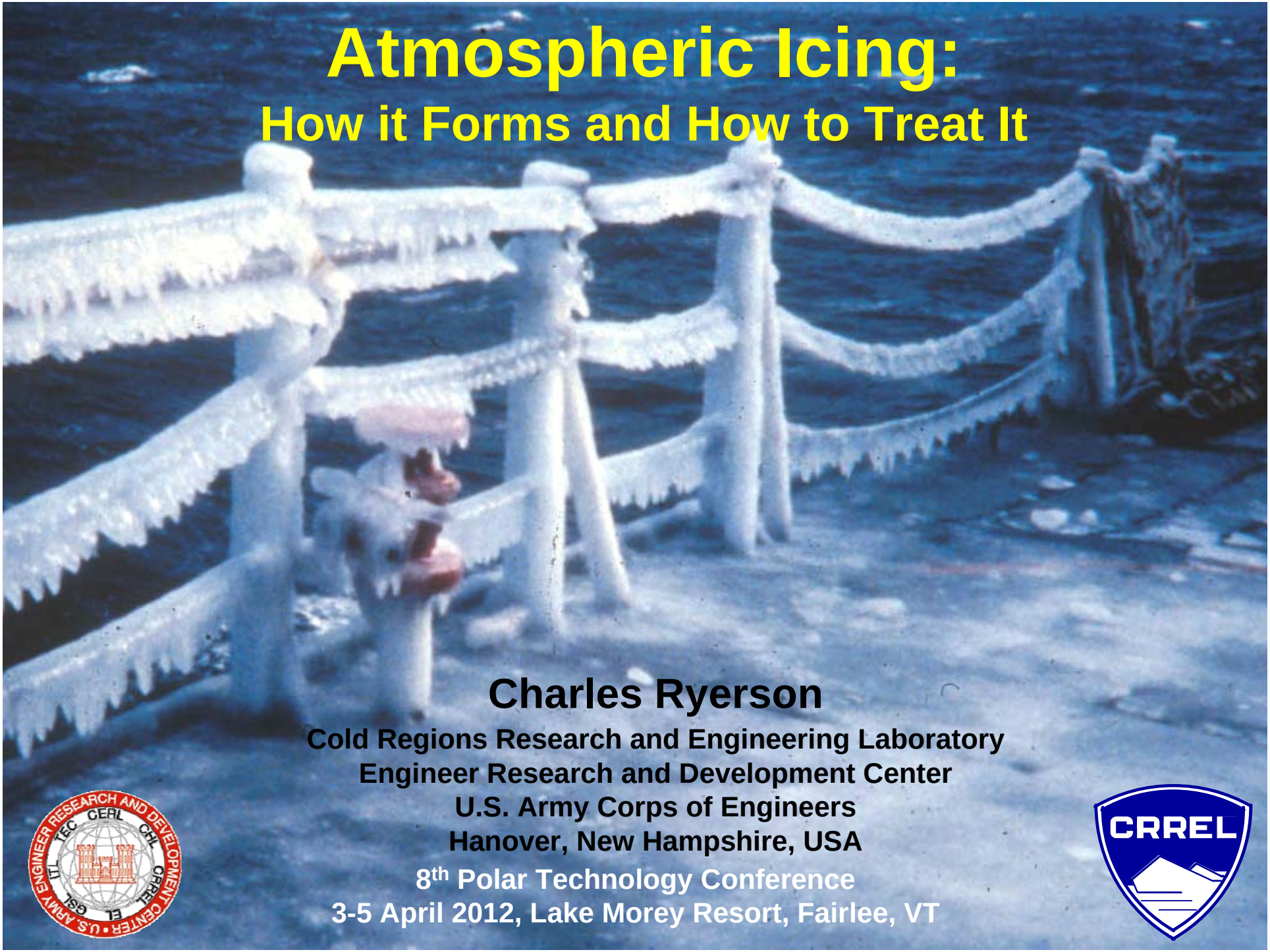
Atmospheric Icing:
How it Forms and How to Treat It



Charles Ryerson

Cold Regions Research and Engineering Laboratory
Engineer Research and Development Center
U.S. Army Corps of Engineers
Hanover, New Hampshire, USA

8th Polar Technology Conference
3-5 April 2012, Lake Morey Resort, Fairlee, VT

Outline

Atmospheric icing types and why important

Hazards/problems

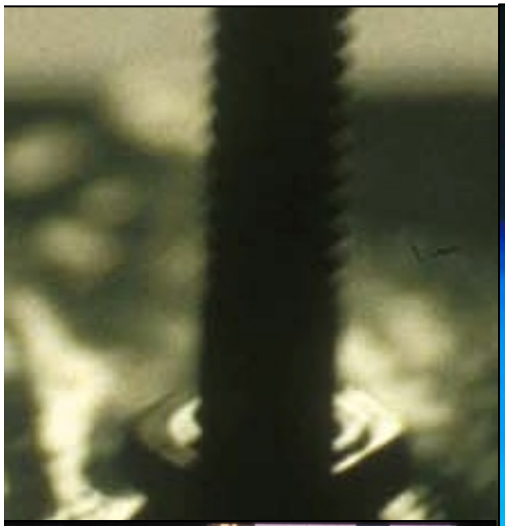
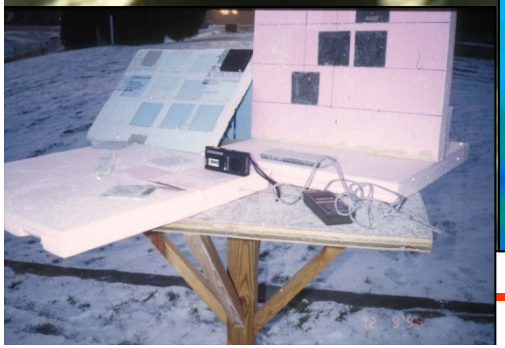
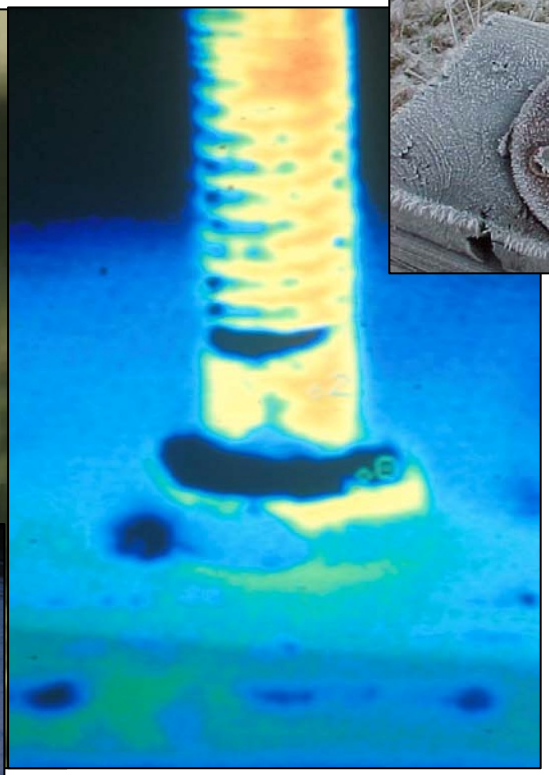
Ice protection technologies

- Anti-icing
- Deicing
- Ice detection

Conclusions

Hoarfrost

- Surface temperature equal to frost point, vapor deposition (sublimation), calm winds, clear sky.
- Causes: Nocturnal radiation frost or cold soaking (objects of high thermal mass)
- Density ~ <0.1 g/cm^3, less than a few mm thick.
- Slippery, obscures windows.

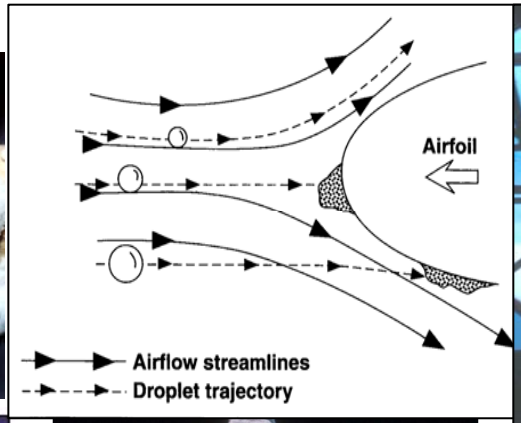




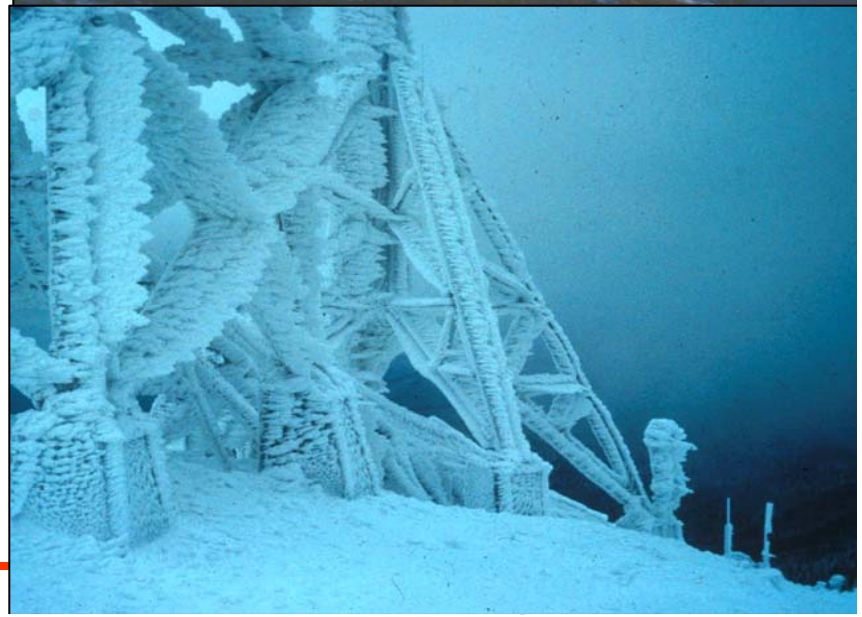

Rime Ice - Cloud and Fog

Collection efficiency fcn: wind speed, drop size, target diameter

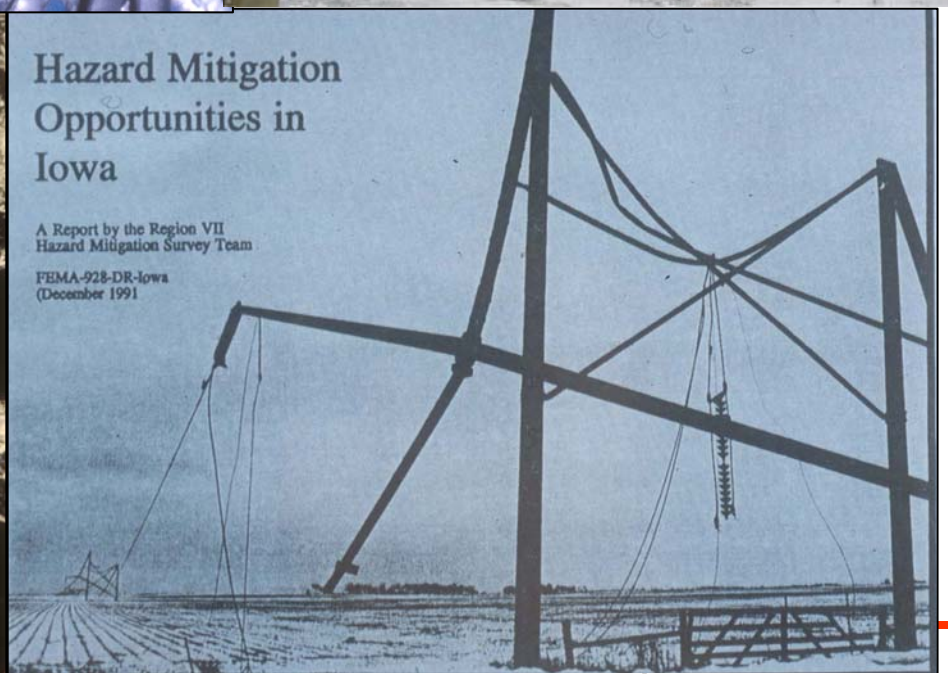
Drops 5-70 μm diameter supercooling

Rapid freezing

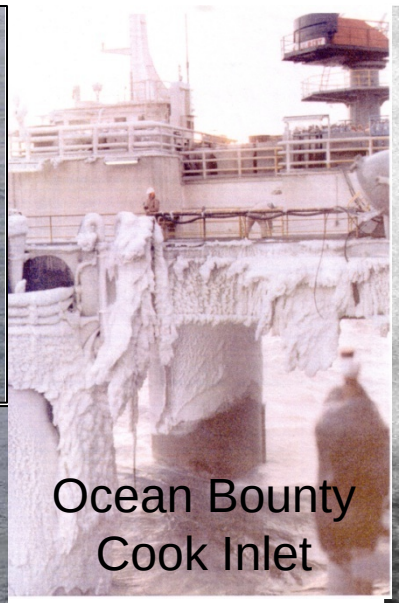


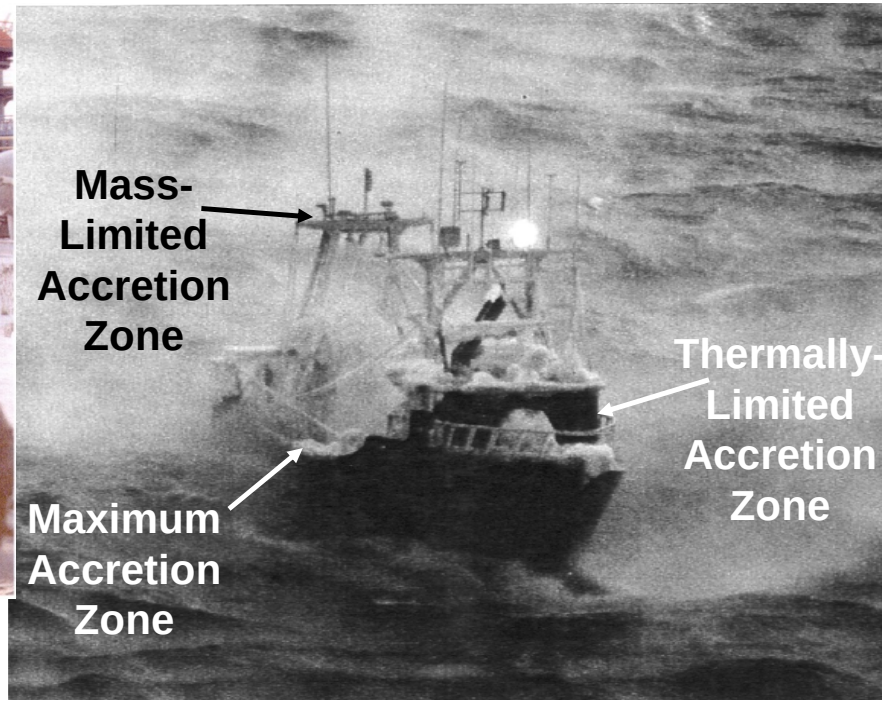


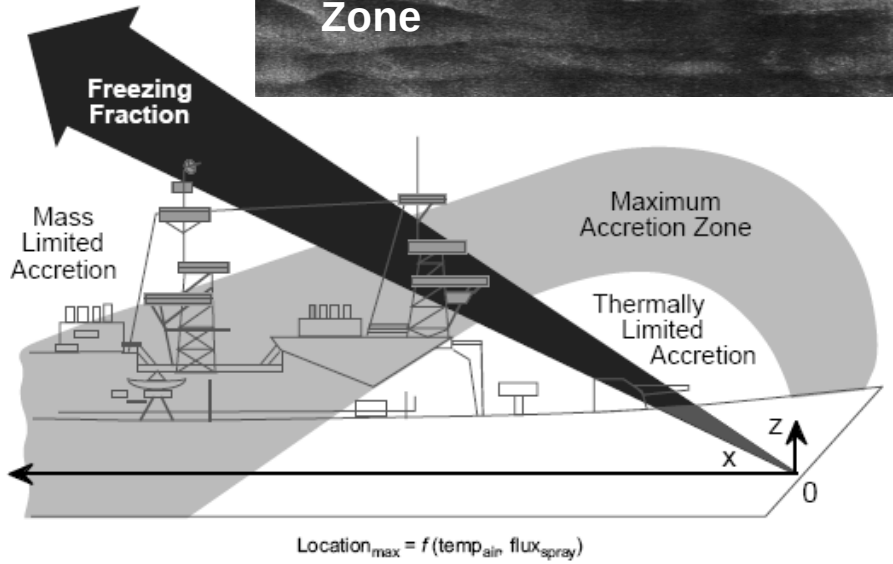
Precipitation Icing – Freezing Rain or Drizzle and Snow



Superstructure Icing



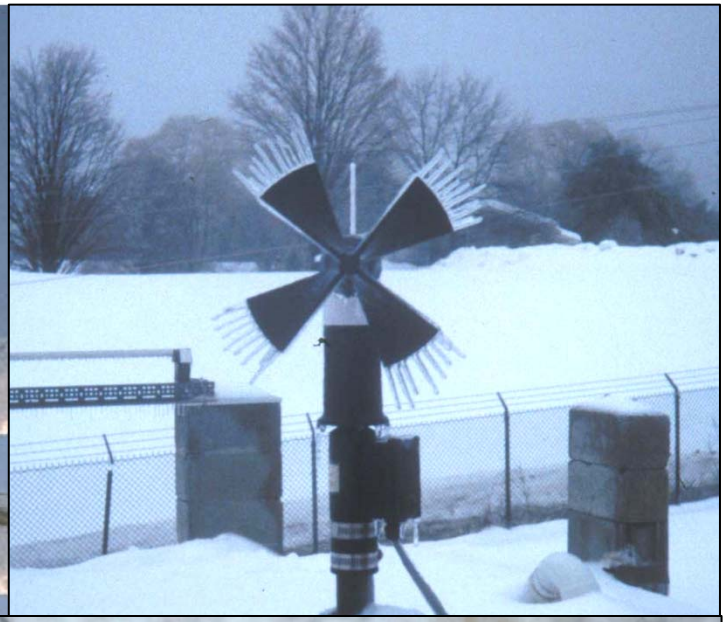




Hazards/Problems

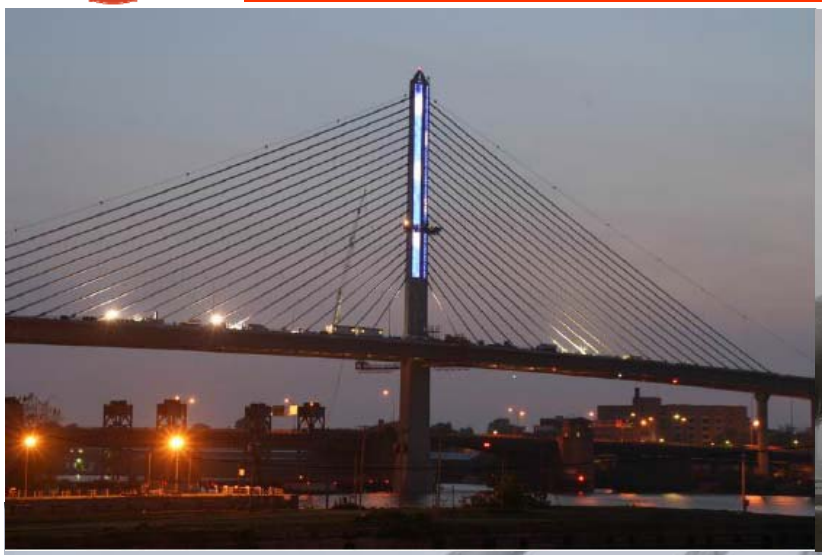
Instrumentation

- Instrumentation
- Bridges
- Wind turbines
- Aircraft
- Telescopes



Hazards/Problems

Toledo Veterans Glass Skyway Bridge – cable stayed



Hazards/Problems

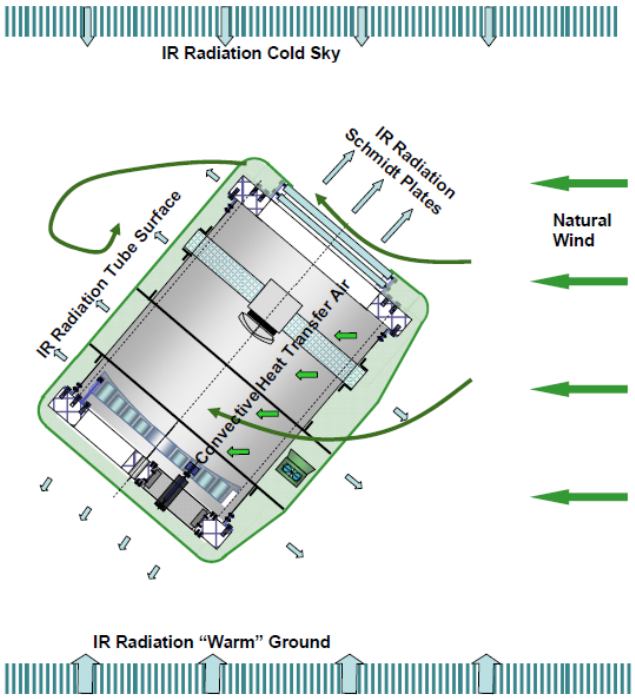
Wind Turbines

Reduced efficiency
Vibration
Fatigue loads
Thrown ice

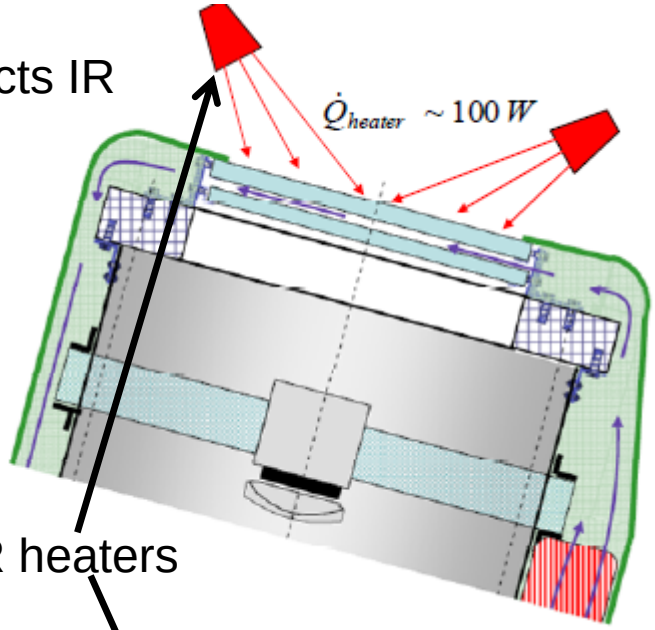
2-kg chunks thrown 200-m

Hazards/Problems

Telescopes



Glass reflects IR



IR heaters

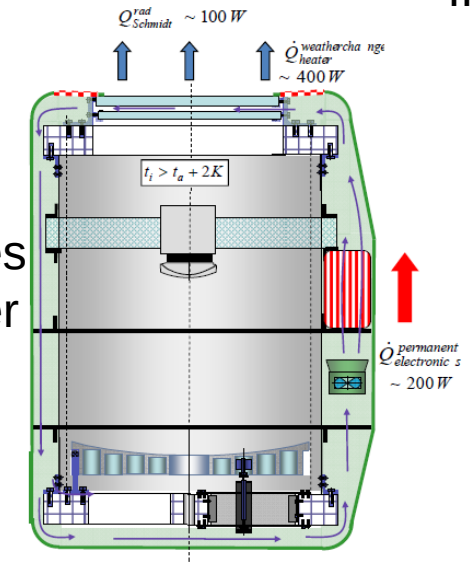


Figure 7: Final de-icing concept

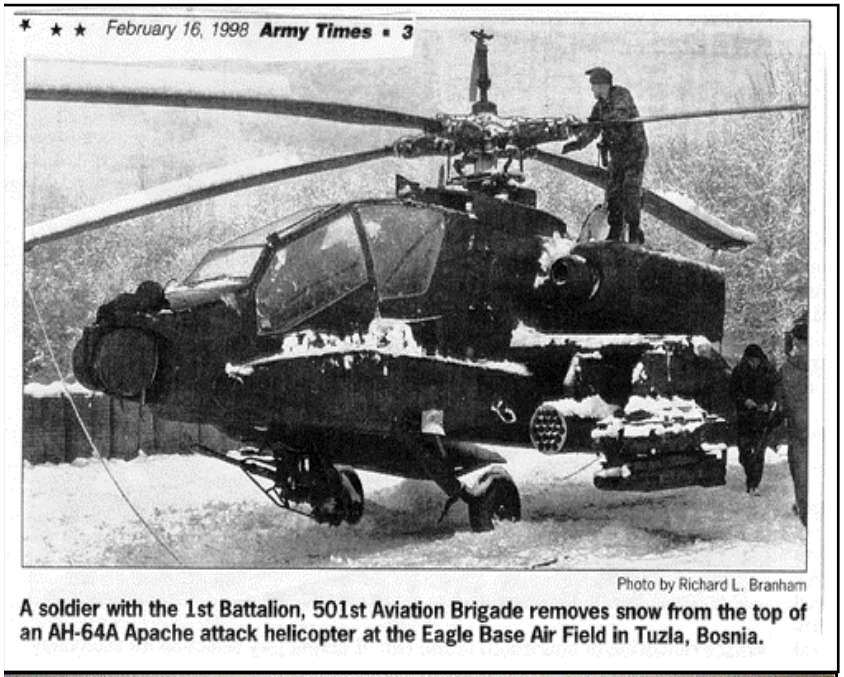
Solution: circulate internal waste heat through lens spaces Keep air a few degrees warmer than ambient – raises vapor pressure of surface to prevent frost.

NOT warmer than 0°C!

Think of your car on a cold winter day

Hazards/Problems

Aircraft preflight/inflight icing



★ ★ February 16, 1998 **Army Times** ▪ 3

Photo by Richard L. Branham

A soldier with the 1st Battalion, 501st Aviation Brigade removes snow from the top of an AH-64A Apache attack helicopter at the Eagle Base Air Field in Tuzla, Bosnia.

Figure 2-f Close-Up Of Ice Formation With Runback.
Photo illustrates in-flight wing leading edge ice formation. NASA Photo.

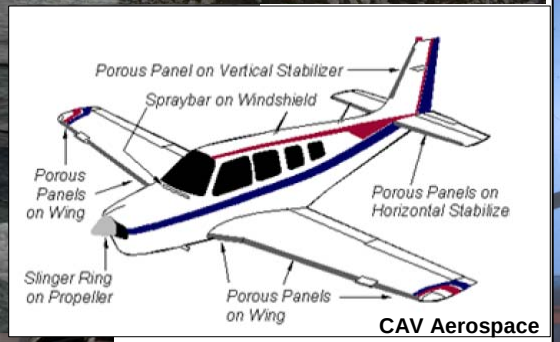
Chemicals


Canadian Frigate HMS *Fredrickton*

Innovative Dynamics Inc.

Fixed Anti-Icing Spray Technology (FAST)


Quixote Corp



CAV Aerospace

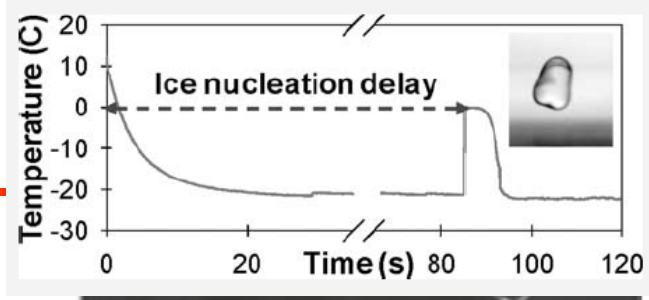
Global Ground Support LLC

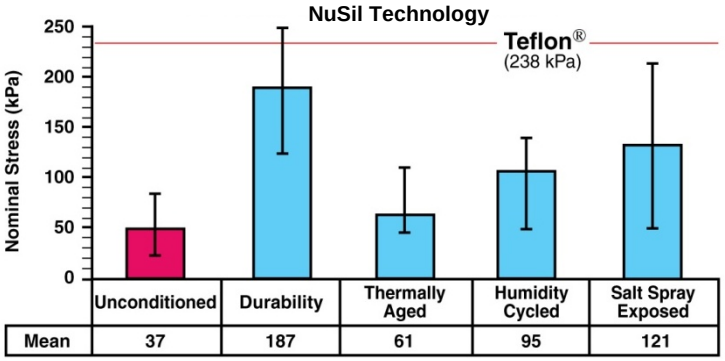

Small hand-sprayers can be used effectively.
Photo: www.Cessna160-162.com.

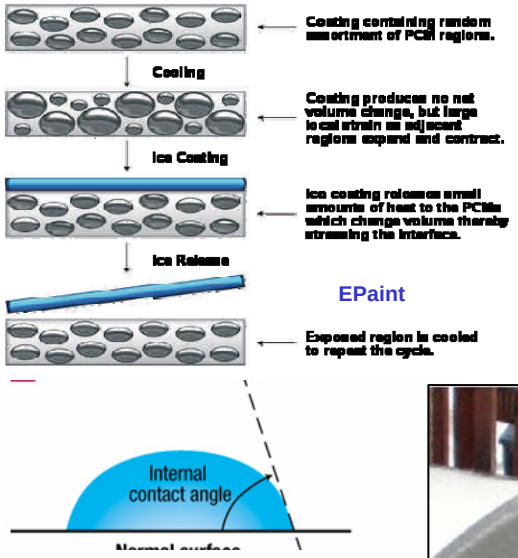

ACDS

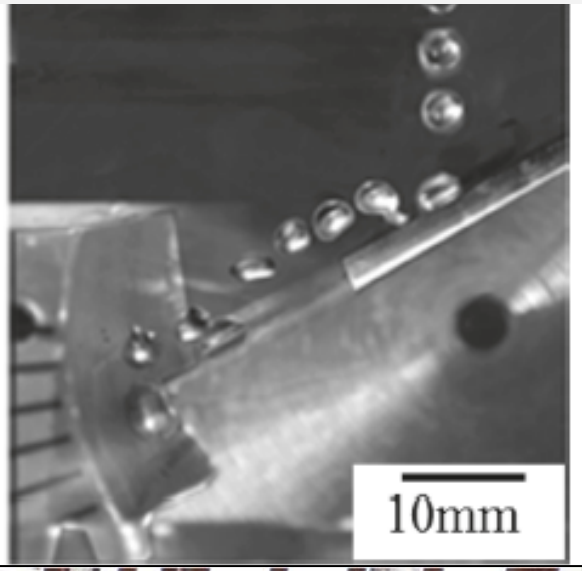
Coatings

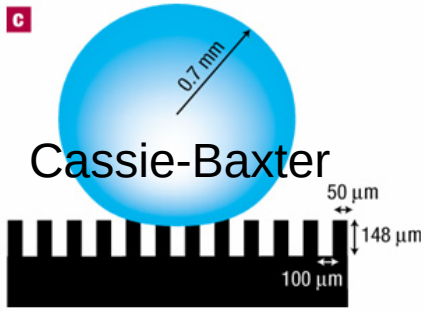
- Traditionally reduce ice adhesion - do not prevent ice.
- Some new Silicone-based coatings have high icephobicity.
- New superhydrophobic coatings shed drops before they freeze.
- Issues: longevity, durability, application, shedding control.
- New low energy nano-surfaces – Lotus leaf bio-mimicing







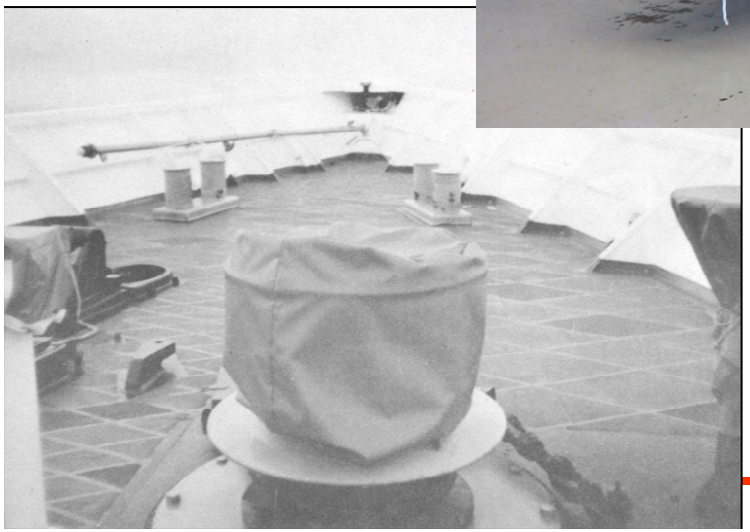


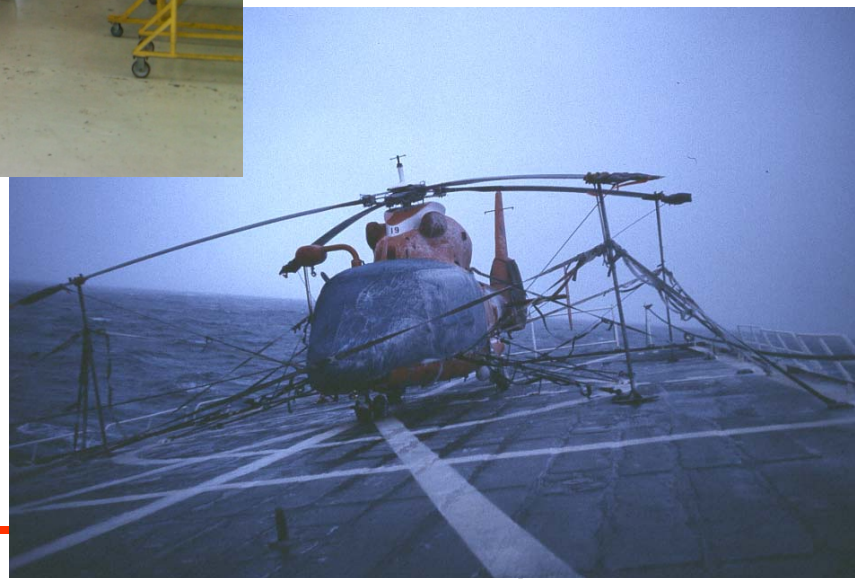


Covers

- Covers prevent icing of items underneath, but covers themselves ice.
- If cover is loose - and icephobic – more easily deiced.
- Covers cause difficulty in usage of covered item.

Jetsocks



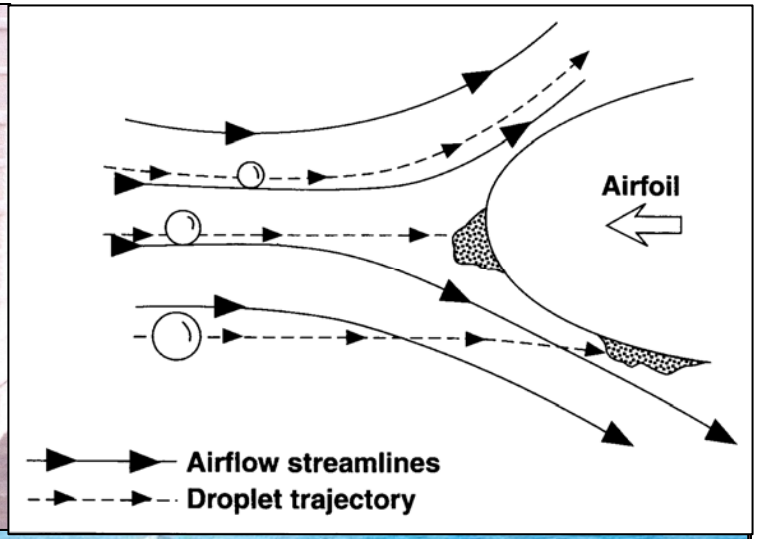


Design

Simplicity and low collection efficiency

Sevan Marine

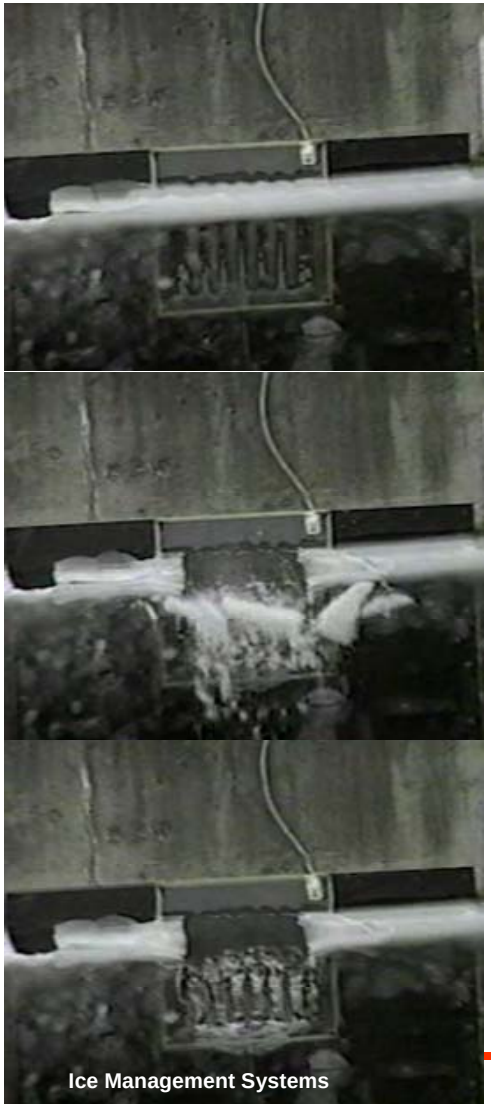
Ocean Bounty



Ocean Bounty

Expulsive

Electro-expulsive and piezoelectric technologies rapidly accelerate surfaces and shear ice from substrates.



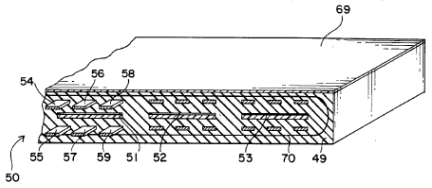
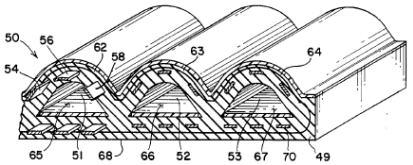
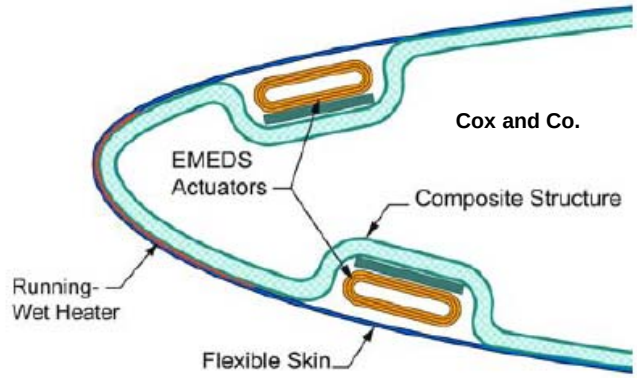
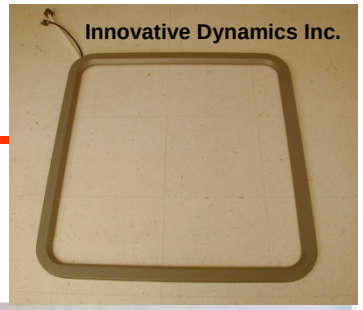


FIG. 5







Heat

Pulse electrothermal, infrared, hot air.

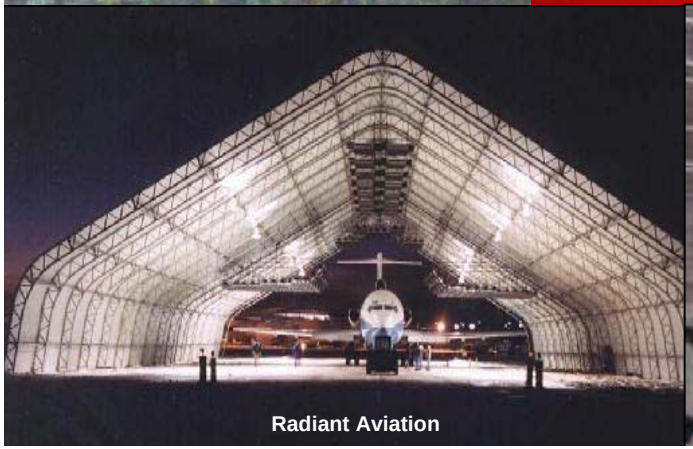
Kelly Aerospace Thermal Systems

EGC Enterprises, Inc.

Schaefer HotZONE Heater

Rockwell Collins ElectroMechanical Systems

Ice Engineering LLC..

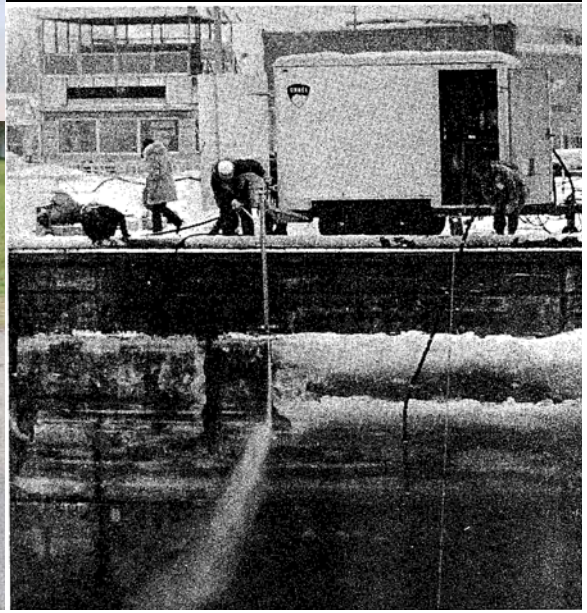


Radiant Aviation

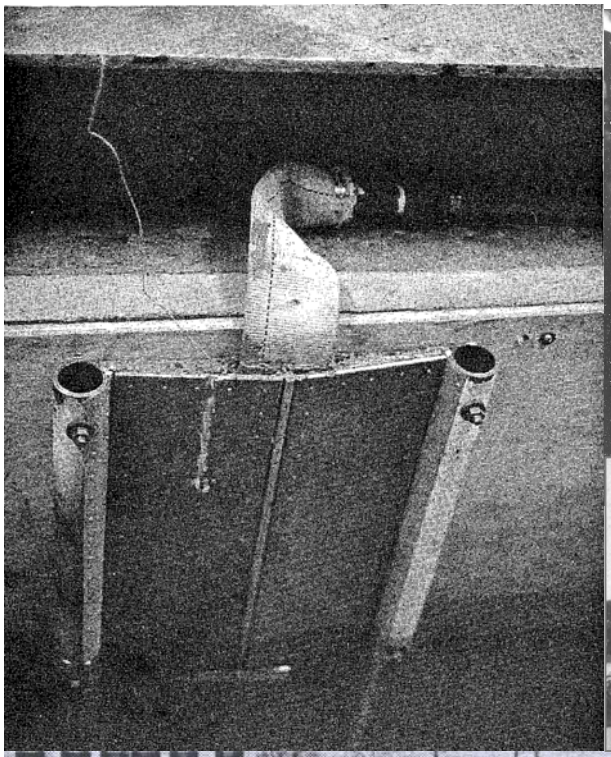
Trimac Industrial Systems, LLC Ice-Cat

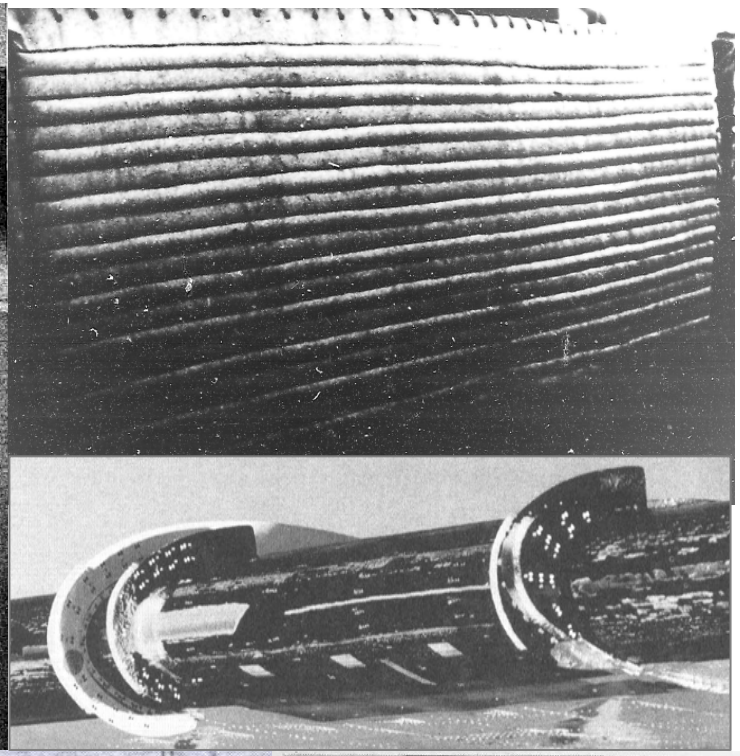
High Velocity Fluid

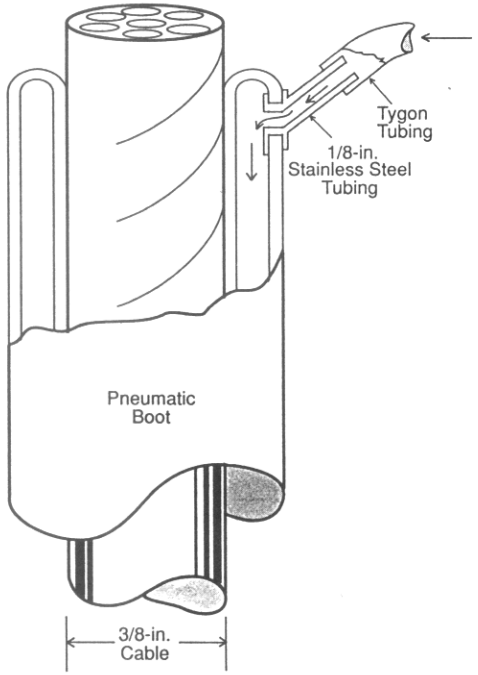
High velocity air, steam (jennys), and water to remove snow and ice.

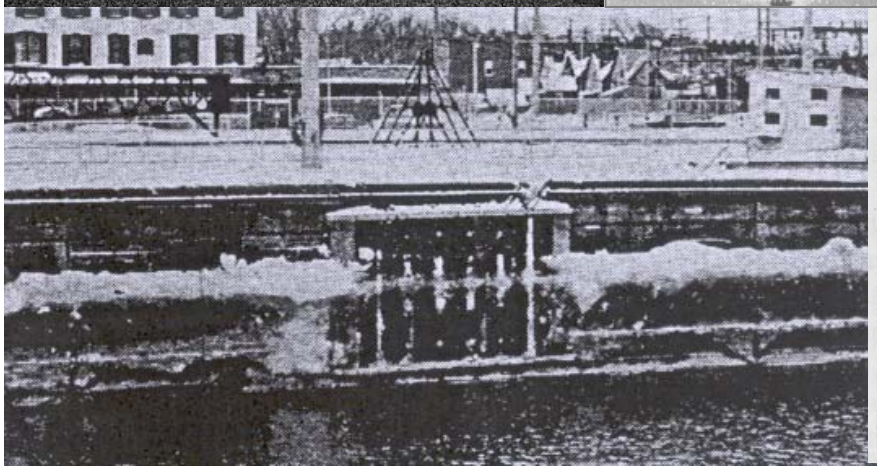


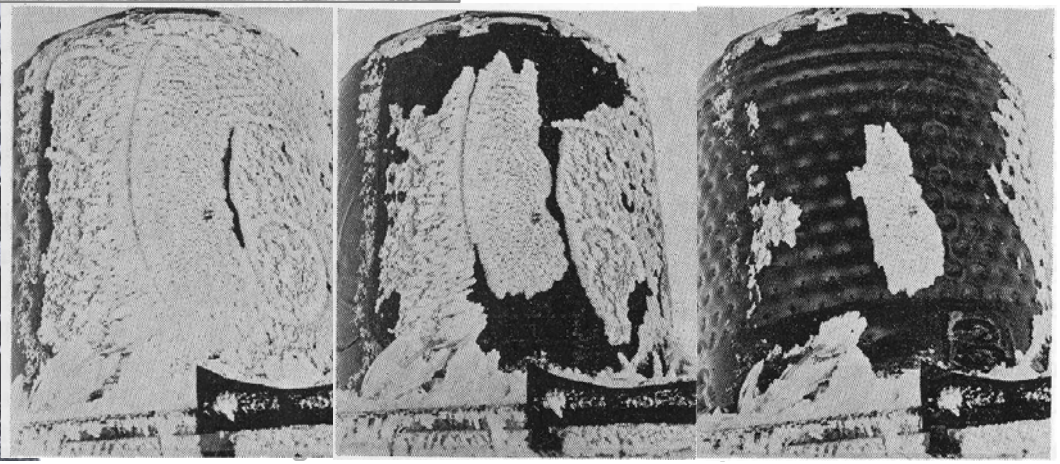
Pneumatic






Tygon
Tubing
1/8-in.
Stainless Steel
Tubing
Pneumatic
Boot
3/8-in.
Cable

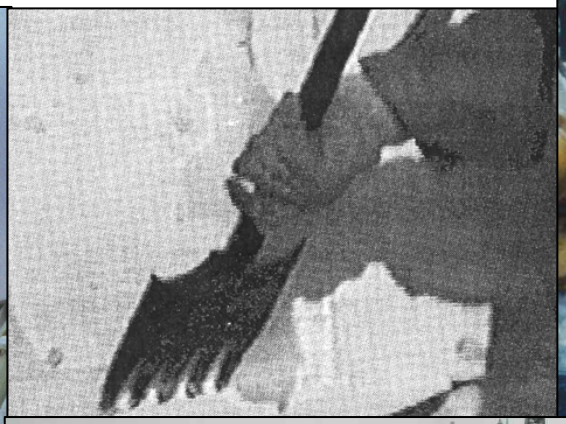




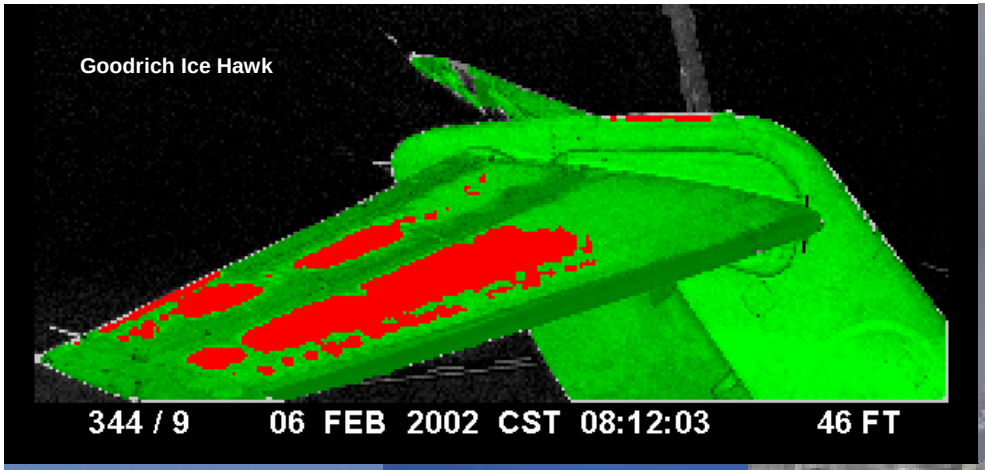
Manual

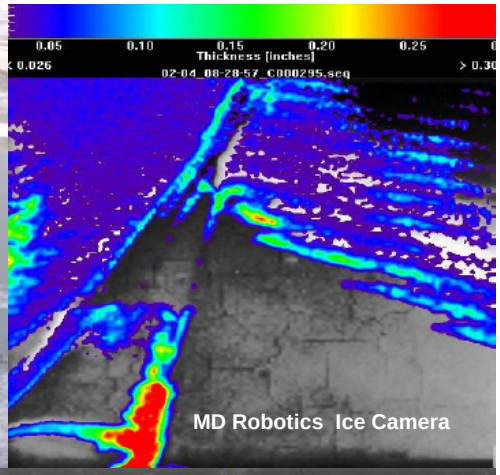
Traditional – but still necessary with automation.

Research Vessel Knorr courtesy George Tupper
Oceanus magazine, Woods Hole Oceanographic Institution).

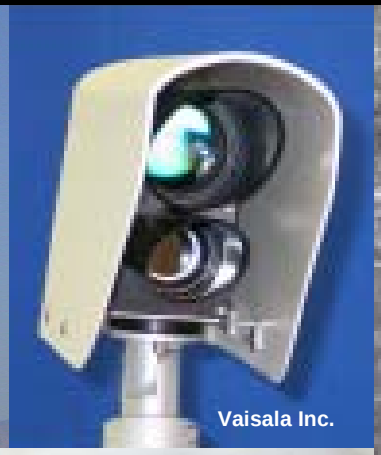


Ice Detection



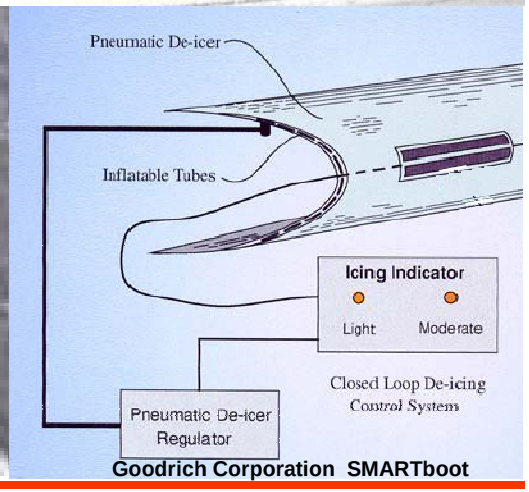



Goodrich Corporation


Vaisala Inc.


Vaisala Inc.


Valley Group Pole Ice



Goodrich Corporation SMARTboot

Goodrich Corporation


Intelligence and Information Warfare
MAIDS

Lessons

- Icing is a safety hazard and reduces productivity.
- Each ice type occurs under different conditions.
- Each ice type can impact operations differently.
- Ice effects are fcn of ice type and structure function.
- Ice protection = anti-icing or deicing + ice detection.
- Technology choice: function of location and operation to be protected, safety, ice type, cost, deice or anti-ice.
- Most technologies not optimized for all environments.
- Some manual deicing may always be needed – there is no panacea.

Questions?

Wry mice, feathers, horns, beaks and scallops - all elements of icing beasts that can bite in the winter night