



Bird Strikes Are NOT Random

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Problematic Attitude Regarding Bird Strikes



- Many people in the upper echelons of airlines and the military believe that bird strikes are totally random events.
- Many pilots share that philosophy:
 - *“You pay your nickel and take your chances.”*
 - *“They’re always out there and if it’s not your day or theirs, you hit them.”*
 - *“It’s just a matter of time and luck.”*
- Until this attitude changes, it will be challenging to incorporate viable counter-bird technology on aircraft.
- Once only a single company demonstrates successful bird strike reduction and markets that safety advantage to the public, then the floodgates will open.



Common Mistaken Beliefs About Bird Strikes



- Bird strikes are totally random events.
- There are no active defensive measures for pilots to employ to reduce bird strike risks.
- Bird strikes are only an “airport problem,” but not an “airplane problem.”
- Birds always dive away from an approaching aircraft.
- Bird strike risks cannot be predicted for specific airports or flights on specific dates and times.



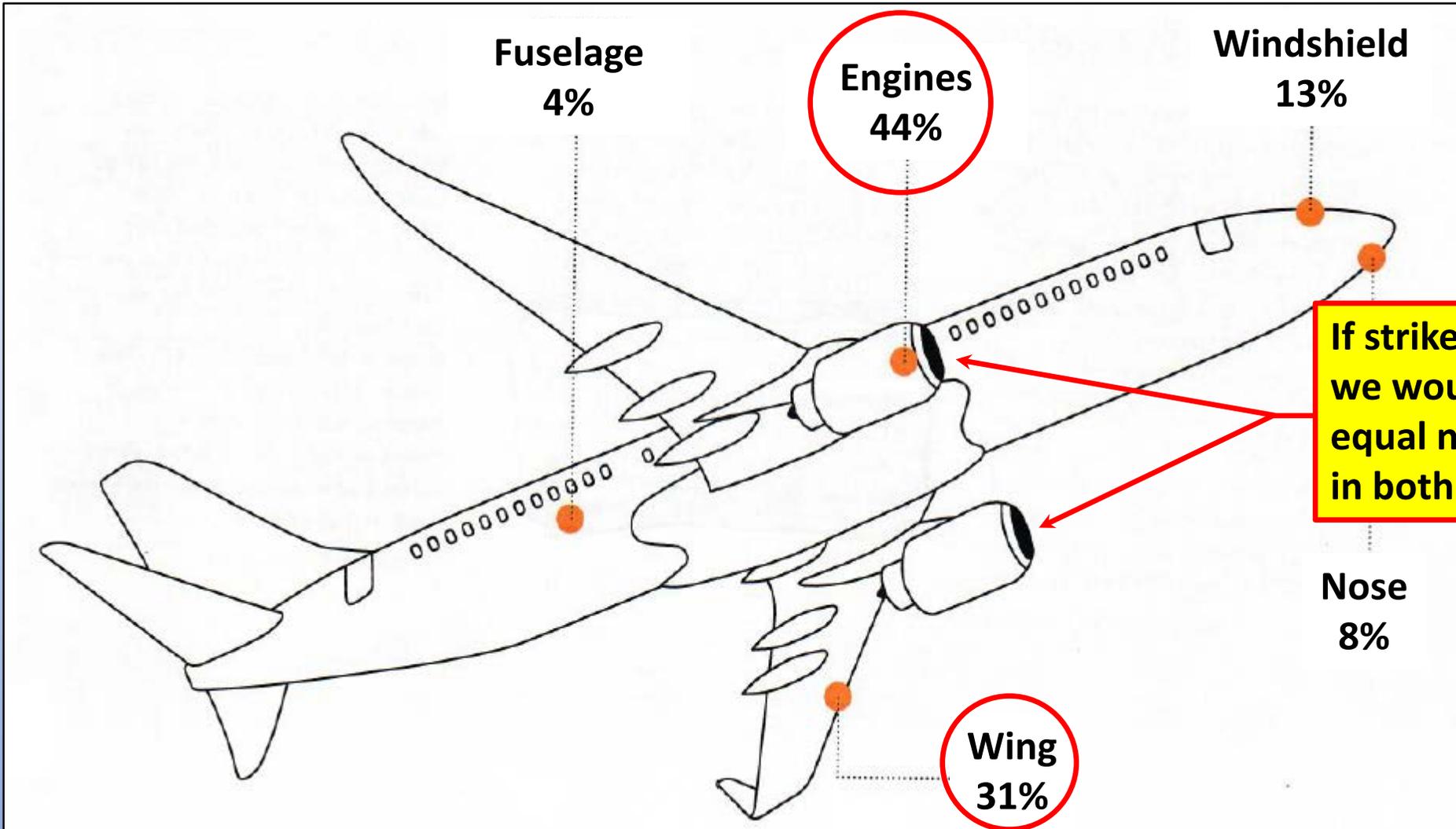
What We Know About Bird Strike Events:



- The lower the altitude, the higher the threat.
- Higher speed and higher power settings increase damage threat.
- The majority of fatal strike events is on departure.
- Wing leading edge lift devices are typically extended.
- The landing lights are usually on (day and night).
- Countermeasures must vary with ambient lighting: day, dusk/dawn, and night.
- Scientific data has shown that birds are often in a defensive or escape posture at impact.
- To avoid the aircraft, the bird must detect the aircraft, decide if it is a threat, and effectively defeat the threat.



Strike Locations on Aircraft



If strikes were random, we would expect about equal numbers of strikes in both engines



Bird Strikes to Engines Are NOT Random



5 October 2014

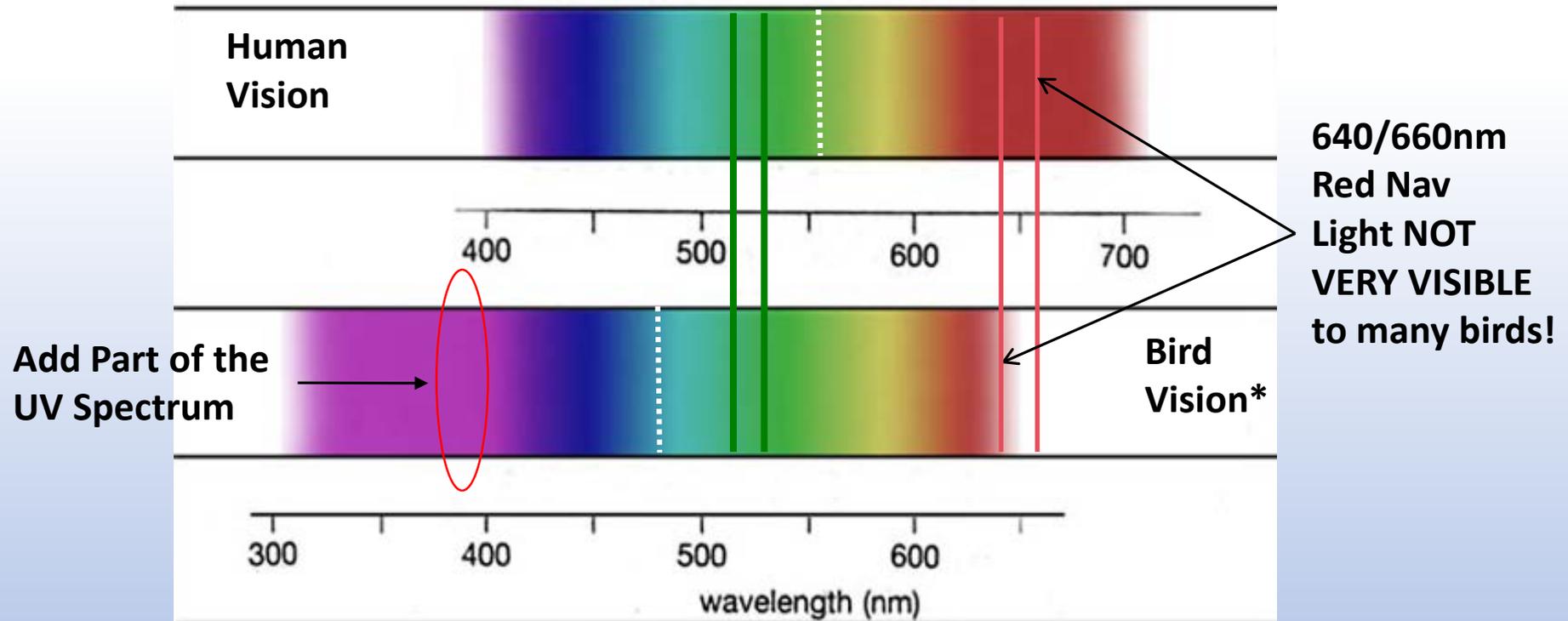
Bird strikes with underwing mounted engines: is there a bias related to left or right position?

Richard A. Dolbeer, Science Adviser, Airport Wildlife Hazards Program, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, 1228 Laguna Drive, Huron, OH 44839, USA; phone: (419) 433-3105, email: dolbeer@bex.net

- 25 years of data showed there was a statistically significant difference with **FEWER bird strikes on the right side** of aircraft.
- There was a 5.6% overall difference with less than a 1/10,000 chance of that count being random. ($P < 0.0001$)
- Three “times of day” categories:
 - Day 53.2%/46.8% 6.4% Difference
 - Dusk/Dawn 55.9%/44.1% 11.8% Difference
 - Night 51.5%/48.5% 3.0% Difference
- Some factor is causing FEWER bird strikes on the right that cannot be random!



Human vs Common Bird Visual Spectrum



- Logical Hypothesis: Since there are **FEWER BIRD STRIKES ON THE RIGHT SIDE**, the difference must be in external lighting.
- Birds avoid the aircraft because they see the green light very well, resulting in fewer strikes on the right.
- Many birds do not see the red light very well and they do not avoid the aircraft.
- * Note: ALL birds DO NOT match the spectral coverage shown in this graphic.



Pilot's Viewpoint of Scientific Studies & Tests



- Large sign on the wall at USAF ANG AFREC Test Center:
 “If it’s not in the field, it doesn’t count!”
- “Someone needs to ‘do something’ to give pilots tools to reduce bird strikes!”
 - 25 years since the USAF E-3 crash (24 fatal).
 - 10 years since Sully’s Hudson River ditching.
 - 5 years since Richard Dolbeer’s discovery that aircraft lighting affects bird strikes.
- Our goal is to be the catalyst that moves the scientifically valid studies onto aircraft ASAP.
- Let’s get serious about bird strikes!



Left/Right Bias Changes With Ambient Light



- Day 53.2%/46.8% 6.4% Difference
- Dusk/Dawn 55.9%/44.1% 11.8% Difference
- Night 51.5%/48.5% 3.0% Difference
- 5.6% overall difference in all lighting conditions.
- **Obvious Conclusions:**
 - Wingtip lighting color affects strike events.
 - Ambient Light intensity affects left/right bias.
 - Landing light blinding apparently reduces bias in low light scenarios.
 - **Bird strikes are an Airplane Problem – NOT an Airport Problem.**



When, Where, & What for US Strikes



- The discovery that bird impact into aircraft engines is not random led to other research in bird strike predictability.
- Source is the latest FAA Wildlife Strike Data Base.
- Last six years of data: 2013-2018.
- Used the 320 US commercial “K” airports that had strikes in Jan 2013.
- Added PHNL as only non-K airport due to strike volume.
- Rank ordered these 321 airports by number of strikes (High to Low).
- Guesses as to top US bird-strike airports????



Top 25 Strike Locations (2013-2018 Count)

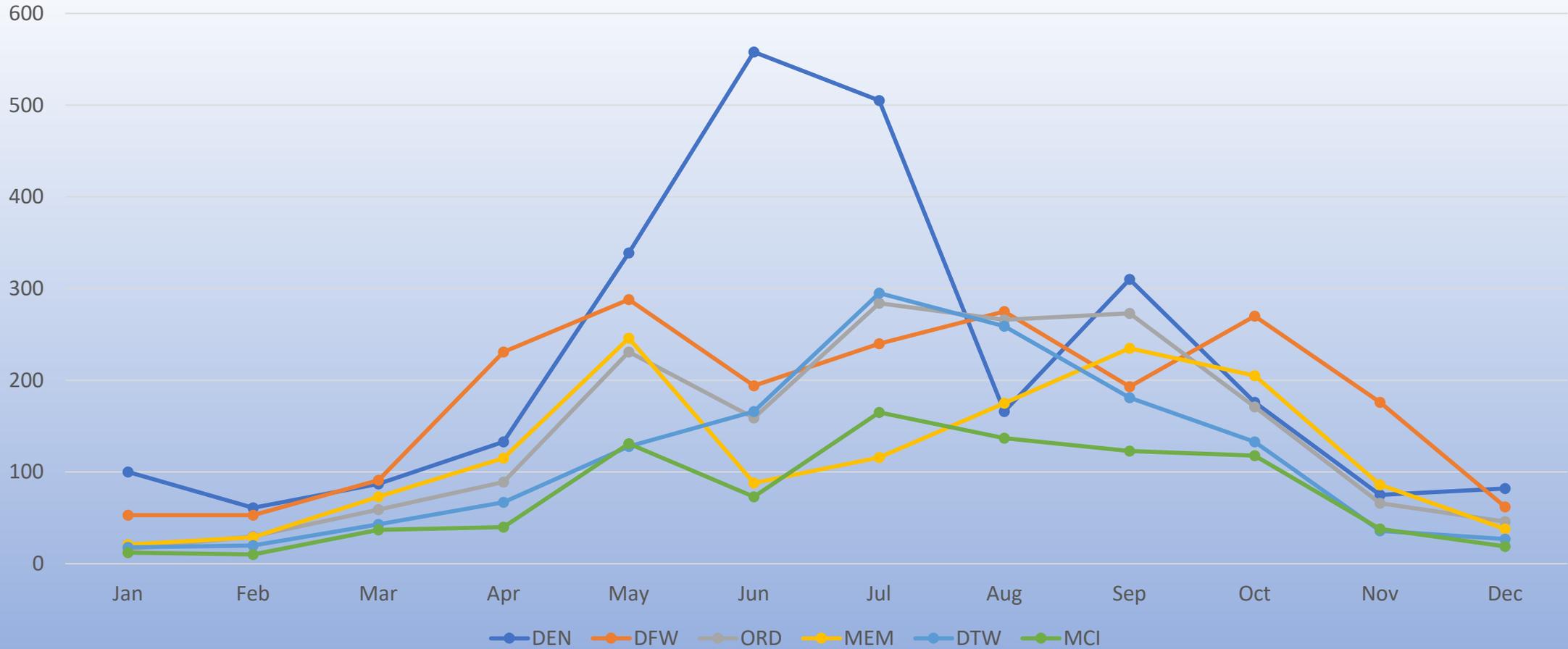


		Six Year Totals													
Rating	Airport ID	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL	1 Yr Avg
1	KDEN	100	61	87	133	339	558	505	166	310	176	75	82	2592	432
2	KDFW	53	53	91	231	288	194	240	275	193	270	176	62	2126	354
3	KORD	16	30	59	89	231	159	284	266	273	171	66	46	1690	282
4	KMEM	21	29	73	115	246	88	116	175	235	205	86	38	1427	238
5	KDTW	18	20	43	67	128	166	295	259	181	133	36	27	1373	229
6	KJFK	64	52	47	52	137	67	129	196	120	242	128	47	1281	214
7	KATL	30	41	61	91	92	122	199	151	162	134	96	55	1234	206
8	KSLC	26	22	47	74	117	200	164	184	196	102	57	26	1215	203
9	KCLT	25	32	48	72	132	79	112	152	172	204	107	33	1168	195
10	KLGA	19	17	38	69	118	44	84	102	148	205	118	53	1015	169
11	KPHL	24	40	27	52	128	73	119	157	89	137	78	29	953	159
12	KEWR	16	15	47	63	108	27	55	80	139	242	122	28	942	157
13	KMCO	60	42	53	64	72	60	60	192	102	118	56	62	941	157
14	KMCI	12	10	37	40	131	73	165	137	123	118	38	19	903	151
15	KSMF	80	32	34	63	82	148	135	64	41	59	72	92	902	150
16	KAUS	32	42	35	66	91	77	91	147	100	110	57	30	878	146
17	KSDF	10	9	26	64	137	55	60	87	192	112	46	12	810	135
18	KLAX	49	37	30	70	79	45	54	54	85	122	69	61	755	126
19	KIAH	18	29	38	77	118	107	95	81	69	47	29	21	729	122
20	KDAL	12	12	51	52	91	63	115	96	80	75	53	23	723	121
21	KBWI	6	10	25	49	108	81	134	98	78	65	49	9	712	119
22	KBOS	14	15	17	44	70	37	75	100	86	94	88	50	690	115
23	KCVG	15	20	15	24	65	53	123	135	78	75	37	21	661	110
24	KMSP	3	2	22	47	91	61	76	125	101	67	36	7	638	106
25	KIND	6	8	30	37	93	39	89	103	100	65	32	12	614	102



2013-2018 Data Top 5 + MCI

Count Variance by Month





Six-Year Total KDEN

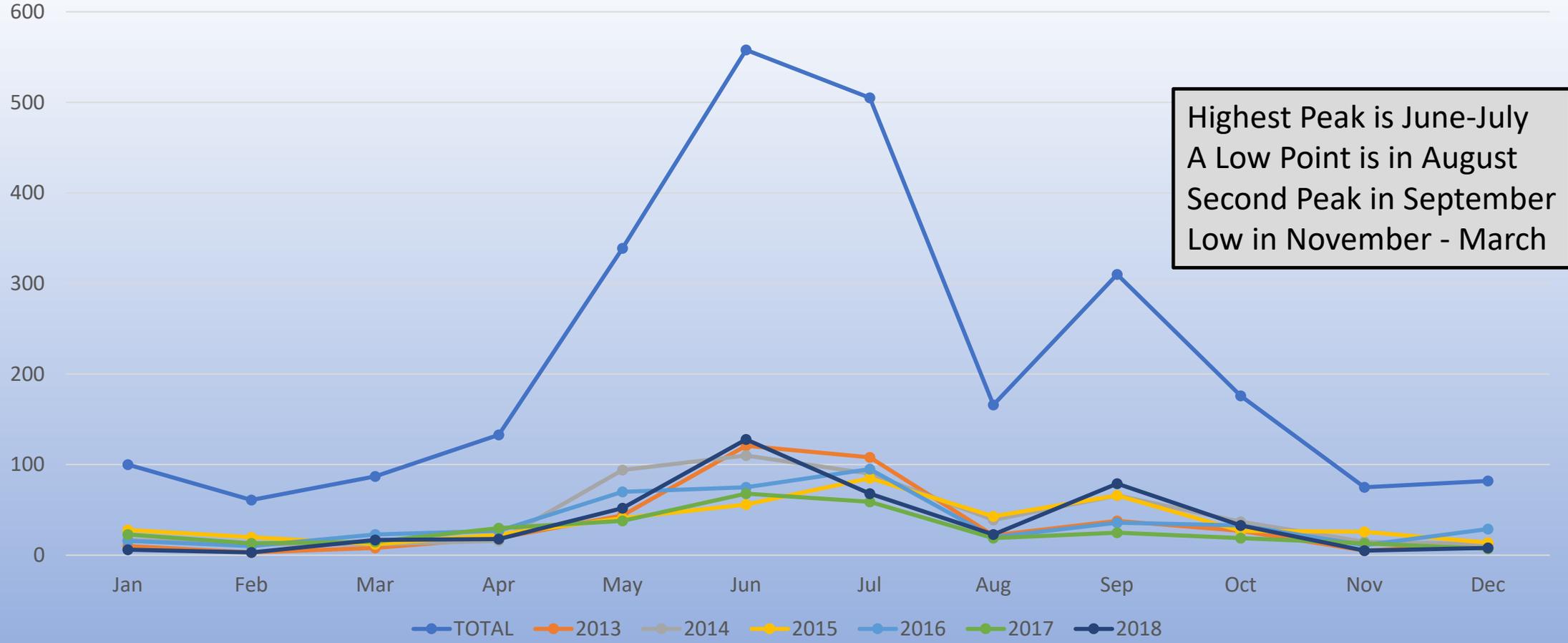
Count Variance by Month





Six-Year Data KDEN

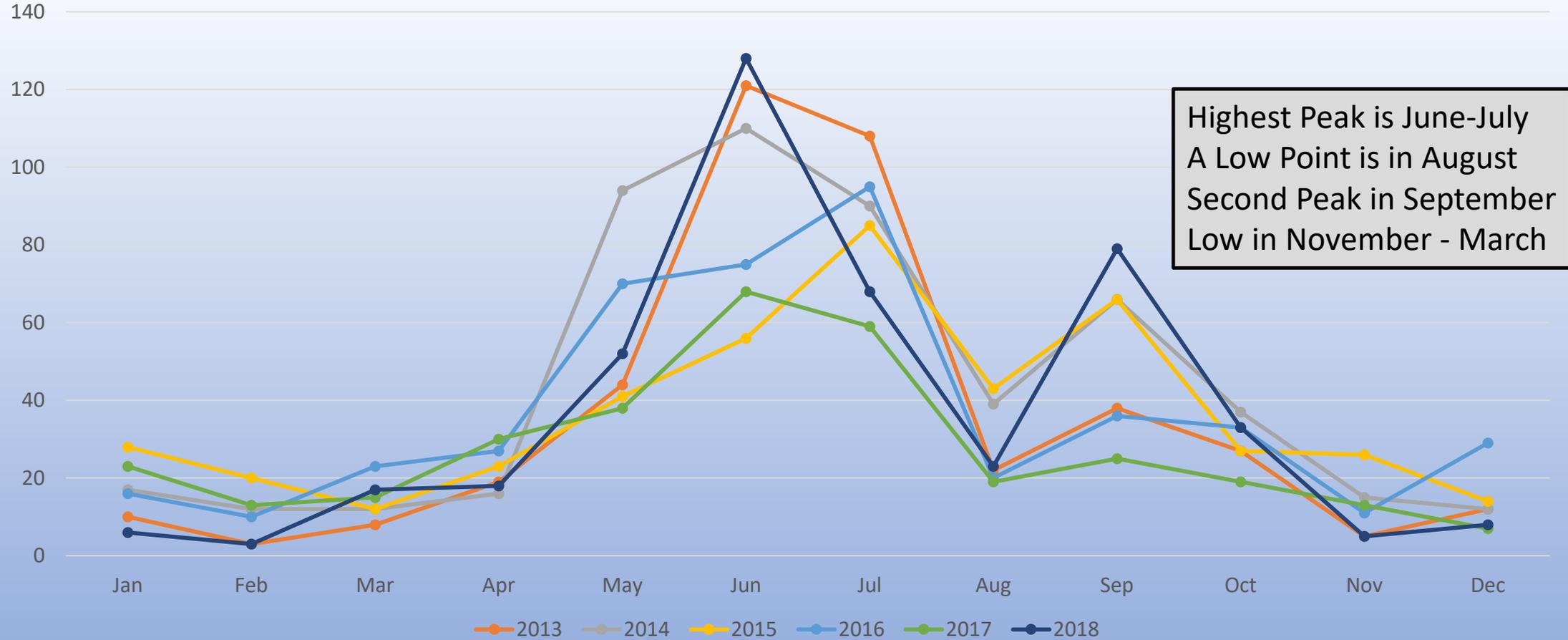
Annual Data is Consistent with 6Yr Total





Individual Year Data KDEN

Annual Data is Consistent with 6Yr Total





Great Lakes Airports in Top 5 (2013-2018)



Count Variance by Month





2018 Data ORD & MCI

Count Variance by Month

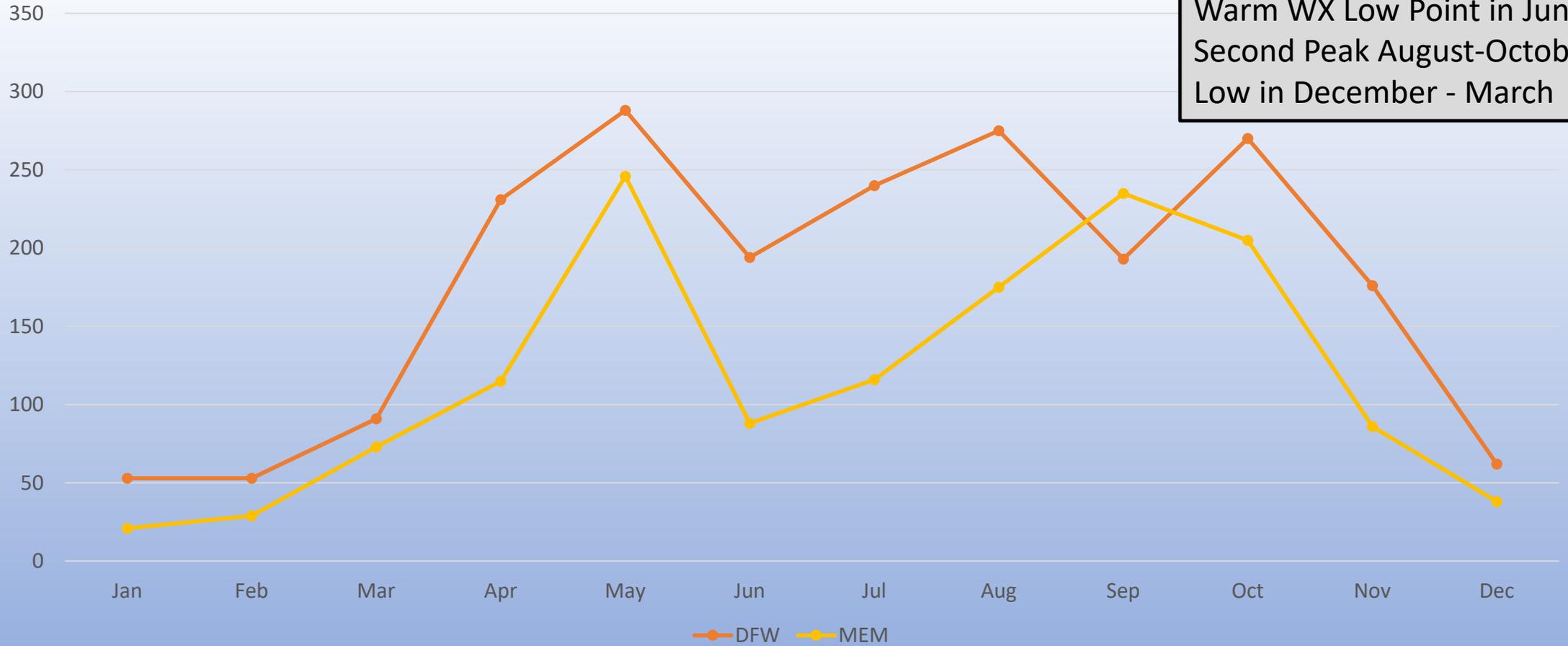


First Peak is May Followed
By a Low Point in June
Higher Peak in July followed
by Decline in Oct
Low in December - March



Six-Year Totals KDFW & KMEM

Count Variance by Month



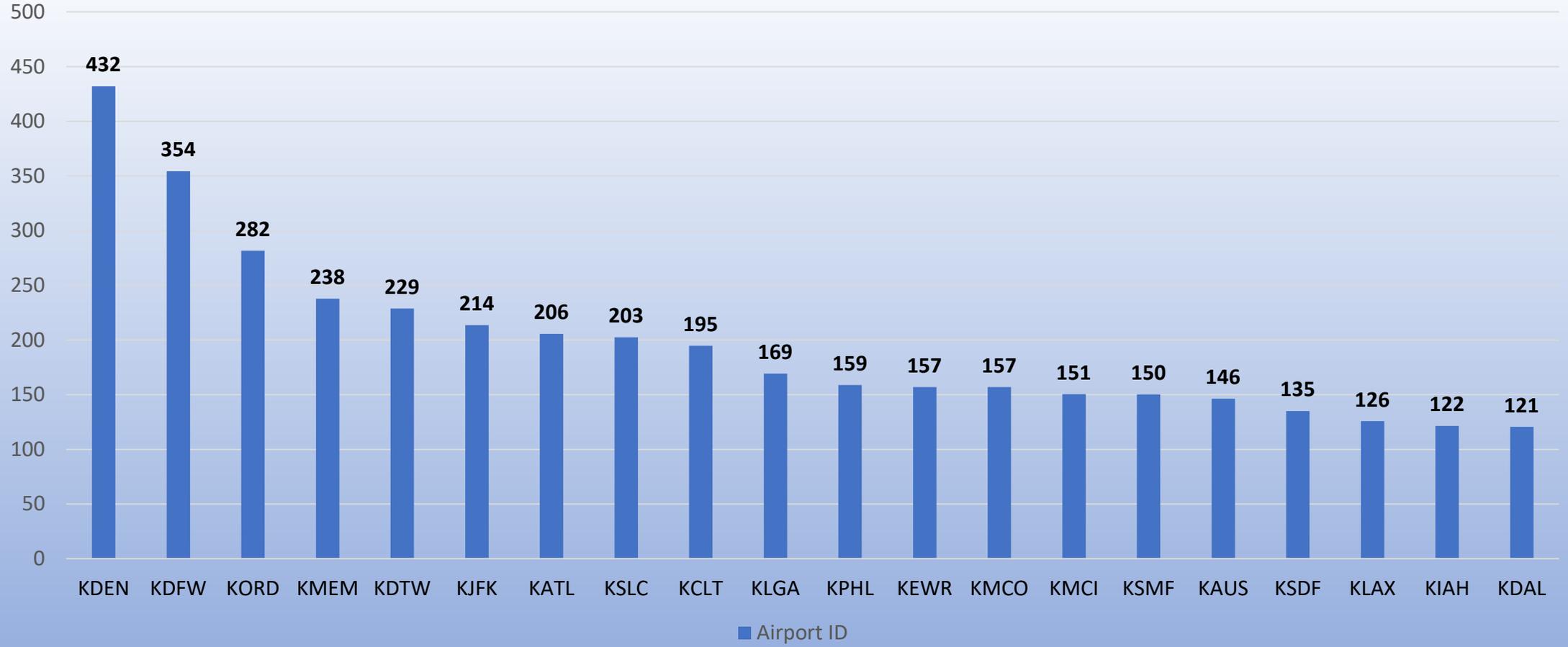
Highest Peak is May
Warm WX Low Point in June
Second Peak August-October
Low in December - March



Top 20 Airports by Annual Average Count



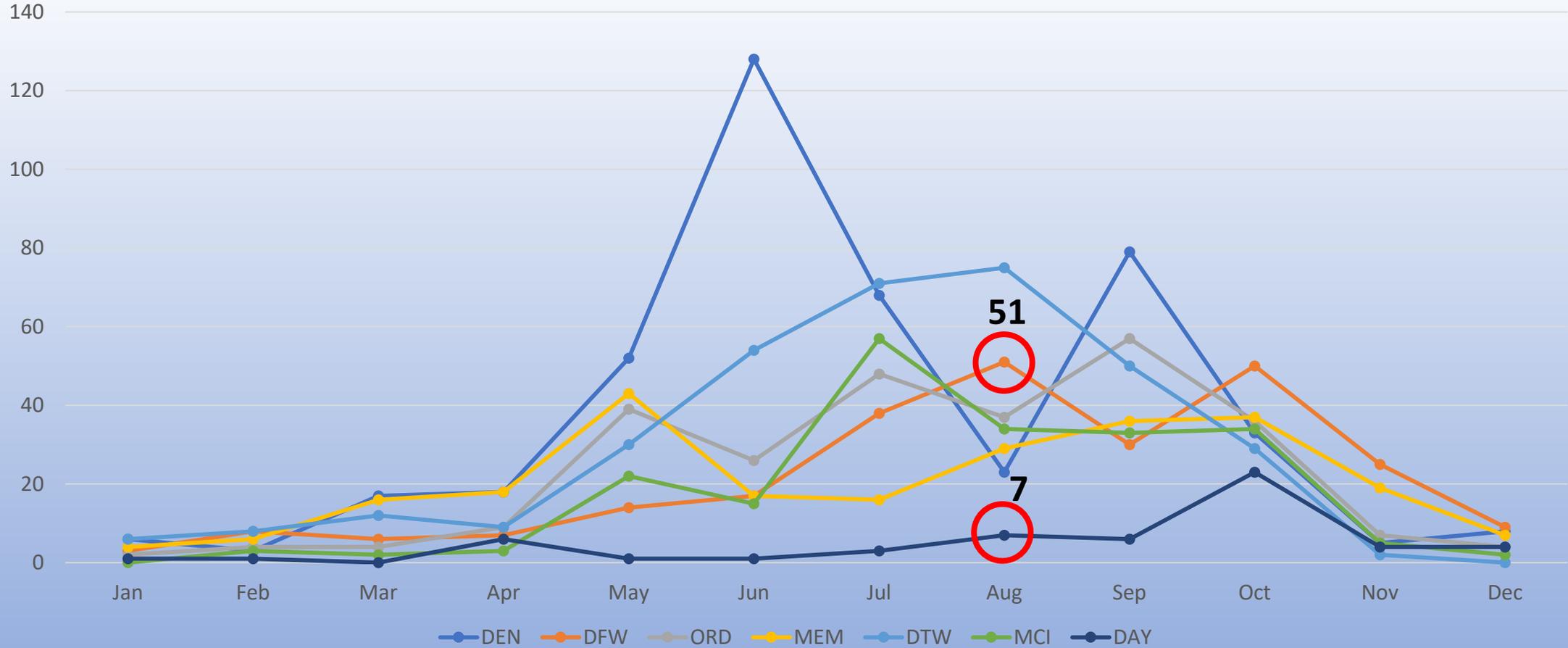
Highest Count Airports by Average Strikes per Year





2018 Strike Count by Month

Count Variance by Month





Bird Strike Count is NOT Strike Risk

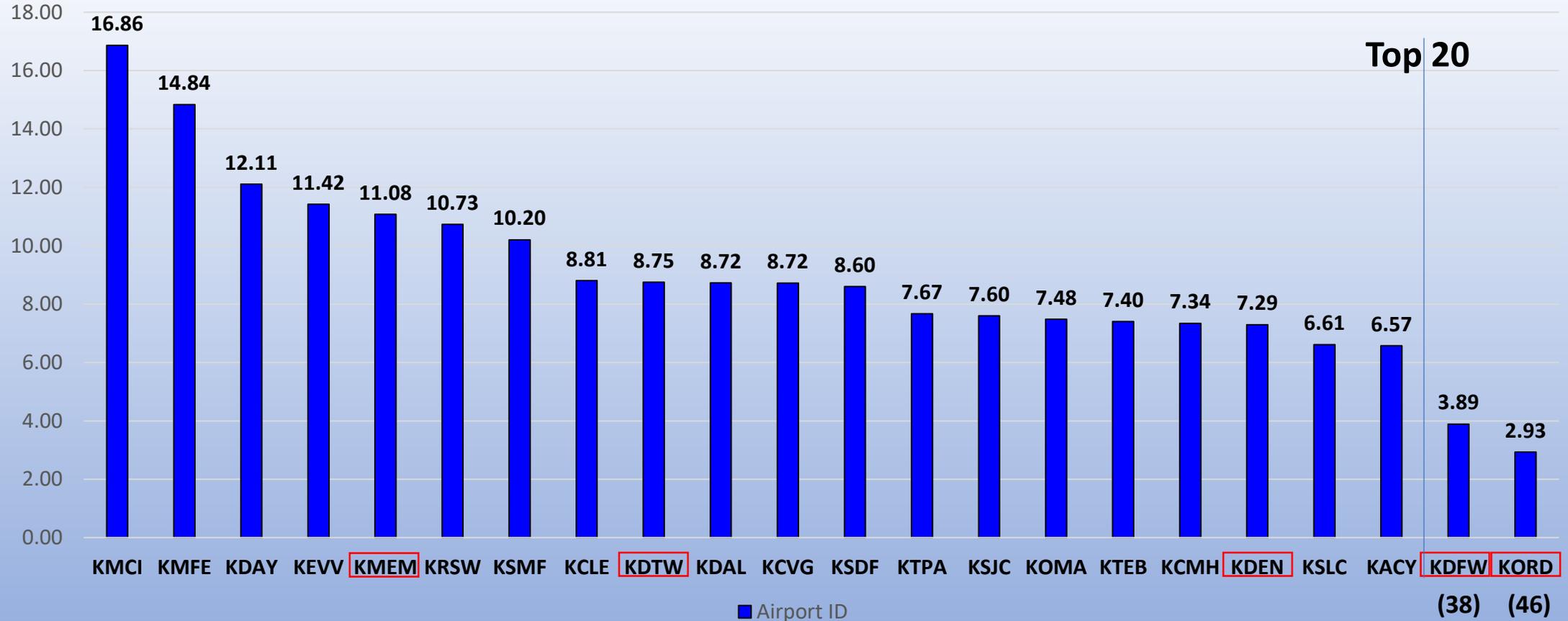


- Risk is number of strikes related to number of flight operations (one takeoff or landing is an operation).
- Total Strikes / Total Operations = Risk per Operation
- Since we can determine historical strikes in a particular month or week, we can predict risk based on historical data and airport operations count.
- Example:
 - In August, 2018 DFW had 51 Strikes while Dayton had 7.
 - DFW ops for August, 2018 was 32,946 while Dayton ops count was 4199.
 - DFW Risk: $51/32,946 = .00155$ DAY Risk: $7/4199 = .00167$
 - DFW Risk is 1.55 strikes per 1k ops while DAY Risk is 1.67 strikes per 1k ops.
 - **STRIKE RISK in August, 2018 was GREATER at DAY than at DFW.**



2018 Annual Highest Risk Airports

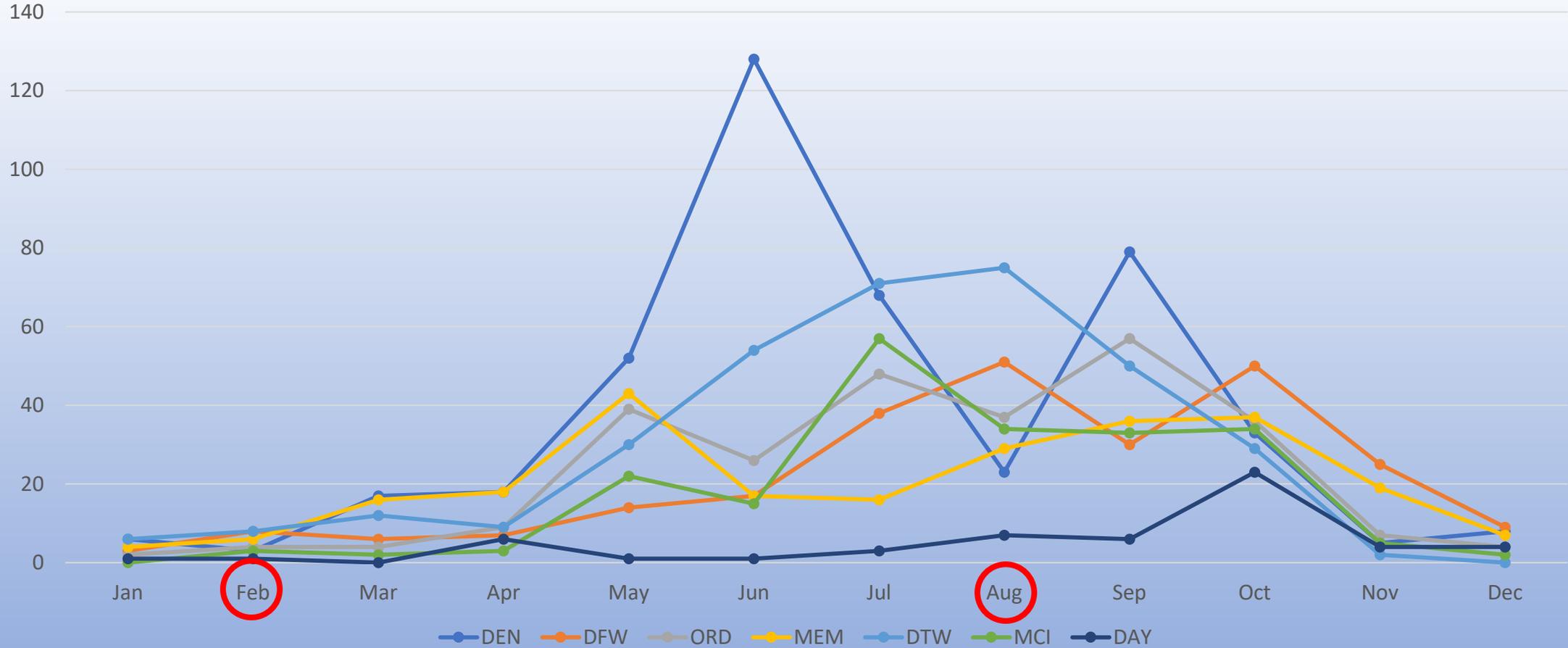
Risk of Strike per 10,000 Operations





2018 Strike Count by Month

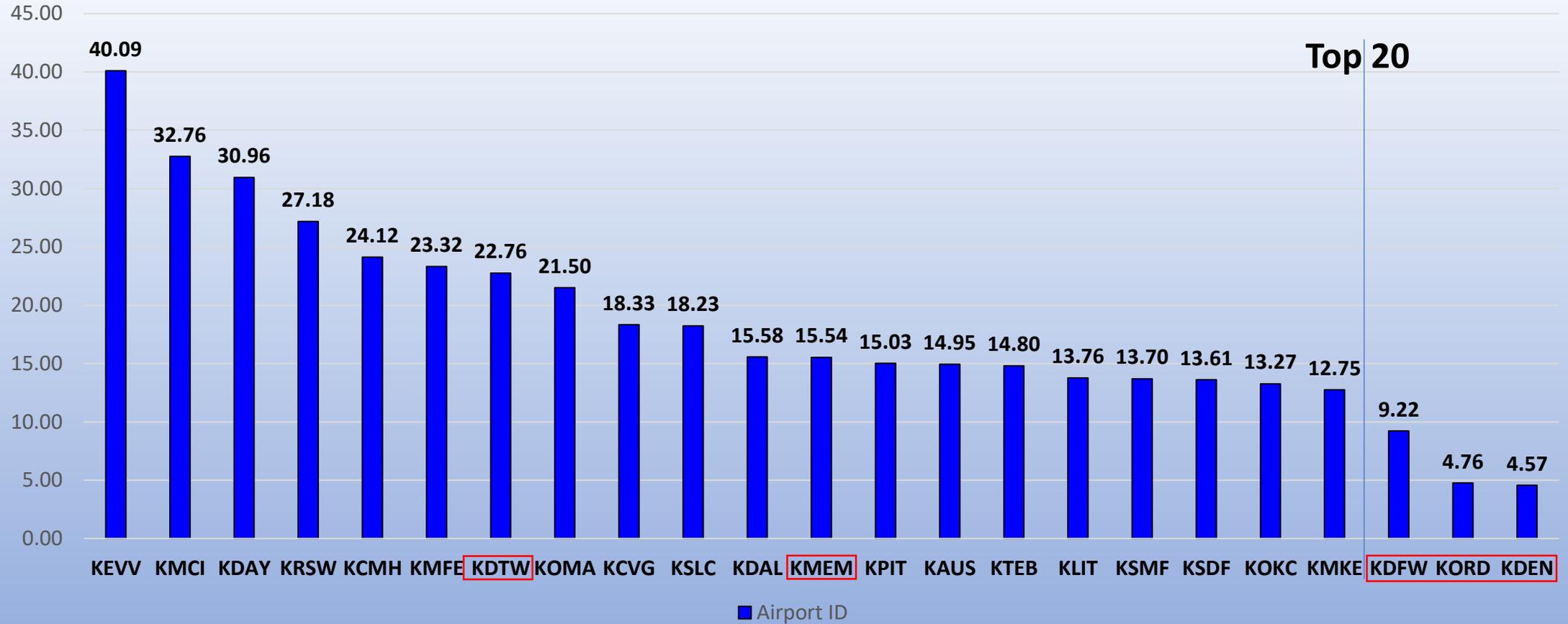
Count Variance by Month





August 2018 Highest Risk Airports

Risk of Strike per 10,000 Operations





Top 3 Bird Threats in August, 2018

- KEVV (Evansville, IN) 12
 - 2018: Killdeer (3), Mourning Dove (2), E. Meadow Lark (1)
 - 6-Year: Mourning Dove (36), Killdeer (15), E. Meadow Lark (7)
- KMCI (Kansas City, MO) 34
 - 2018: Barn/Cliff Swallow(12), Killdeer (6), Mourning Dove (3), E. Meadow Lark (3)
 - 6-Year: Swallows* (35), Larks* (19), Killdeer (9), Mourning Dove (9), SUB (20)
- KDAY (Dayton, OH) 13
 - 2018: Barn Swallow (3), Rock Pidgeon (2), Mourning Dove (2)
 - 6-year: Barn Swallow (18), Killdeer (15), E. Meadowlark (10), European Starling (10)
- KRWS (FT. Myers, FL) 18
 - 2018: Barn Swallow (10), Mourning Dove (3), Common Nighthawk (2)
 - 6-Year: Barn/Tree Swallows (22), E. Meadowlark (14), Mourning Dove (9)
- KCMH (Columbus, OH) 24
 - 2018: Mourning Dove (5), Killdeer (5), Canada Goose (3)
 - 6-Year: Killdeer (21), Barn Swallow (16), Mourning Dove (12), European Starling (10)



February, 2018 Highest Risk Airports



Risk of Strike per 10,000 Operations





Top 3 Bird Threats in February, 2018



- KTPA (Tampa, FL) 7
 - 2018: Mourning Doves 3, Brown Pelican 2, Sand Pipers 2, Snapping Turtle 1
- KOAK (Oakland, CA) 8
 - 2018: Barn Owls 2, Gulls 2, Kestrel 1
- KSMF (Sacramento, CA) 5
 - 2018: Pintail Ducks 2, Gulls 2, Meadowlark 1
- KAUS (Austin, TX) 6
 - 2018: Gull 1, Shrike 1, Mourning Dove 1, Unknown 3
- KMEM (Memphis, TN) 6
 - 2018: Ducks 1, Blue Heron 1, Meadowlark 1, Unk Small 2, Coyote 1



Risk Knowledge Leads to Real Time Use of Smart Countermeasures!

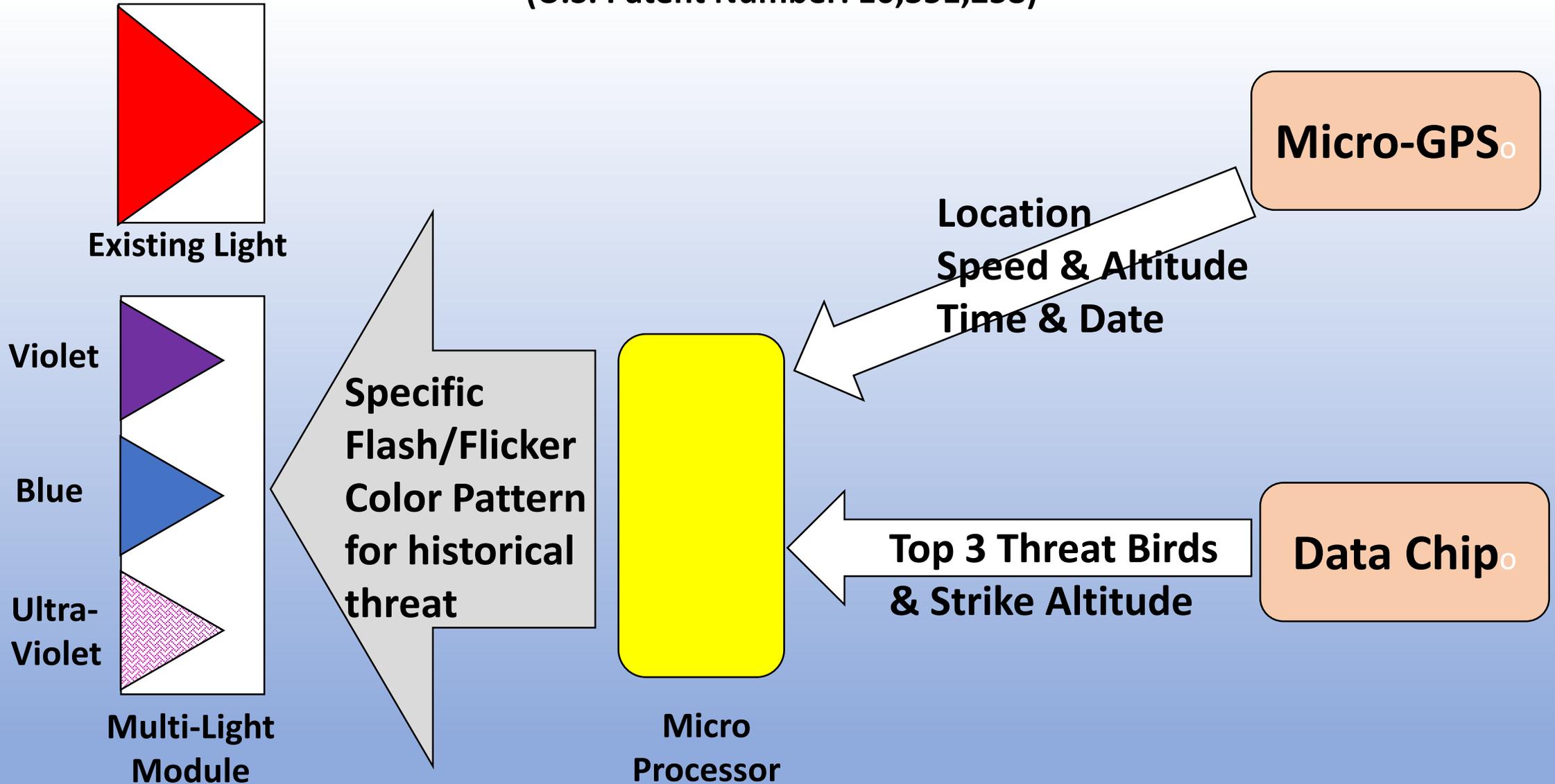


- Strike Risk is NOT RANDOM and can be quantified from historical data connecting location, calendar date, types of expected threats, time of day, etc.
- Real time risk analysis is possible in modern aircraft via relatively simple technology.
- Wildlife Strike Data Base may be on-board an aircraft in a microchip.
- The data base identifies the departure, enroute, and landing threats based on real world historical data and real-time location, altitude, and speed.
 - May be accomplished within each “smart light” without pilot entry.
 - May also be presented to aircrew for part of departure or arrival briefings.
- A “smart” light knows real-time location, speed, and altitude from micro-GPS and adjusts the Counter-Bird lighting for the historical threat on current date, time of day, and types of birds expected.



Counter-Bird “Smart” Lighting Concept

(U.S. Patent Number: 10,351,258)





Departure Threat Screen

(U.S. Patent Number: 10,351,258)

DATE: 18 May 21

TIME: 13:22:43Z

<u>KMEM</u>	<u>1410Z</u>	<u>KSMF</u>	<u>1700Z</u>	<u>340</u>
DEPARTURE ID	ETD	DESTINATION ID	ETA	CRUISE ALT

Departure Threat: (Historical Data from +/- 3 days and +/- 2 Hours of ETD)

- 16 May 20 1440Z 2 x Starlings at 600' MSL L wing RW 18R
- 17 May 20 1333Z 1 x Lark at 500' R Windscreen RW 18R
- 18 May 20 1230Z 1 x Starling at liftoff 50' AGL RW 27
- 18 May 20 1325Z 1 x RT Hawk at 2700' L engine RW 09
- 20 May 20 1605 3 x Starlings on T/O roll R wing and radome 18R

KMEM is #4 in Top 25 Departure Risk CONUS Airports



Arrival Threat Screen

(U.S. Patent Number: 10,351,258)

DATE: 18 May 21

TIME: 16:32:05Z

<u>KMEM</u>	<u>1418Z</u>	<u>KSMF</u>	<u>1722Z</u>	<u>320</u>
DEPARTURE ID	ETD	DESTINATION ID	ETA	CRUISE ALT

Arrival Threat: (Historical Data from +/- 3 days and +/- 2 Hours of ETD)

- 17 May 20 Day NTG 1 x jack rabbit struck on rollout RW 16L
- 17 May 20 1605Z 1 x Swallow 1200' MSL RW 16L
- 19 May 20 1730Z 1 x Small Unknown 5 NM NE 1550 MSL RW 16L

KSMF is #58 in Top 25 Arrival Risk CONUS Airports



What About Landing Lights?



- 1989 USAF Study through Clemson University concluded, *“Birds do not make evasive maneuvers to avoid approaching aircraft(s) with their landing lights on.”*
- The FAA Wildlife Strike Reports seem to support that conclusion.
- Landing light design, location, and operational usage should change in high bird threat areas.
- Landing light modifications should significantly decrease night and dusk strike events.

SECURITY CLASSIFICATION OF THIS PAGE			
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11. TITLE (Include Security Classification) RADAR TECHNIQUES FOR AIR FORCE APPLICATIONS IN AVOIDANCE OF BIRD-AIRCRAFT COLLISIONS AND IMPROVEMENT OF FLIGHT SAFETY			
12. PERSONAL AUTHOR(S) Sidney A. Gauthreaux, Jr.			
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM 6/1/78 TO 12/31/78	14. DATE OF REPORT (Year, Month, Day) 1 February 1979	15. PAGE COUNT 10
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Evaluation of the influence of aircraft landing lights on flight behavior of migrating birds at night has been completed. Birds do not make evasive maneuvers to avoid approaching aircrafts with their landing lights on. Evaluation of the AN/TVS-5 image intensifier shows that it is an ideal instrument to use in quantifying and monitoring bird migrations. The correlation between migration traffic rate and the density of bird echoes on the radar screen is identical on different nights when the magnitude of migration is the same. An automatic system composed of an image intensifier in combination with a closed circuit television video tape system has been developed to gather more accurate data on nocturnal migration. <i>Keywords: bird strike; collision avoidance; radar; nocturnal bird migration; animal migration; etc.</i>			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL		22b. TELEPHONE (Include Area Code) 767-4278	22c. OFFICE SYMBOL NL



What About Daytime?

- The Left/Right Bias Report shows a 6.4% difference, apparently from wingtip light color.
- We expect a reduction in daytime strikes with more specialized modifications which are in work now.
- 62% of fixed-wing strikes are in daylight; helos are 50%/50%.





Many Bird Strikes Are Undetected

- Total Data 2013 - 2018 81,698 Strikes
- Total Known 70,944
- Total Undetected by Crew 10,754
- Undetected Strike Percentage 13.2%
- 41% of total strikes were into an engine 33,496
- Undetected Engine Strikes 4,409
- Undetected engine strikes are dangerous because in many cases, the engine could have been saved from gradual self-destruction.
- Often after a bird strike, a pilot's first question is, "Did we take one into an engine?"
- Catastrophic damage is obvious, but undetected moderate or even minor damage can progress into an engine loss.

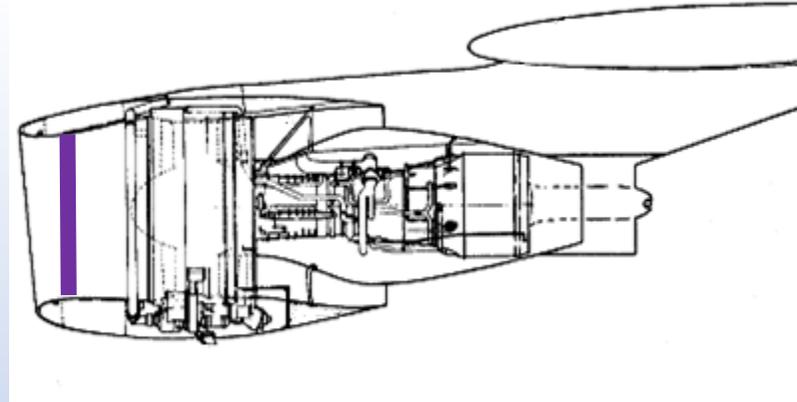


Specialized Intake Lighting

(U.S. Patent Number: 10,351,258)



Laser Barrier
Inside Intake



- Makes engine **MUCH MORE VISIBLE** to birds.
- Provides **Positive Confirmation** and **Count** of “bird into engine” events.

Potential to identify
impact points





Our Solution: Address the Bird's 3D Problem and Help Him Avoid Impacting the Aircraft

- **Detect** the aircraft.
 - Introduce highly visible attention-getting lighting patterns based on the threat.
 - Selectively illuminate the aircraft with no negative effects on crew or ops.
 - Modify landing light patterns and colors.
 - Help birds detect and avoid engines based on the local bird threats.
- **Decide** if the aircraft is a threat to him.
 - Use lighting that helps birds decide that the aircraft is a threat.
 - Use visible cues to appear as a natural enemy.
- **Defeat** the perceived threat/attack by the aircraft.
 - Earlier detection, tracking, and escape decisions will increase successful avoidance of the aircraft.



Counter-Bird Lighting- The Next Logical Step

(U.S. Patent Number: 10,351,258)



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QUESTIONS?