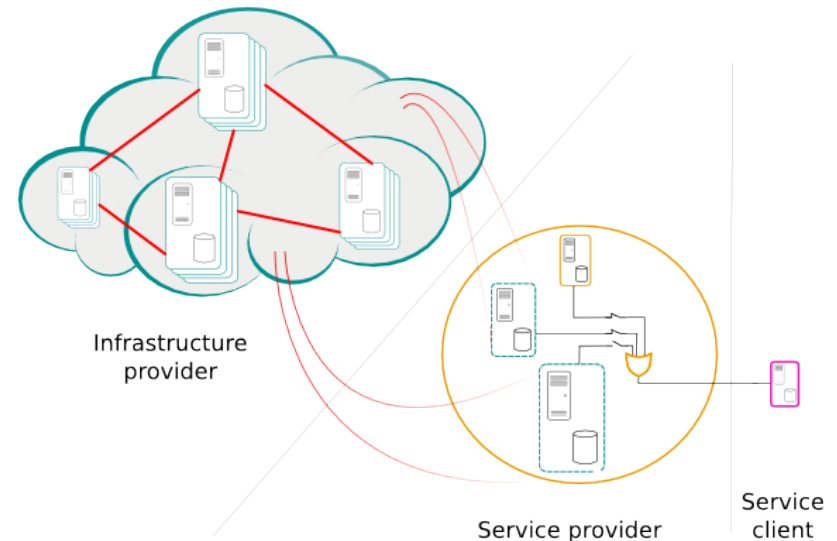
"Cloud Computing" by Davide Lamanna - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons -

Crowd as Processor Techniques for Aviation

- **Good for tasks that benefit from human judgement and flexibility**
  - Evaluating images
  - Interpreting unconstrained text
- **Analyze web camera images to provide summary visibility data with trending**
  - Alaska Cameras
  - Helicopter Emergency Medical Services
  - Oil Platforms
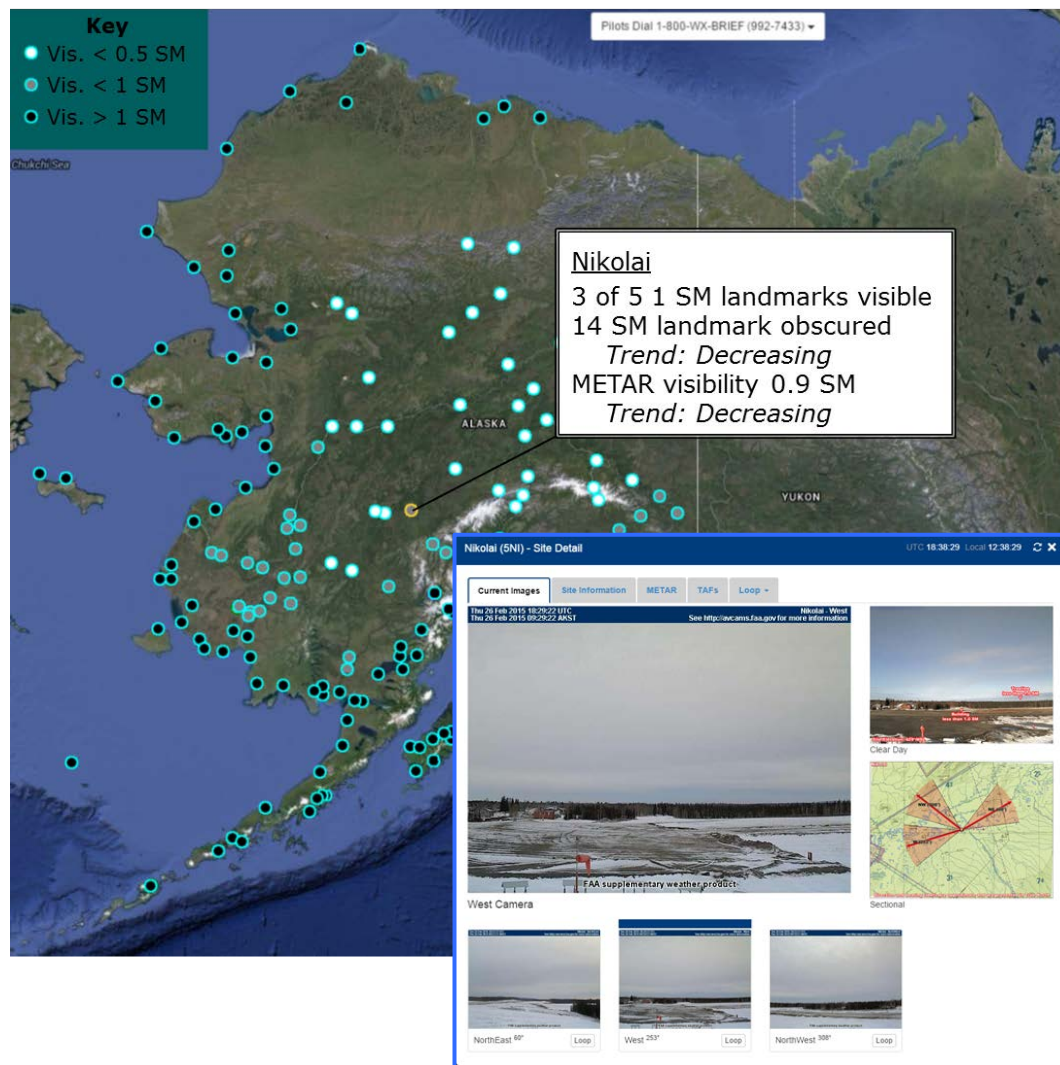
Crowd as Sensor Techniques for Aviation

- **Smart phones can sense air pressure, acceleration, humidity, magnetic field, temperature**
  - Phone users can volunteer observations
    - mPing app by NOAA/NSSL similarly solicits observations from "weather geeks"
  - Data can be gathered by apps providing services to the user
    - Google's crowd-source of auto traffic

Gives access to a much larger volume of data than a fixed sensor network could provide

Crowd as Sensor Techniques (Aircraft)

- **Aircraft can and do serve as sensor platforms**
  - This is already done with programs like MDCRS/AMDAR
  - Data can also be gathered through streams like ASDI
  - This capability will be enhanced as ADS-B is enhanced

- To improve prediction of trajectories
  - Wind Speed
  - Wind Direction
  - A/C Weight
  - A/C Configuration
  - Pressure Altitude

- To improve atmospheric models
  - Wind Speed
  - Wind Direction
  - Static Temperature
  - Static Barometric Pressure
  - Humidity
  - Eddy Dissipation Rate

- To improve hazardous weather awareness
  - Turbulence
  - Icing
  - Wake Vortex
  - Windshear
  - Microburst

Where is there advantage in using crowd/cloud sourcing?

- **For cases where large numbers of human contributors are tapped to arrive at a conclusion:**
  - Amazon uses its Mechanical Turk service to catalog and compare products, and it sells the service to many other users
  - At least 200 million Captchas are decoded every day

Widely used where human recognition capability exceeds that of computers
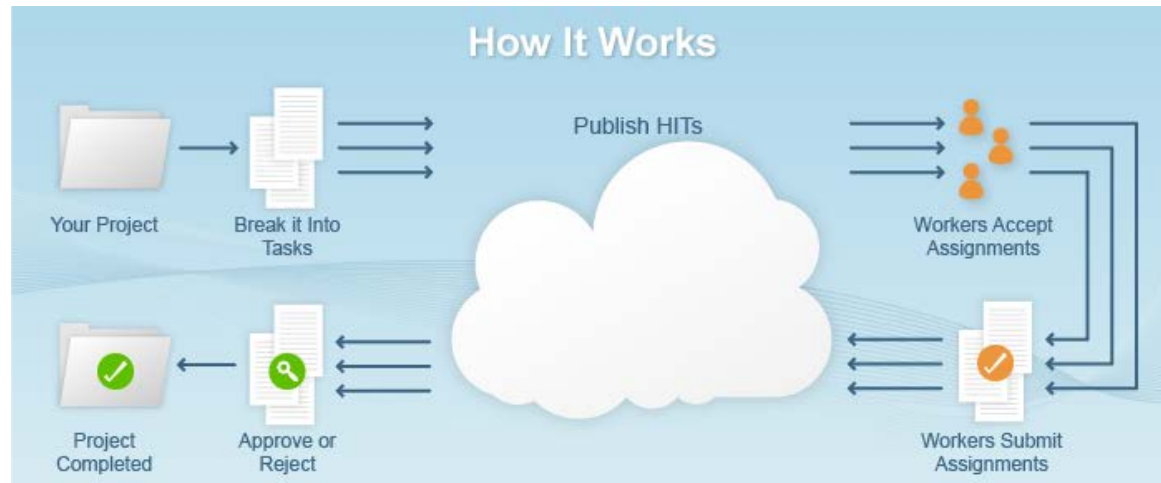
Where is there advantage in using crowd/cloud sourcing?

- **For cases where data drawn from existing sources (e.g., cell phones) is used for new purposes (e.g., Google Maps traffic mapping)**
  - The alternative is creation of large-scale infrastructure, which would be prohibitively expensive
  - Or, the crowd-sourced data are gathered opportunistically to provide information to provide finer grained information than existing systems
- **The advantages of cloud computing are in**
  - Buying only the computing resources needed at any given time
  - Distributed redundant storage of data to avoid catastrophic loss
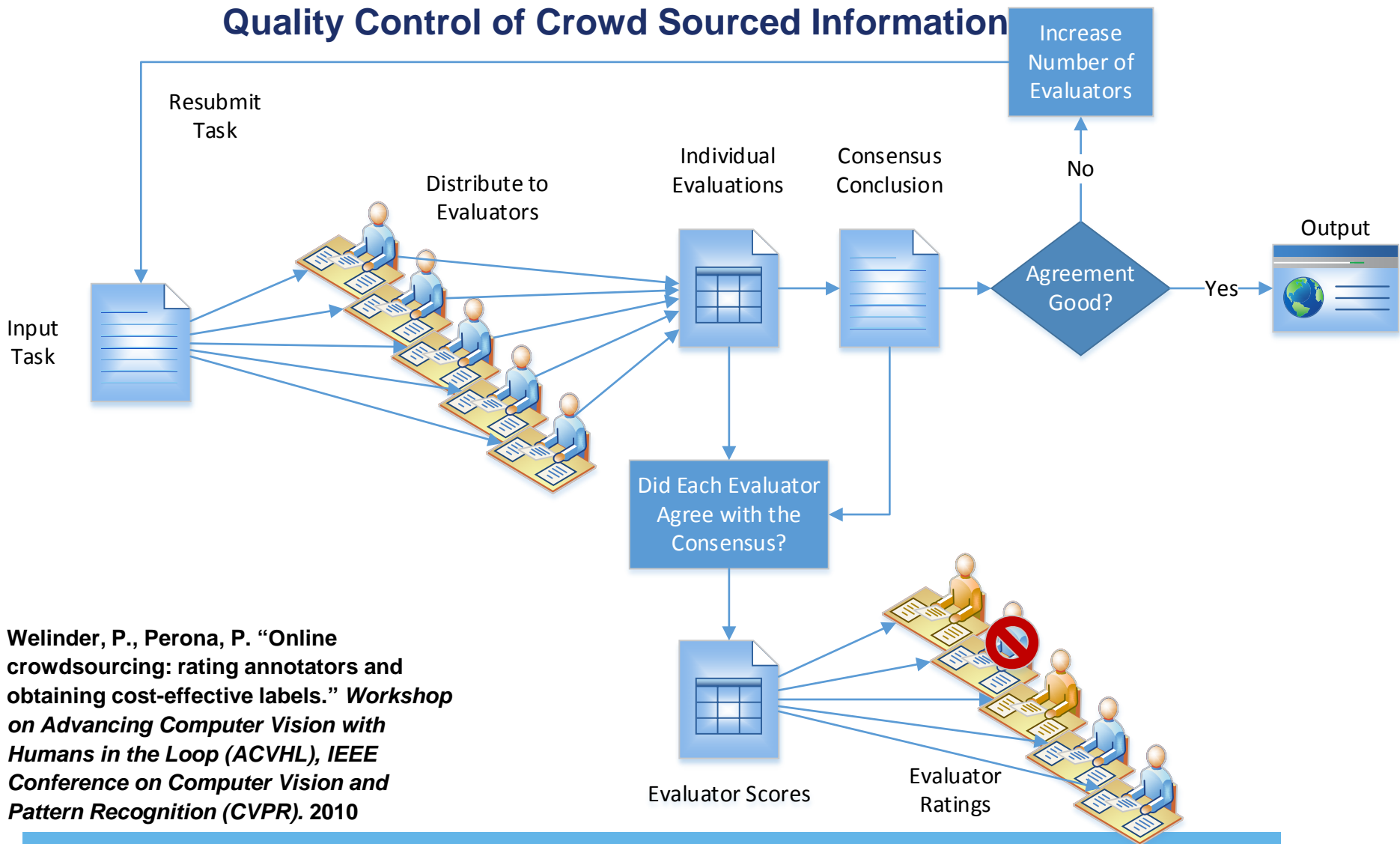 - Sharing the costs of desired redundancy across many users

Crowd Sourcing Service Example

- **The most well-known example of crowd sourcing service is Amazon's Mechanical Turk Service, which advertises:**
    - Access more than 500,000 Workers from 190 countries worldwide
    - Workers have a variety of skill sets and capabilities
    - Scale up and down in minutes
    - Amazon Mechanical Turk provides mechanisms to help you receive accurate results on *Human Intelligence Tasks* (HITs) .
        - Send your exclusively to Mechanical Turk Masters, who have proven accuracy in specific types of HITs.
        - You can also use one of the System Qualifications provided by Mechanical Turk, such as location or approval rating, or create your own custom Qualification.

    - You decide how much to pay
    - Pay only when you're satisfied with the work.
    - Amazon Mechanical Turk collects a 10% commission on top of the reward amount you set for Workers.

How It Works

Your Project → Break it Into Tasks → Publish HITs → Workers Accept Assignments → Workers Submit Assignments → Approve or Reject → Project Completed

Quality Control of Crowd Sourced Information

Resubmit Task

Distribute to Evaluators

Individual Evaluations

Consensus Conclusion

Increase Number of Evaluators

No

Output

Agreement Good?

Yes

Input Task

Did Each Evaluator Agree with the Consensus?

Welinder, P., Perona, P. "Online crowdsourcing: rating annotators and obtaining cost-effective labels." *Workshop on Advancing Computer Vision with Humans in the Loop (ACVHL), IEEE Conference on Computer Vision and Pattern Recognition (CVPR).* **2010**

Evaluator Scores

Evaluator Ratings

Effective crowd-sourcing quality control techniques are readily available

Potential QA Enhancements

- **Image processing algorithms, may complement the crowd-sourced approach with potential for:**
  - Enhanced quality assurance
  - Faster notification of weather changes
  - Increased confidence in the information
  - Higher tolerance to issues/failures (i.e. camera movement) through redundancy

Federal Aviation Administration
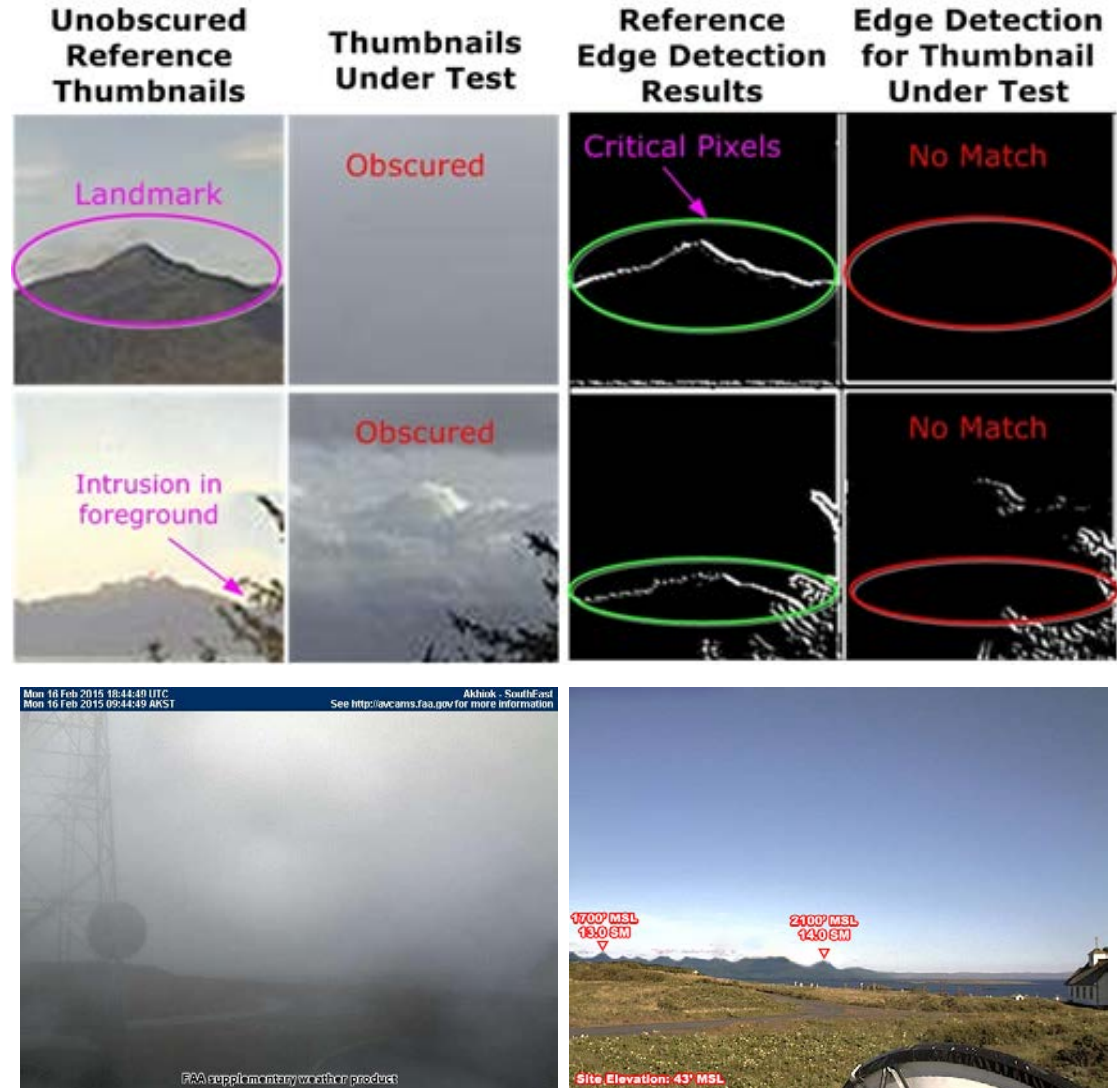
Crowd Source Possibilities

- **Weather Radar, lightning downlinked from aircraft**
- **Estimate turbulence**
  - From acceleration of multiple passenger or crew phones
- **Estimate winter runway conditions and airport facility availability**
  - From auto traffic flow around the airport
- **Detection of unusual air pressure situations**
  - From smart phone pressure sensors (on ground or in unpressurized aircraft)
- **Using smart phones as dedicated sensors enhanced with anemometer, infrared camera cell phone attachment, etc.**
- **Analyze ASDI and NWS archives to forecast airspace reaction to weather**
  - A cloud computing, big data application
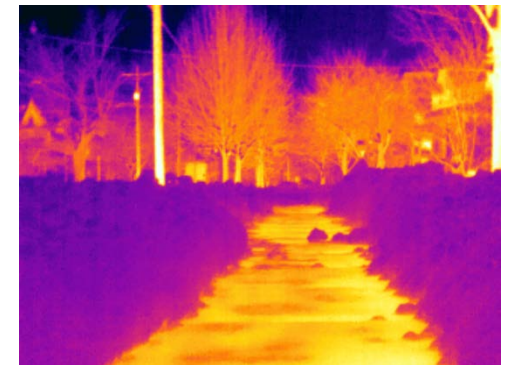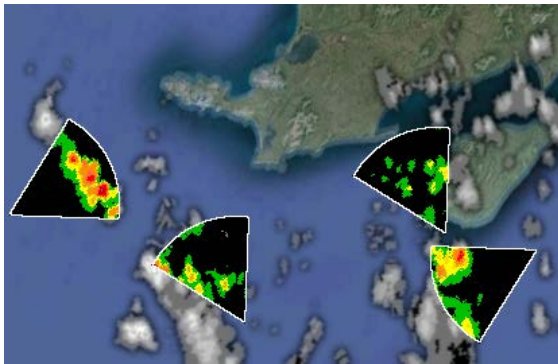
WTIC Crowd/Cloud Demonstration Plan

- **Plan**
  - Use crowd sourcing techniques and cloud technology to enhance video and still images in Alaska for access and use by General Aviation aircraft

- **Current shortfalls of existing camera data**
  - Each camera must be evaluated individually by the user
  - User must examine cameras for each potential landing site individually
  - Camera images are only available where Internet is available, limiting their utility for aircraft in flight, and bandwidth consumption is high

WTIC Cloud/Crowd Demonstration Plan
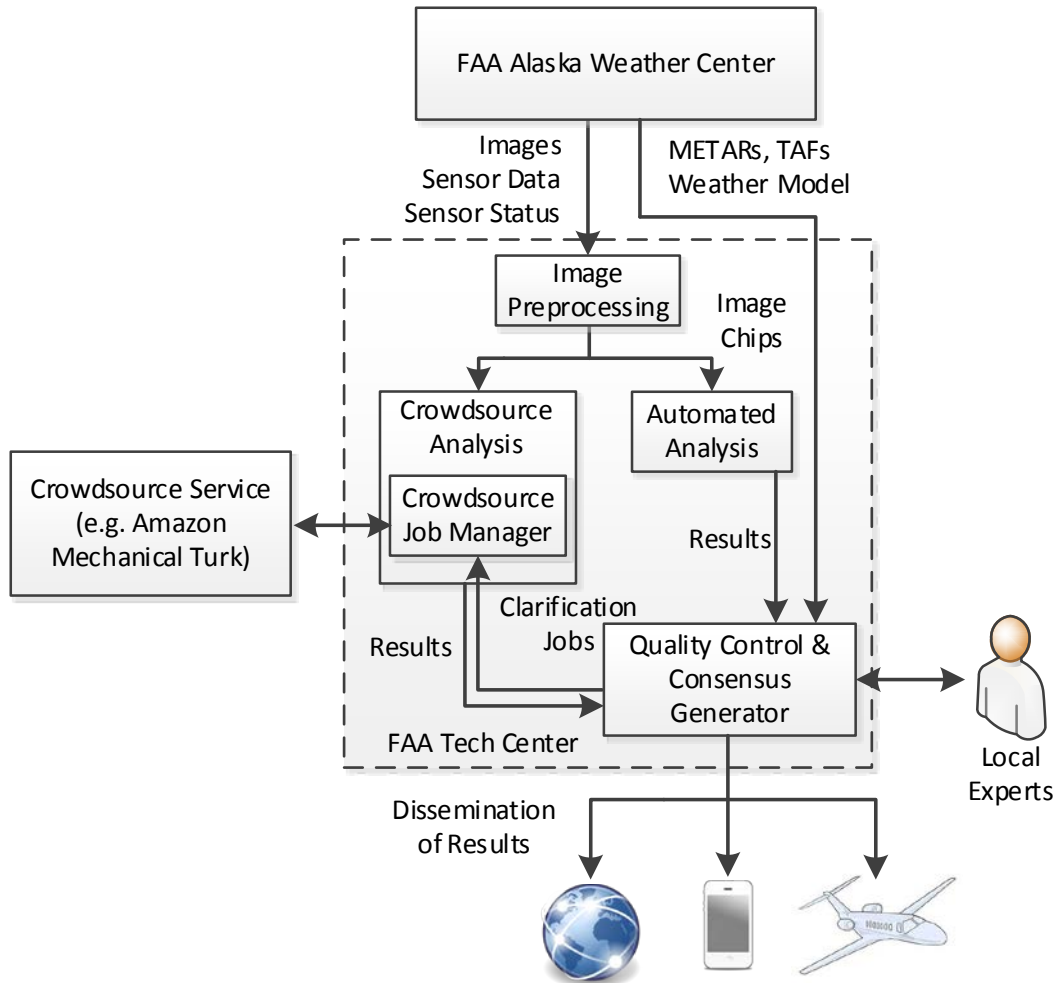
- **Goal: To demonstrate the utility and feasibility of crowd-sourced processing of Alaska camera data**
  - Minimize initial infrastructure and software development investment
  - Demonstrate crowd-sourced image evaluation
  - Implement prototype quality control
    - Via crowd-source statistics
    - Via comparison to image processing results

Current Alaska Webcam Image

Reference Image (with visibility cues)

Current Image (10 min. Update)

Camera Orientations

Notional Crowd Sourced Output of Images

Key
- Vis. < 0.5 SM
- Vis. < 1 SM
- Vis. > 1 SM

Pilots Dial 1-800-WX-BRIEF (992-7433) ▾

Nikolai

3 of 5 1 SM landmarks visible
14 SM landmark obscured
    Trend: Decreasing
METAR visibility 0.9 SM
    Trend: Decreasing
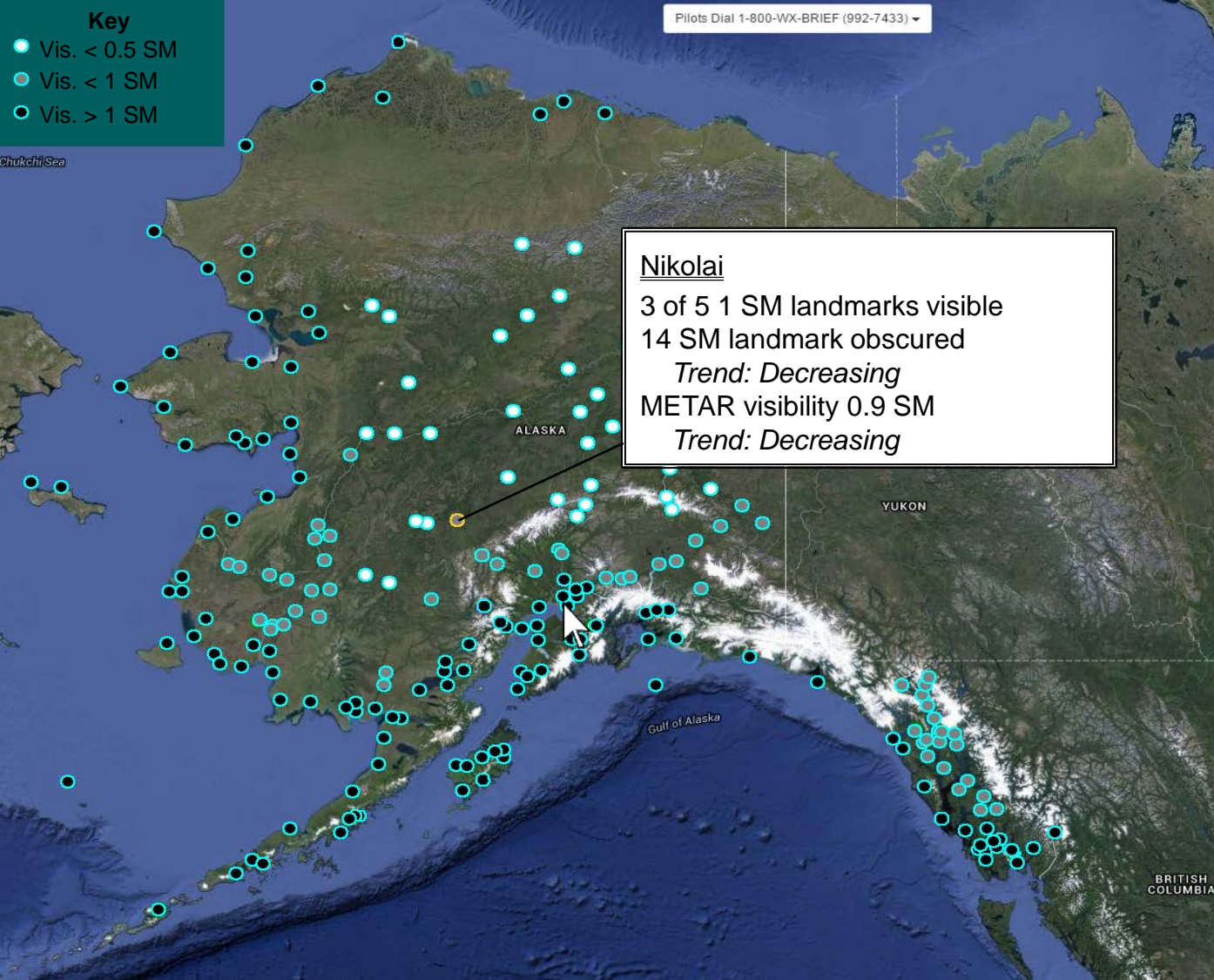
- **Icons give gross estimate of visibility at a glance**
- **Icon pops ups visibility detail and trend**
- **Variations are possible that provide more or less detail**

WTIC Cloud/Crowd Demonstration

- CAPTCHA's ("Completely Automated Public Turing test to tell Computers and Humans Apart") are routinely used by web sites to prevent automated software from overwhelming them
  - Picture CAPTCHA's could be used to determine visibility to specific landmarks in the Alaska camera imagery
  - Instruct the user to select all pictures that show the same scene.
  - Include two known good pictures of the target of interest, perhaps one in color and the other in monochrome. That way 2 matches = poor visibility and 3 matches = good visibility.
  - Strategy is used by Google to convert house numbers to text for Google Maps Street View as well as to interpret text.

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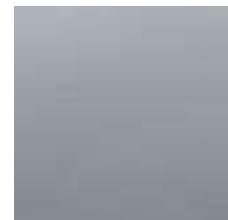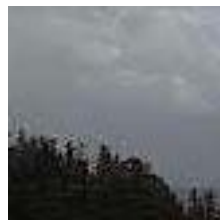
WTIC Cloud/Crowd Demonstration

- **Objectives**
  - Obtain insight into the feasibility of a timely, highly available summary display of visibility across a region
    - Prototype image-evaluator and end-user interfaces
    - Prototype edge-detection visibility determination automation
    - Validation of the crowd-sourced concept for this data set
    - Insight into the most effective way to blend automated and crowd-sourced evaluation, and assess benefit of automation
    - Refined strategy for determining how many human evaluations are required for a given situation
    - Insight into the feasibility of real-time evaluation for the entire set of Alaska cameras
    - Use of cloud technology at Tech Center for storage and processing