9-2011

The Bird Ingestion Hazard to Commercial Aircraft Engines and How It Is Addressed

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Niagara, September 2011

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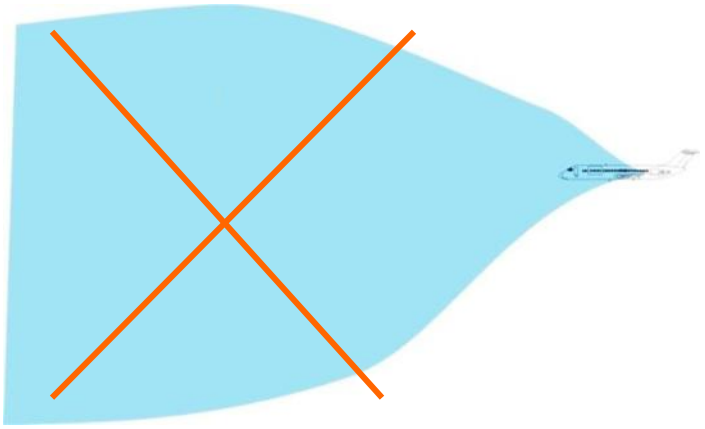
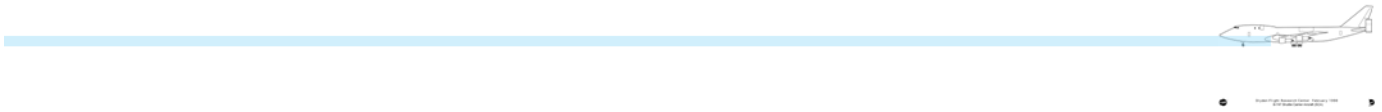
A MISCONCEPTION

Turbofan engines are huge vacuum cleaners - birds are sucked in from everywhere



REALITY

They are only ingested if they are in line with engine



HOW FLEET SAFETY IS ASSURED

- Certification regulations for bird ingestion are designed to achieve required safety goals
- Manufacturers design engines to meet the rules with safety margins
- The technology and rules have been evolving, it is a learning process

RULE CHANGES WITH TIME

1. 1965 FAR 33.13/19 , details in AC 33-1
2. 1968 AC33-1A
3. 1970 AC33-1B
4. 1974 FAR 33.77 (in amdt 6)
5. 1984 FAR 33.77 (amdt 10)
6. 2000 FAR33.76 (amdt20) becoming effective ~1994
7. 2007 FAR33.76 (amdt 243 becoming effective ~2001
8. 201? Hudson accident, Bird III committee

BIRD RULES ARE BASED ON WEIGHT CLASSES

Small (flocking)	<4ozs
Medium (flocking)	>0.75 – 2.5lbs
Large Flocking	>2.5 – 8lbs
Large(single)	>4lbs

1960’S - 1974

FAR 33.13/19 , details in AC 33-1, -1A, -1B

Foreign Object Ingestion (ice, birds, tire, gravel etc.)

small birds (2-4ozs)

medium birds (1-2lbs)

large birds (4lbs)

Takeoff power and initial climb speed

Medium/Small run-on at least 5 minutes at desired minimum 75% thrust with no indications of imminent shutdown

4lb large bird, safe shutdown

The run-on capability is “advisory”

1974 – 1990

FAR 33.77 (amdt 6)

Established bird requirements in FOD rule and adopted details similar to AC 33-1B

1.5lb medium birds, up to maximum of 8 birds

5 minute run-on, 75% thrust

1984 FAR 33.77 (amdt 10)

Medium (and small) birds aimed at critical areas

Significant change, thrust & run-on MUST be demonstrated

1990's

In the mid-80's, industry & regulators recognized that 1.5lbs was not enough, we were meeting flocks of large gulls, the "Bird Committee" was formed and created a separate bird rule

- FAR33.76 (amdt20)
- Substantial rewrite of requirements
  - Medium birds increased to 2.5lbs for mid- & large-sized engines
    - Mix of 1.5 & 2.5lb, up to 5+6 dependent on engine size
    - Ingest at critical conditions
    - 75% thrust capability
    - 20 minutes run-on with throttle excursions to simulate go-around and baulked landing.
  - Law in 2000 but becoming effective mid-90's
- Large single bird 4/6/8lbs safe shutdown

Another significant increase in requirements

2000 - 2008

1990’s - Elmendorf accident, goose populations on the rise

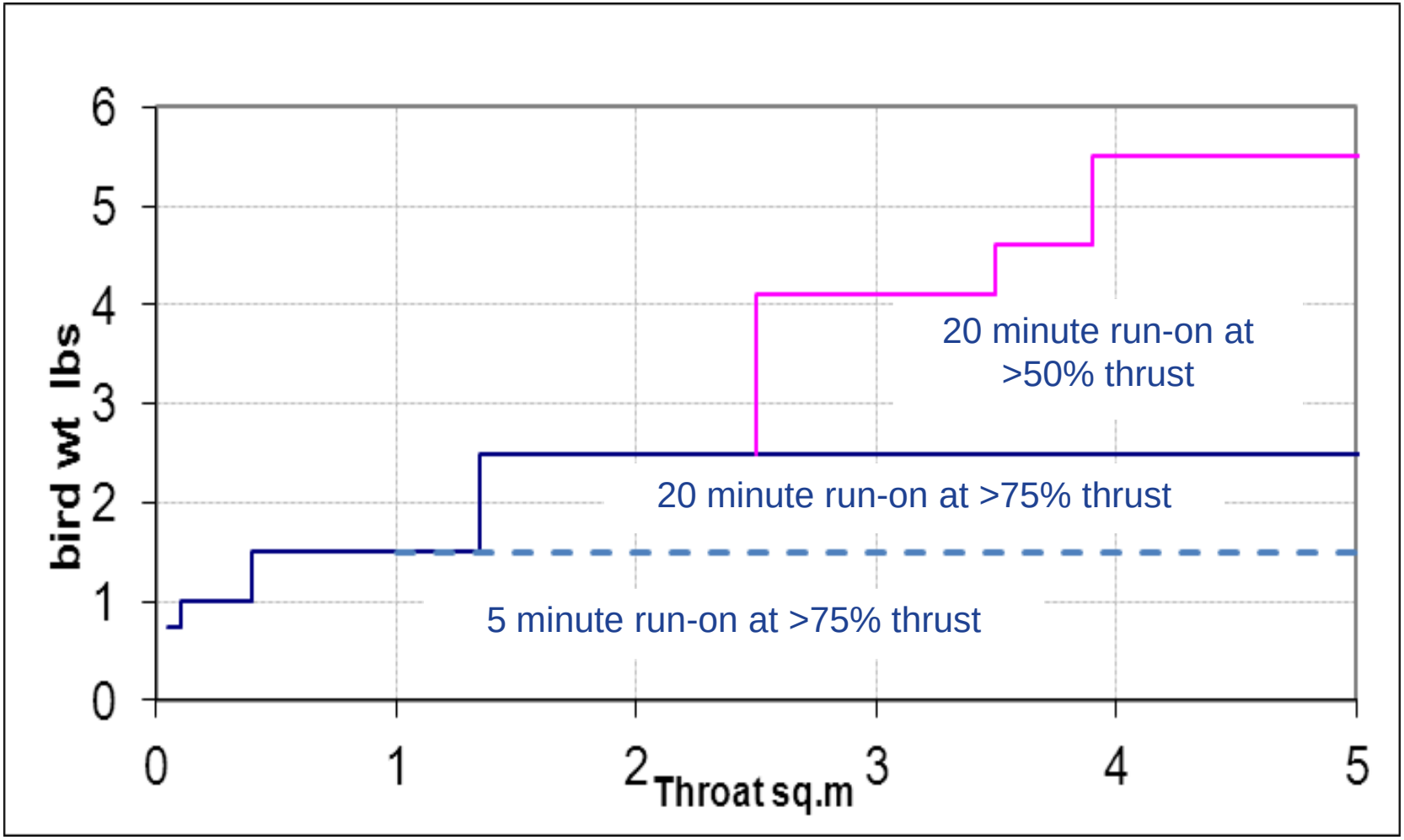
- Bird II formed, 2000-2002 added Large Flocking Bird Rule for larger engines
  - 4.1 to 5.5lbs demonstration at takeoff power
    - 50% thrust capability
    - 20 minutes run-on with throttle excursions to simulate go-around
    - Law in 2007 but becoming effective ~2001

  A further significant increase in requirements

2009 THE HUDSON EVENT

- Aircraft ingested geese into both engines during early climb
- Lost virtually all thrust, landed in the river
- AIA working group (industry & regulatory agencies) has been reviewing last decade of bird ingestion data to assess the effectiveness of current rules, and whether revised rules need to be promulgated

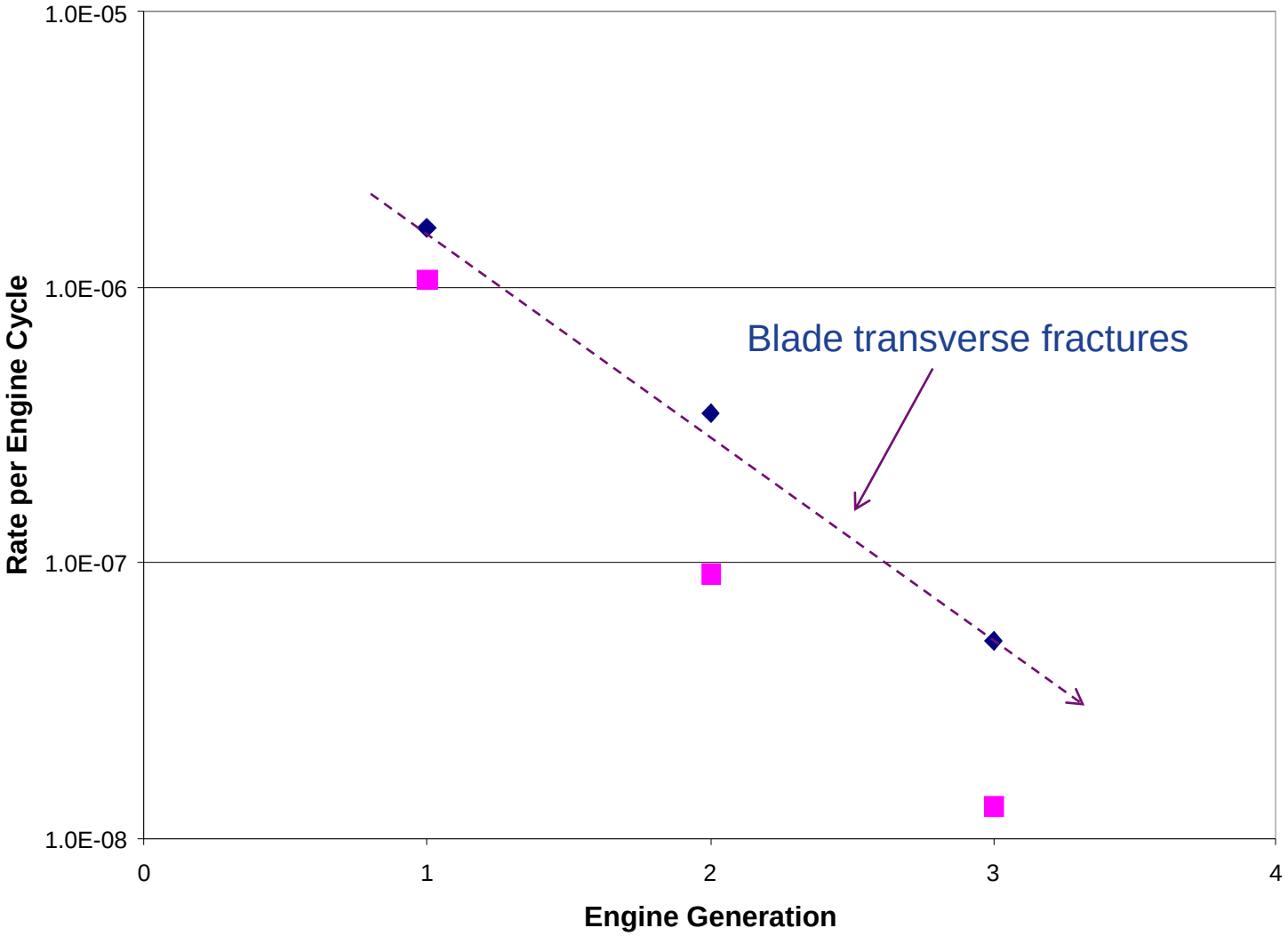
THE ENGINE REQUIREMENTS FOR CONTINUED THRUST HAVE INCREASED SIGNIFICANTLY



HAVE WE CHANGED ENGINE CAPABILITY?

- YES
- Each working group database reflects later engine standards
- Power loss rates improved
  - FAA report showed IFSD's down 75% with FAR33.77
- 33.76 (2.5lb birds) showing further improvements
  - But still fewer than half of flights in latest database
- LFB rule currently has relatively little experience
  - Just a few engines certified to that standard

SEVERE FAN BLADE DAMAGE RATES DECREASING WITH EACH ENGINE GENERATION



EFFECT OF ENGINE CHANGES ON FLEET PERFORMANCE TAKES TIME

- Aircraft/engines have useful lives of 20-30 years
  - Bird ingestion is a learning process
  - Changes are evolutionary
  - Long design cycle, even longer service lives
- Hudson engines were designed over 20 years ago, they are still in production
- Ingestion database composition has changed, but is still not a majority of “2.5lb” engines
  - 1969-1999 data approximately two-thirds AC33 certified, the remainder nearly all FAR33.77
  - 2000-2008 still much less than half FAR33.76

It can take more than a decade for new, more capable designs to become majority of fleet

BIRD COMMITTEES / WORKING GROUPS

- Industry works with the regulatory agencies to review service experience with bird ingestions, pool data together into database
  - Current WG data 2000 thru 1Q 2009
  - Follows on from LFB data collected 1995-1999
    - Data EIS-95 from earlier committee included
  - Includes FAA wildlife database
  - Includes EASA/CAA database
- Review adequacy of rules to meet hazard
- Focus is on safety, not cost

DATABASE COMPARISON

1970-1999

- $265x10^6$ flights
- 16,000 engine events
  - ~98% <2.5lbs

2000-2008

- $289x10^6$ flights
- 11,300 engine events
  - ~97% <2.5lbs
  - ~95% <2.5lbs with ‘generics’ (bird weight class estimated from engine damage)

- There is no statistical difference between LFB rates in databases
  - SEI (single-engine ingestion) of 2.5-8lb approximately 1 per 400,000 flights
  - MEI (multi-engine ingestion) closer to 1 per 8 million flights

ALTITUDES/SPECIES

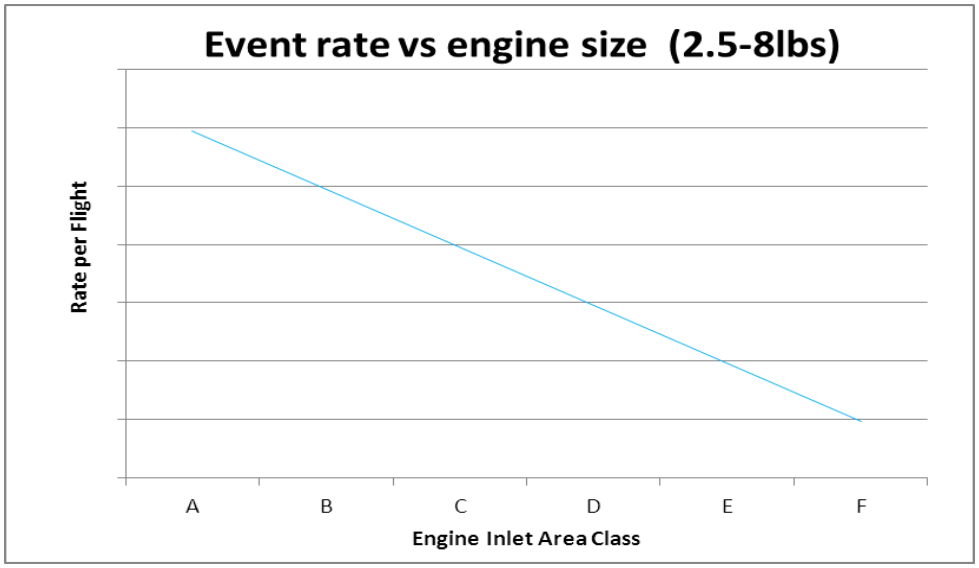
Altitudes (AGL)

86%	0-200ft
9%	200-1000
4%	1000-5000
1%	>5000

Bird Species

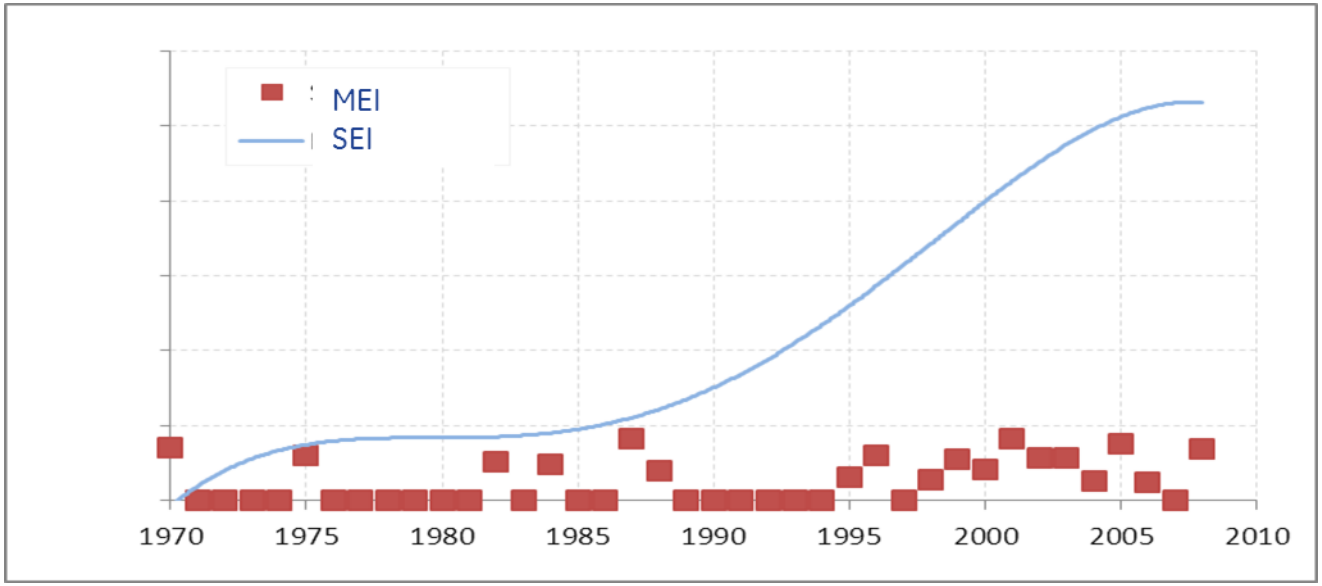
- Approximately 20% of ingestions are identified, the remainder will be almost all small/medium birds
- Gulls are still the highest proportion of identified species (approximately 30%)

INGESTION RATE REDUCES WITH ENGINE SIZE



- Mid-sized engines do ingest 2.5-8lb birds at less than half the rate of large engines
  - Large engines have a much greater inlet area, so more probable for birds to be in their path
  - Avoidance by bird - easier to dodge a 6ft engine than 10ft?

YEARLY MEI'S OF 4-8LB BIRDS ARE RELATIVELY CONSTANT

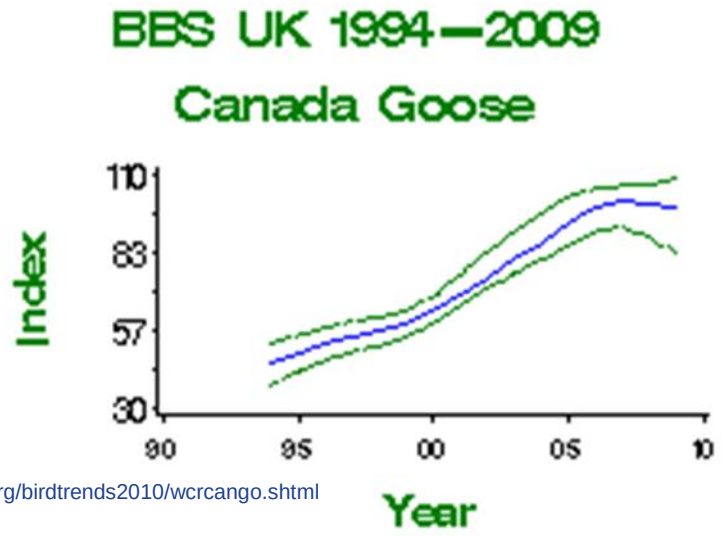


- 4-8lb SEI per flight rose through 90's
  - recent trend is flattening
- Multi-engine ingestions remained flat at 0 to 3 events each year

Control measures are working, encounters near airports are smaller flocks

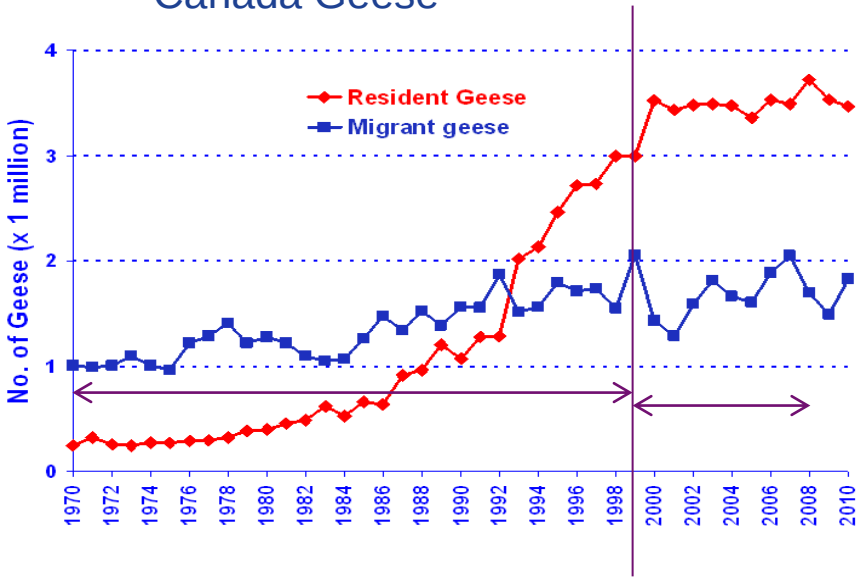
ARE MAJOR GOOSE POPULATIONS STABILIZING?

- N. American Canada & Snow Goose population growth appears to have slowed
- N. America something changed late 90's
  - Population control?
  - Carrying capacity?
  - U.K. in 2005 similar

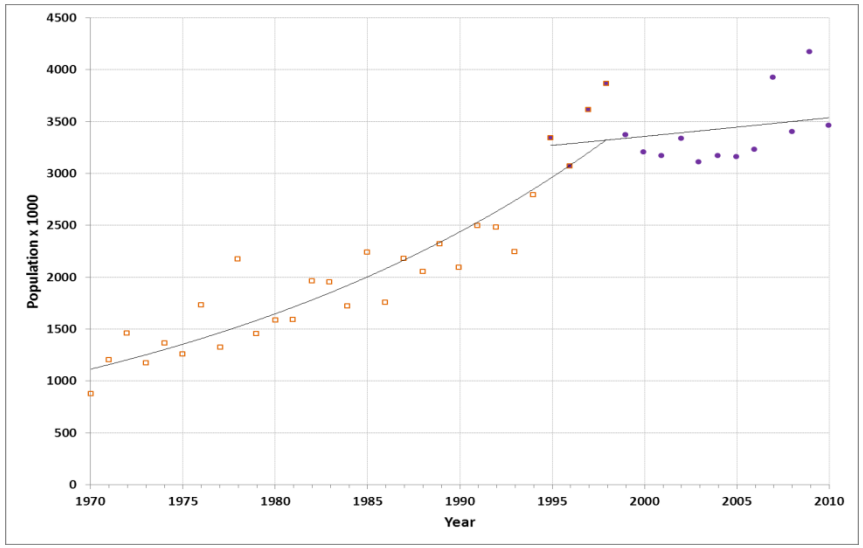


http://www.bto.org/birdtrends2010/wcrcango.shtml

Canada Geese



Snow Geese



WHAT CAN WE DO NEXT?

- Engines
  - The rules will change again

- Engines designs have been continually improving
  - Technology has limits
  - We need a multi-discipline approach to address the hazard

WHAT CAN WE DO NEXT?

- **Continue to control the hazard at airports**
  - It is effective
    - A trash transfer station 2,000 ft from LGA??
      - Seemed crazy, but excellent study done
- **Warn the crew**
  - Avian radar at airports is essential
  - BASH is a good model (AHAS/NEXRAD)
- **Deter from path**
  - What do birds perceive as a threat?
    - They don’t move out of the way of cars
- **Avoid**
  - Only seconds for crew to react @ 200-250 mph
  - They need technology – radar?

SUMMARY

- The hazard does not appear to be growing as it was through the 90’s
- Field experience is constantly monitored, and we continue to learn and improve
- Later generation engines are showing significantly better capability than early designs due to new technology and rule changes
- The commercial fleet has an excellent safety record and will continue to become even safer as we continue efforts to reduce the probability of ingestion and newer engines move into the fleet