FLIGHT SAFETY FOUNDATION

2010 Annual C-FOQA Statistical Summary Report

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Enclosed is a statistical summary of Flight Operations Quality Assurance (FOQA) results for flight data processed through the Austin Digital Inc. eFOQA Event Measurement System (EMS). By opening this packet you indicate your acceptance in protecting the proprietary and confidential information of Austin Digital Inc. The enclosed information cannot be distributed, data manipulated in any manner, or otherwise reproduced.

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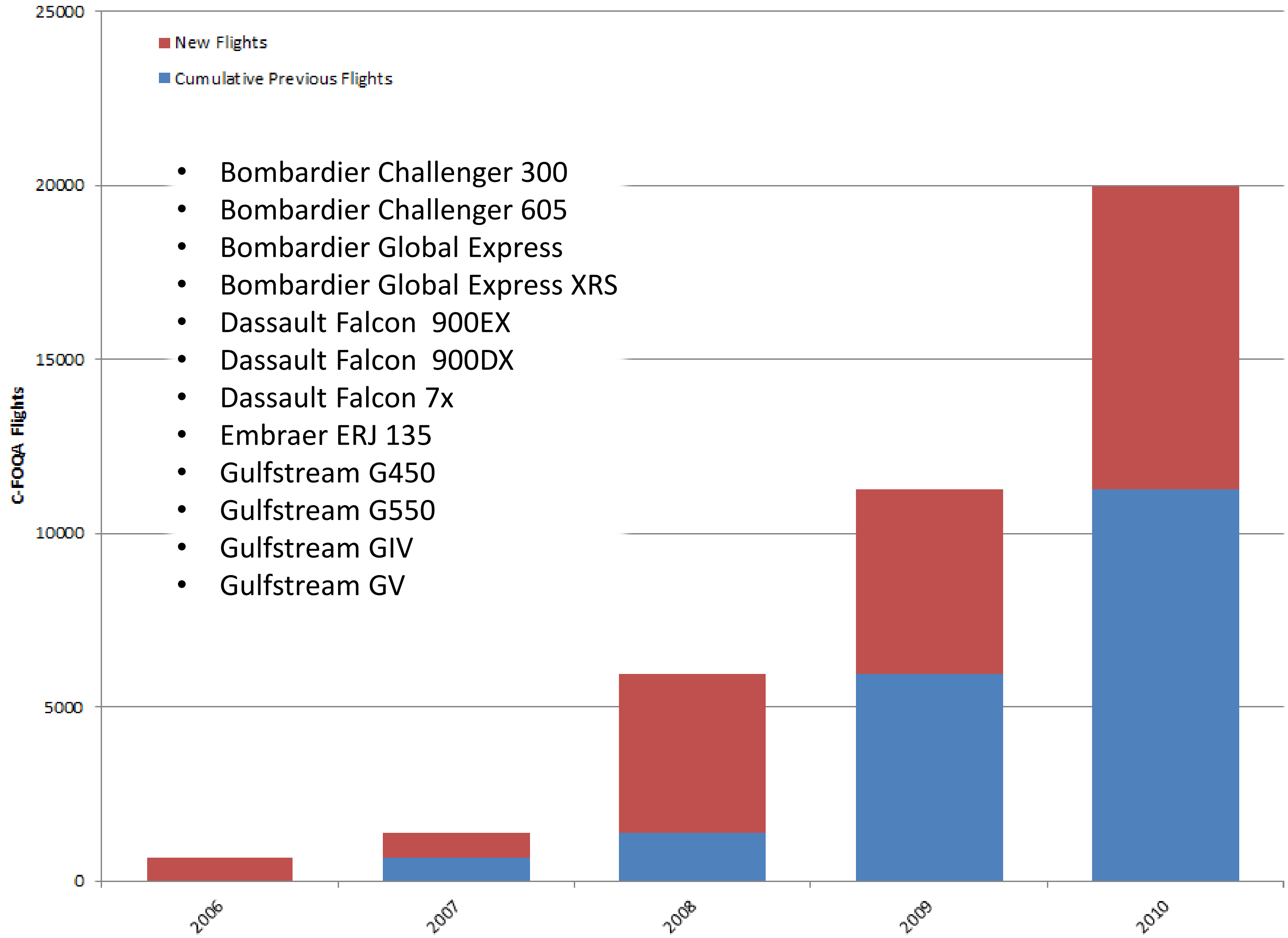
C-FOQA Enrollment

As of Q4 2010, 46 aircraft of the following types contributed to the aggregated C-FOQA data set:

- Bombardier Challenger 300
- Bombardier Challenger 605
- Bombardier Global Express
- Bombardier Global Express XRS
- Dassault Falcon 900EX
- Dassault Falcon 900DX
- Dassault Falcon 7x
- Embraer ERJ 135
- Gulfstream G450
- Gulfstream G550
- Gulfstream GIV
- Gulfstream GV



Reprocessing of Historical Data

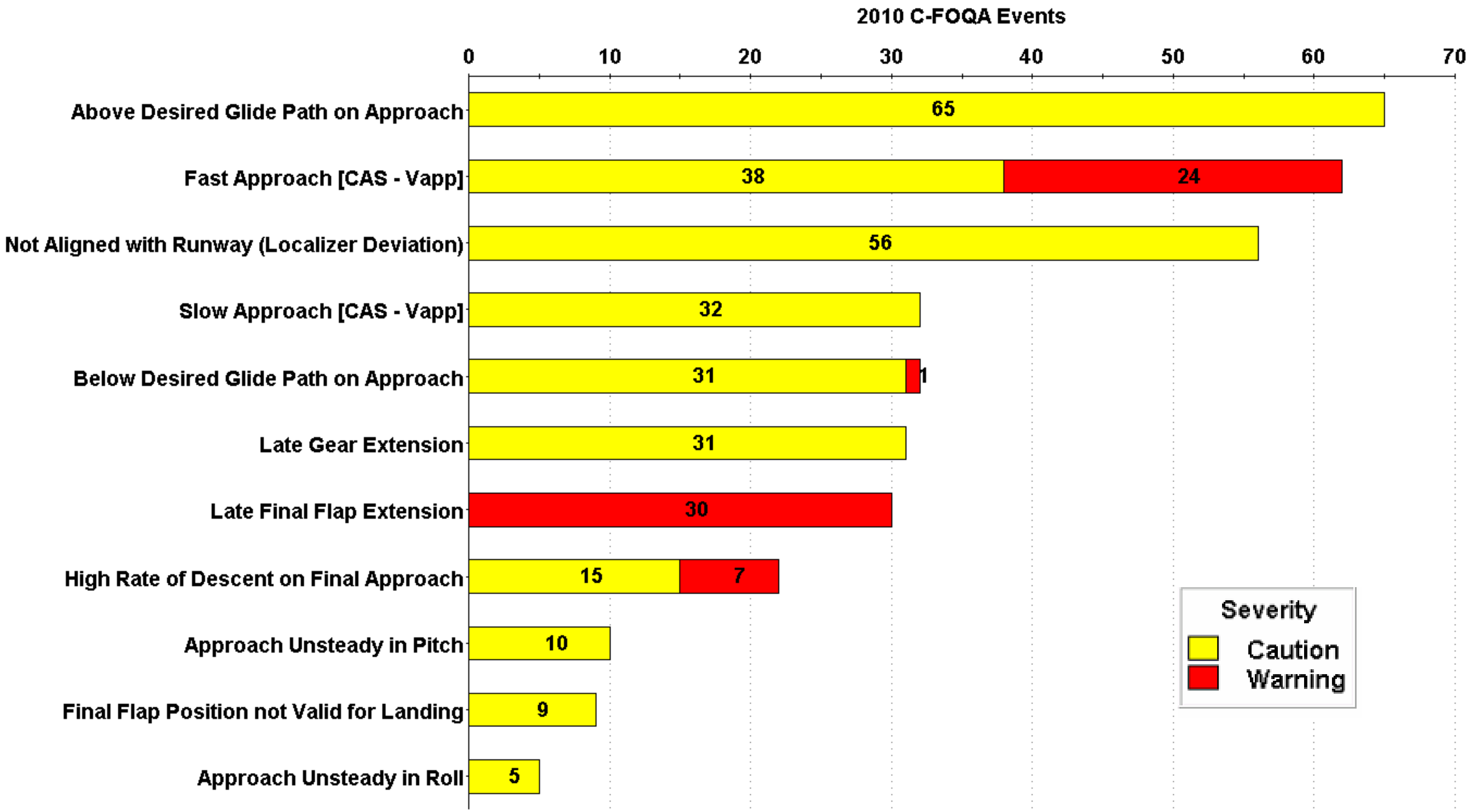
Due to the evolving nature of the C-FOQA program, event definitions and triggering limits may have changed since enrollment. Because of this, it was deemed necessary to reprocess all of the data using the current (as of March 2011) configuration.

The advantage of reprocessing all of the data with the same configuration is that it assures that all the trend numbers are compared to the same standard which in turn allows you to have a normalized trending comparison. This is more indicative of actual operational trends and removes the need to compensate for changes in the configuration over the years.

Section I: C-FOQA Operation Summary

This section contains C-FOQA's operational performance and event rates for 2010.

Breakdown of Unstable Approach Events by Type (2010)



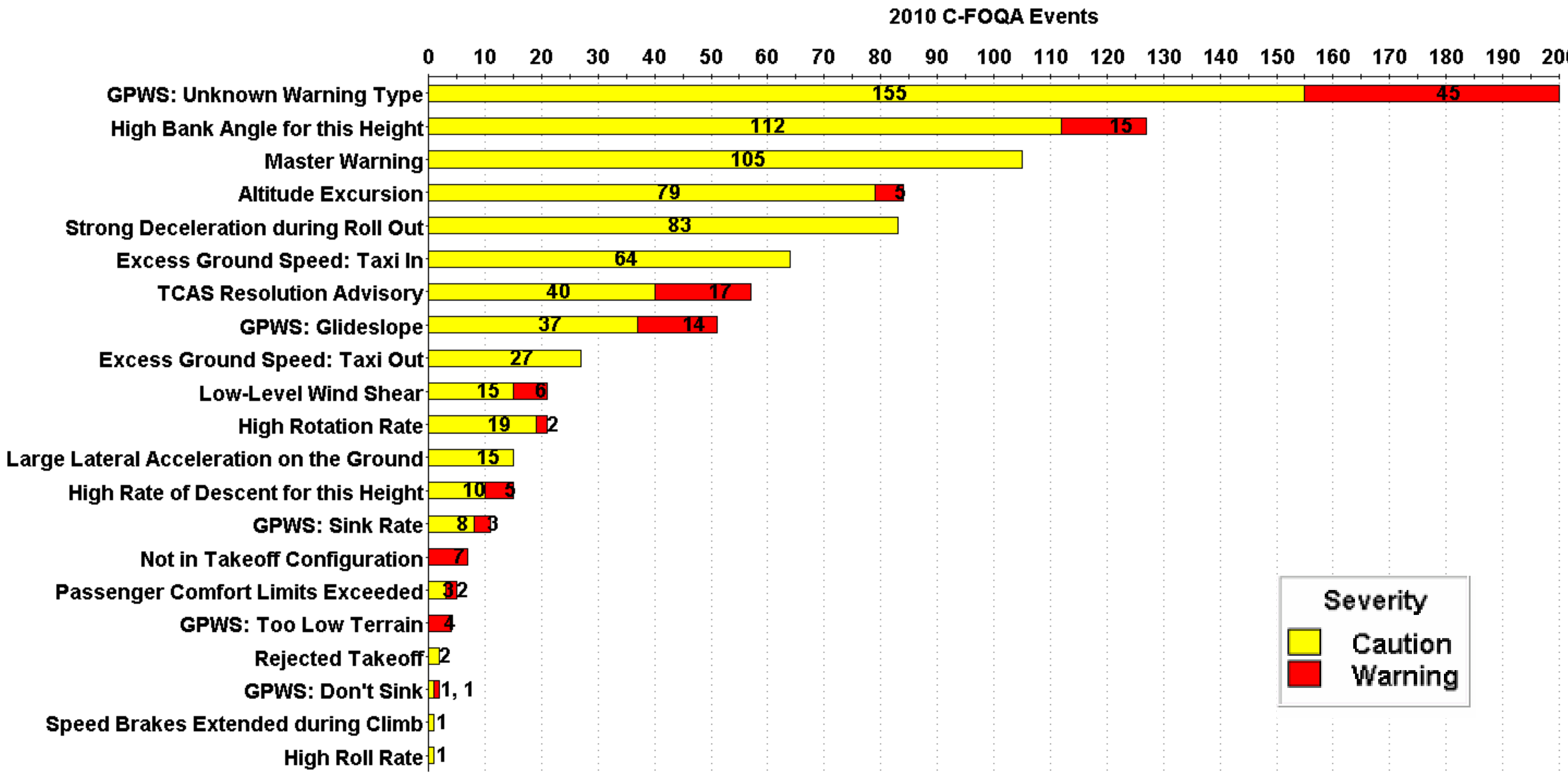
Breakdown of Aircraft Limitation Events by Type (2010)

Event Type	Caution Events	Warning Events
EGT Limit Exceedance	0	0
Airspeed Low Relative to Stall Speed	0	0
Stall Warning	0	0
Climb Airspeed Low Relative to Vmca	0	0
VMO (Max Operating Velocity) Limit Exceedance	**1**	0
MMO (Max Operating Mach) Limit Exceedance	**5**	**1**
Flap/Slat Altitude Limit Exceedance	0	0
VFE (Flap Airspeed) Limit Exceedance	**69**	**3**
Slat Airspeed Limit Exceedance	0	0
VLE (Gear-Down Airspeed) Limit Exceedance	0	0
MLE (Gear-Down Mach) Limit Exceedance	0	0
VLO (Gear Retraction Airspeed) Limit Exceedance	**1**	0
VLO (Gear Extension Airspeed) Limit Exceedance	**6**	**1**
Takeoff Weight Limit Exceedance	0	0
Vtire (Tire Speed) Limit Exceedance	0	0
Upper Maneuv. Load Limit Exceedance (Flaps Up)	0	0
Upper Maneuv. Load Limit Exceedance (Flaps Down)	0	0
Lower Maneuv. Load Limit Exceedance (Flaps Up)	0	0
Lower Maneuv. Load Limit Exceedance (Flaps Down)	0	0
Max Operating Altitude Exceedance	**1**	0
Takeoff Altitude too High	0	0
Slat Mach Limit Exceedance	0	0
Taxi Weight Limit Exceedance	0	0
Landing Weight Limit Exceedance	0	0
Brake Temperature Limit Exceedance (Takeoff)	0	0
Brake Temperature Limit Exceedance (Taxi In)	0	0
Fuel Temperature Too Low	0	**1**
Fuel Temperature Too High	0	0

Breakdown of Aircraft Maintenance Events by Type (2010)

Event Type	Caution Events	Warning Events
Engine Fire	0	0
Smoke Warning	0	**1**
Uncommanded Pitch	0	0
Uncommanded Roll	0	0
Uncommanded Yaw	0	0
Roll Attitude Disagreement	0	**1**
Pitch Attitude Disagreement	0	0
Thrust Reversers Not Stowed while Airborne	0	0
No Fuel Flow	0	0
Low Hydraulic Pressure	**1**	**3**
Cabin Pressure Warning	0	**1**
Engine Stall or Surge In-Flight	0	0
Reverse Thrust while Slow	**188**	0
Hard Landing (vertical speed method)	0	0

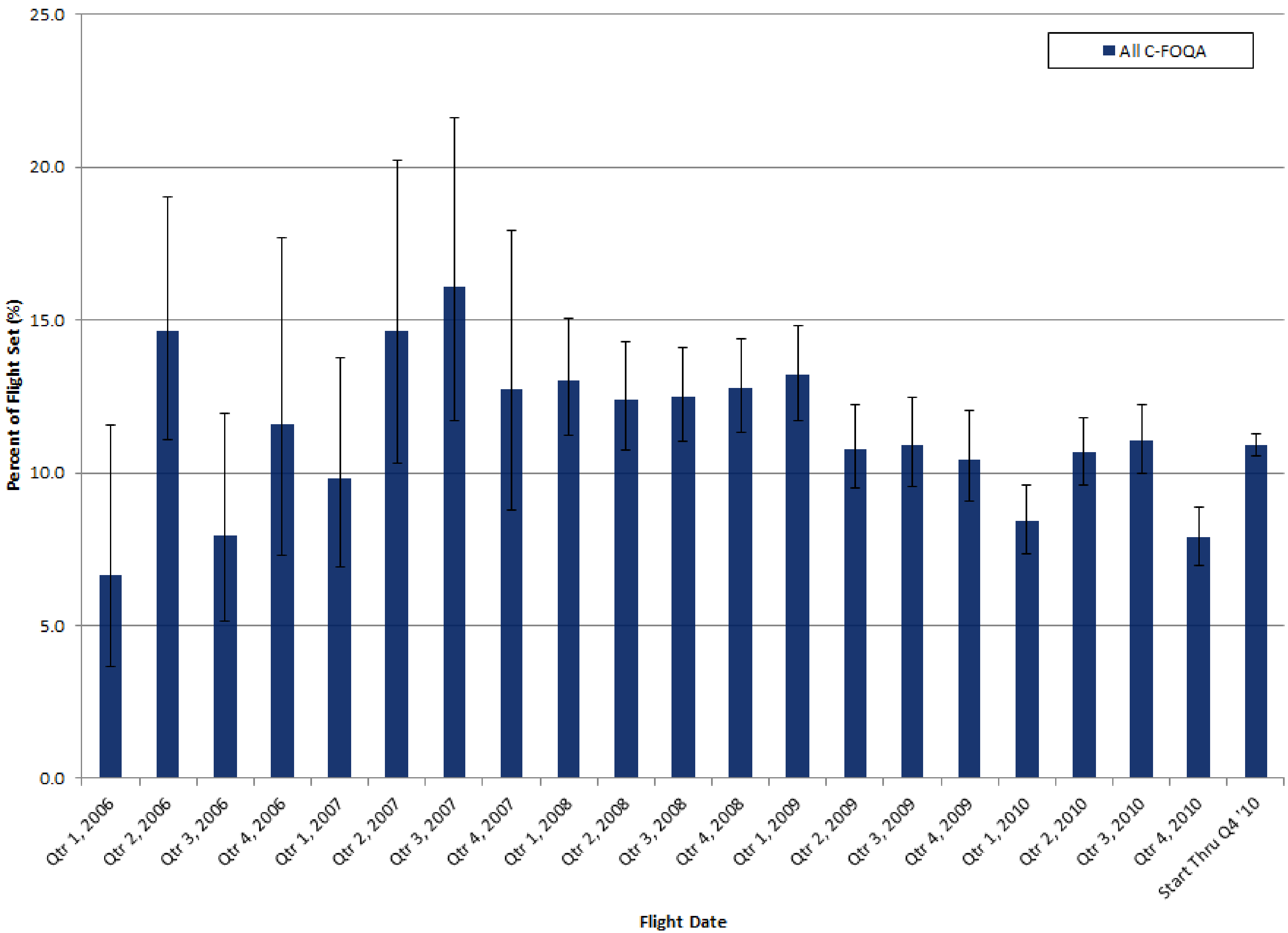
Breakdown of Flight Operations Events by Type (2010)



Section II: Flight Operations Trending

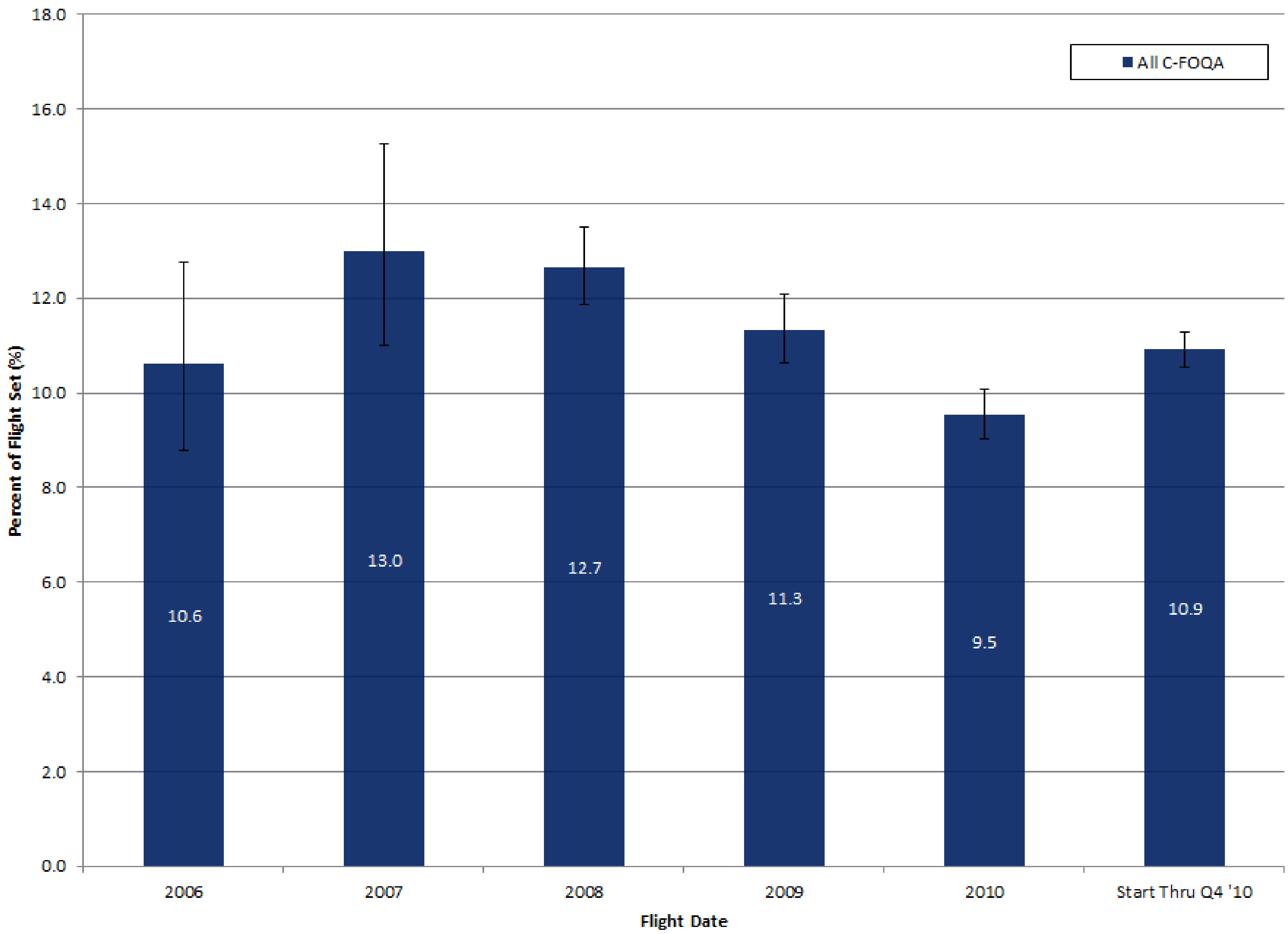
This section contains C-FOQA's Flight Operations performance and event rates.

Quarterly Flight Operations Event Rates



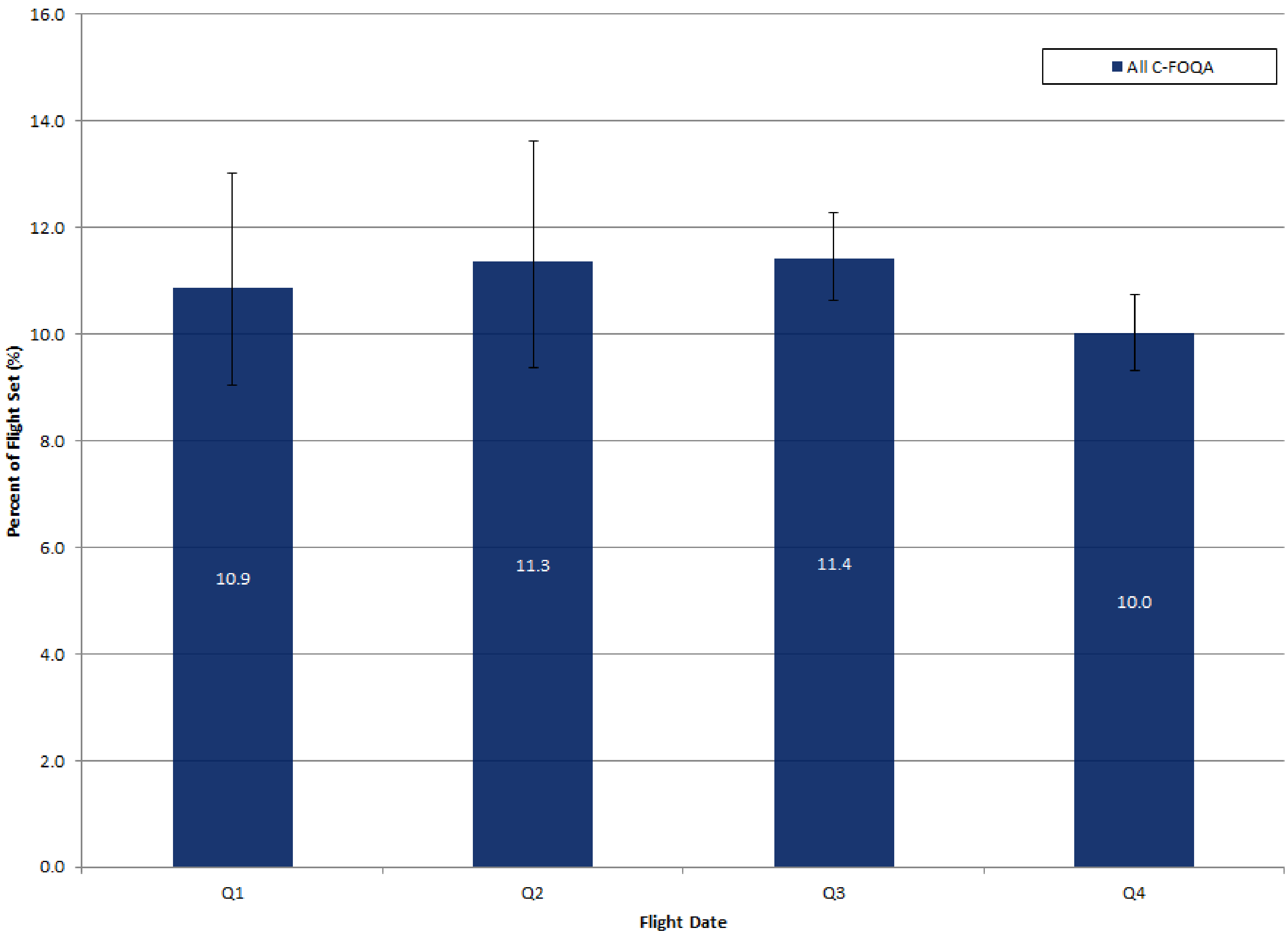
***Error Bars Calculated with 90% confidence interval**

Annual Flight Operations Event Rates



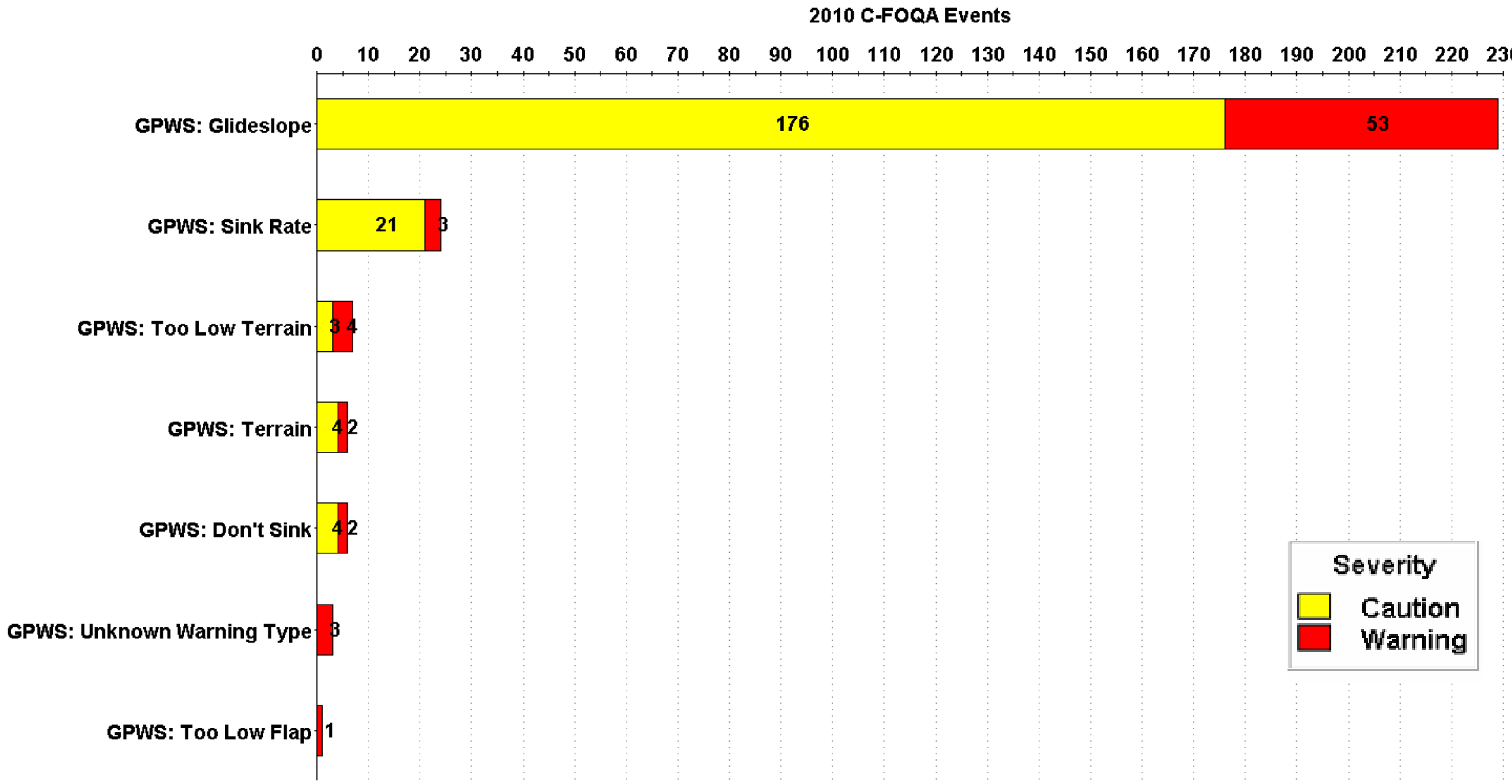
***Error Bars Calculated with 90% confidence interval**

Seasonal Flight Operations Event Rates



*Error Bars Calculated with 90% confidence interval

Breakdown of GPWS Events by Type (2010)*



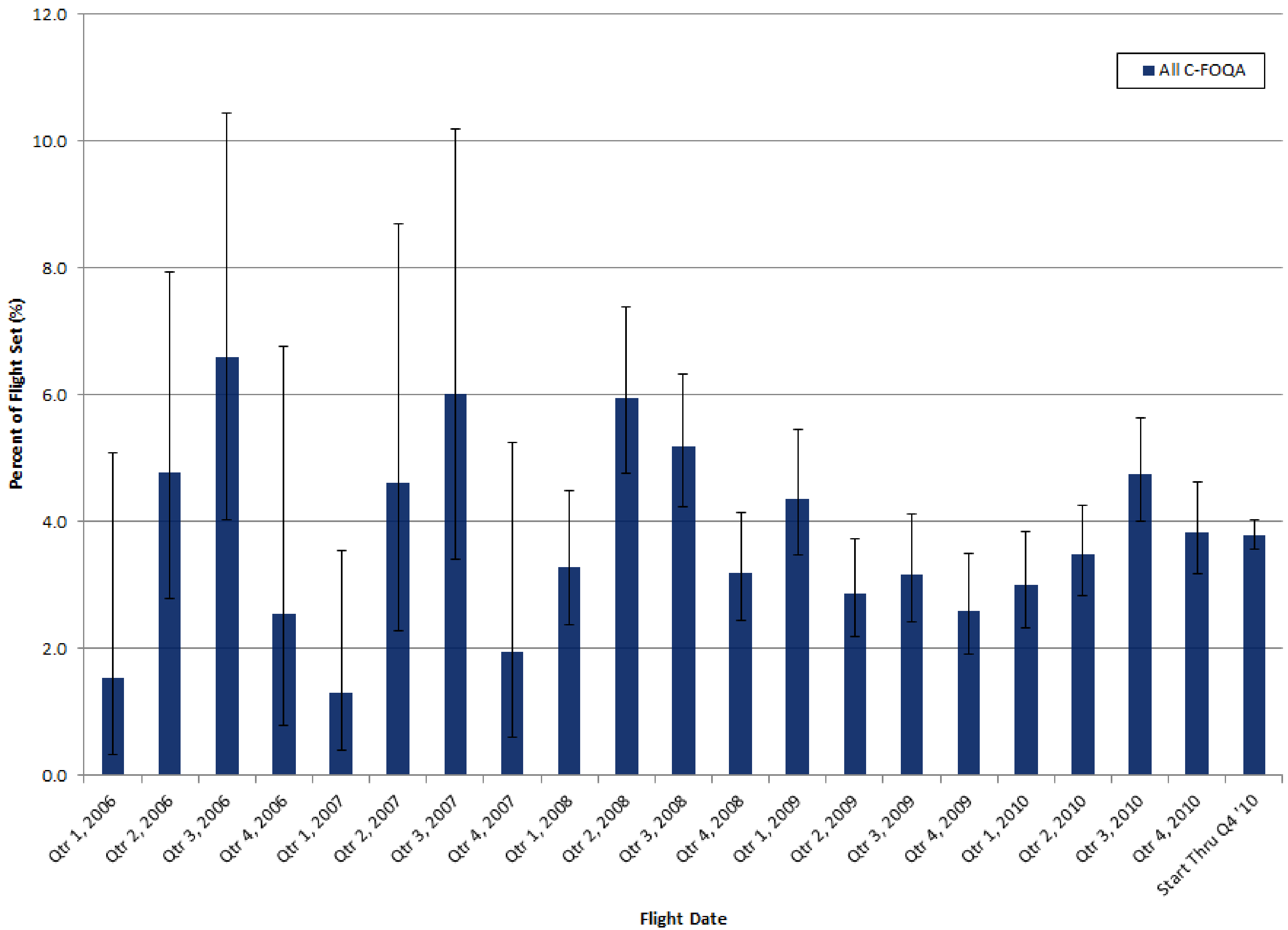
*** This slide represents all GPWS events that occurred over the previous year. For events where the GPWS warning type is not explicitly indicated from the recorded data (i.e. GPWS: Unknown Warning Type), an emulation of the possible GPWS mode envelopes is used to estimate the most likely cause for the alert. The GPWS emulation algorithm may result in the removal or addition of events.**

Section III: Approach Stability Trending

This section contains C-FOQA's approach performance and event rates.

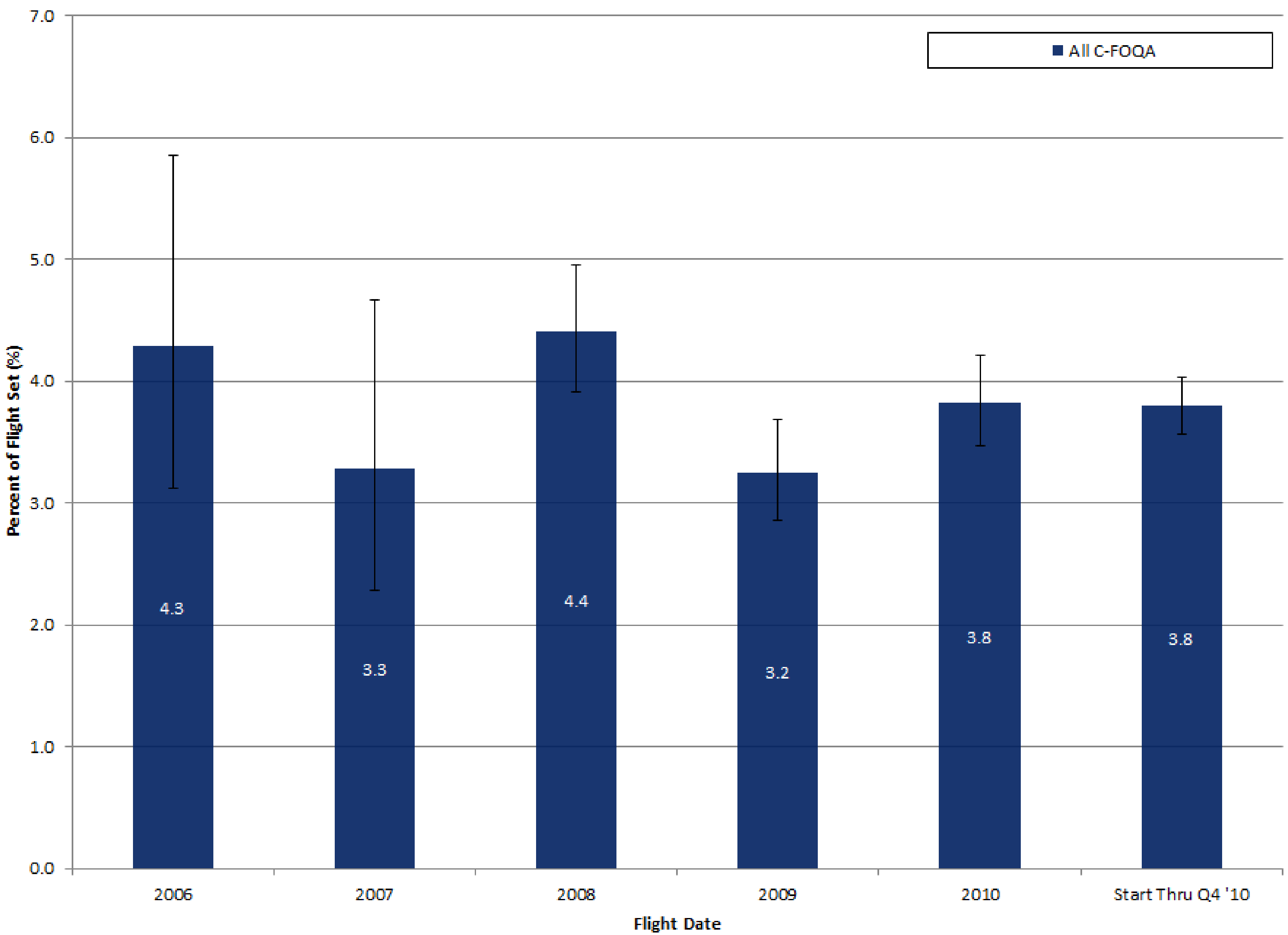
The C-FOQA Standard Event Limits (C-FOQA SEL), established by the Flight Safety Foundation, are used for group analysis and can be found in the Appendix.

Quarterly Unstable Approach Event Rates



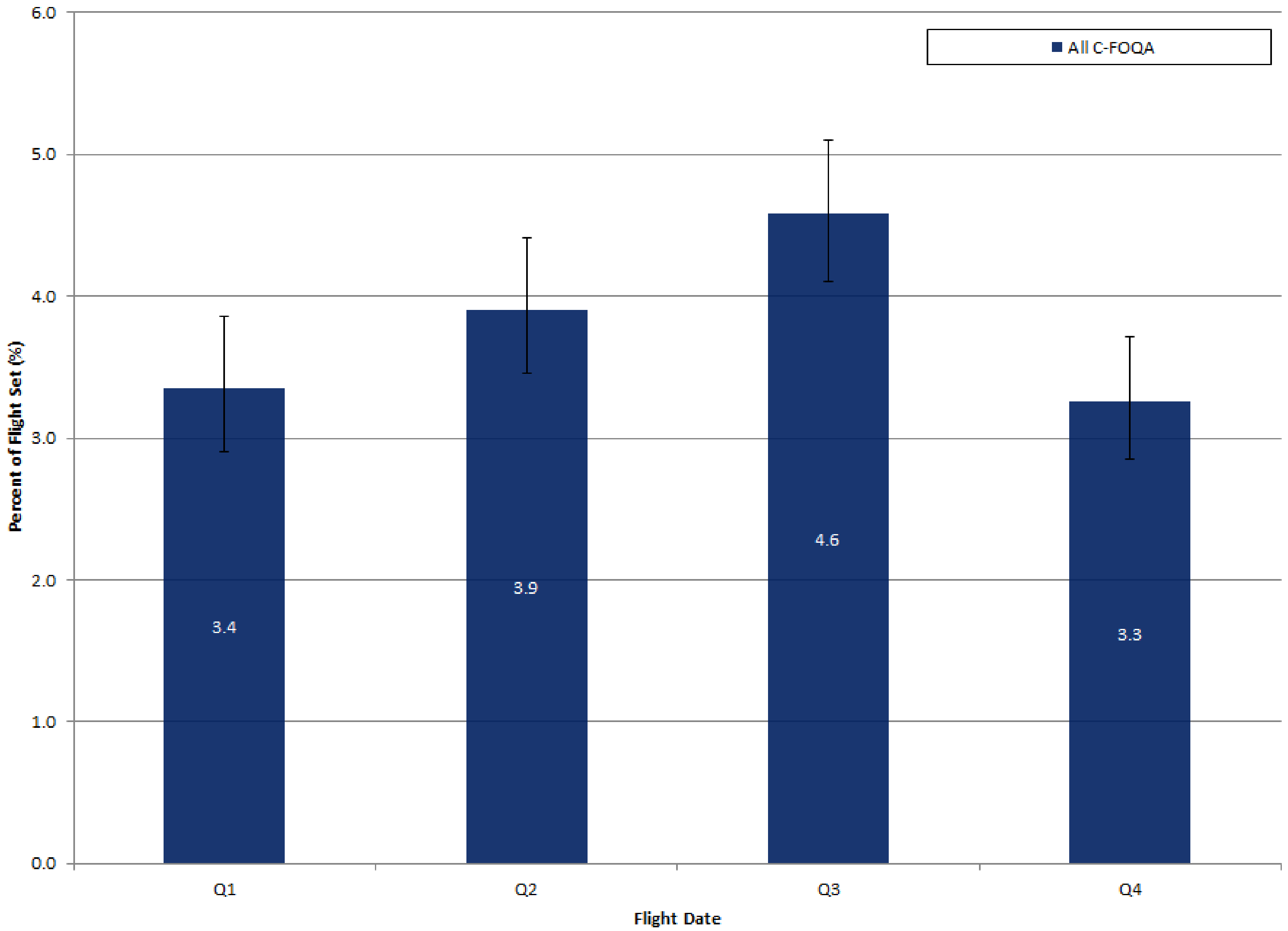
***Error Bars Calculated with 90% confidence interval**

Annual Unstable Approach Event Rates



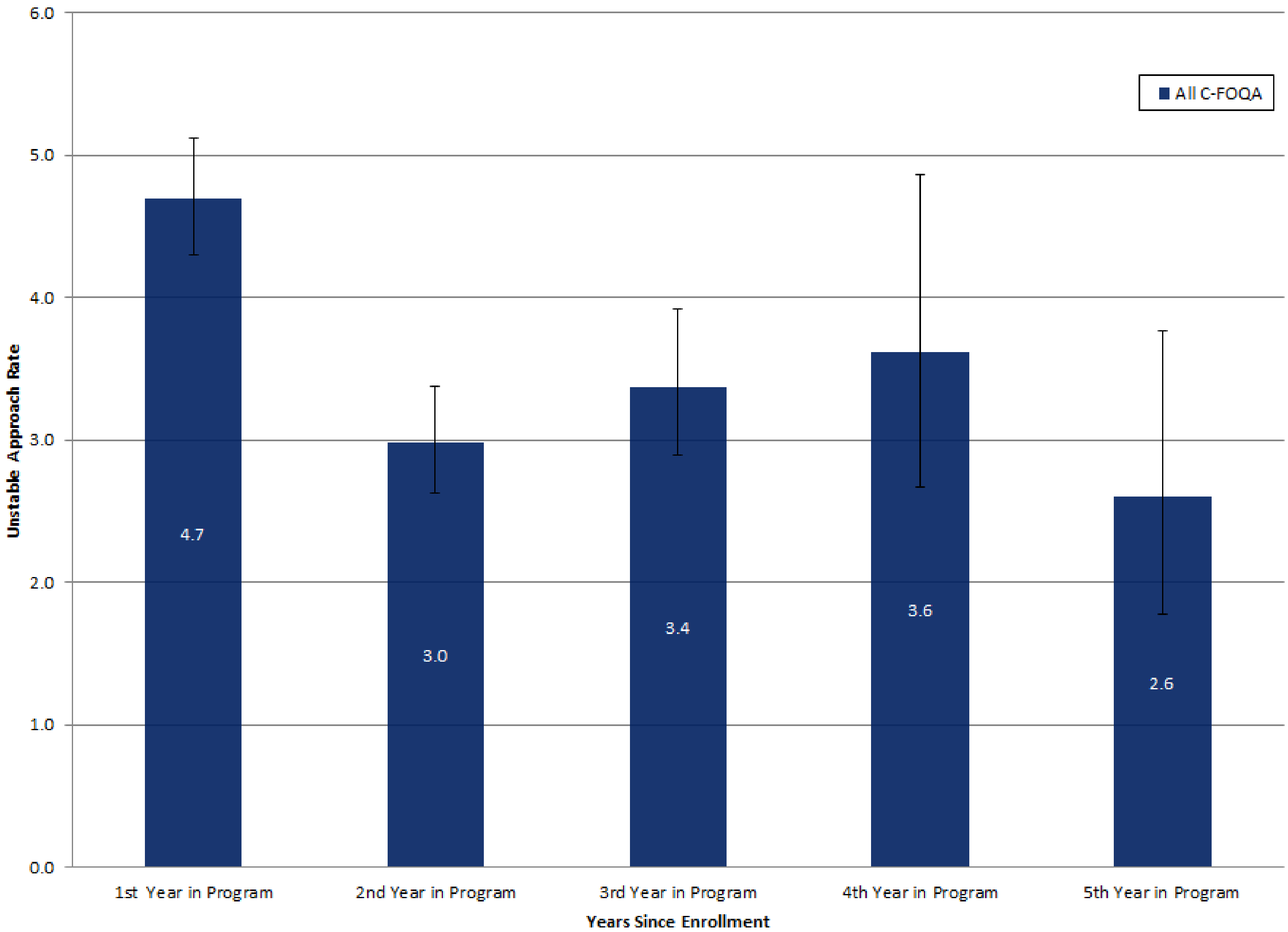
***Error Bars Calculated with 90% confidence interval**

Seasonal Unstable Approach Event Rates



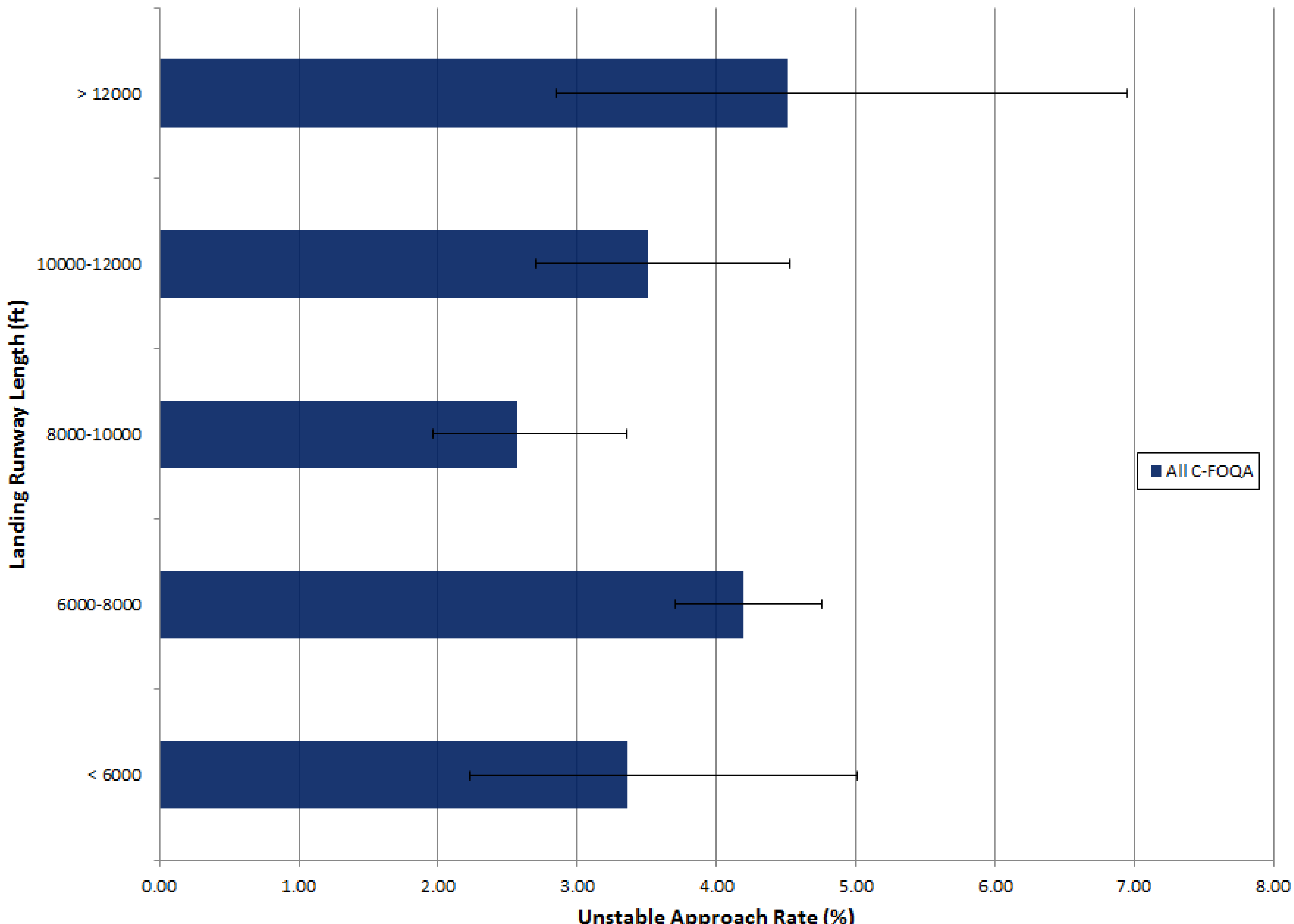
***Error Bars Calculated with 90% confidence interval**

Enrollment Duration Unstable Approach Event Rates



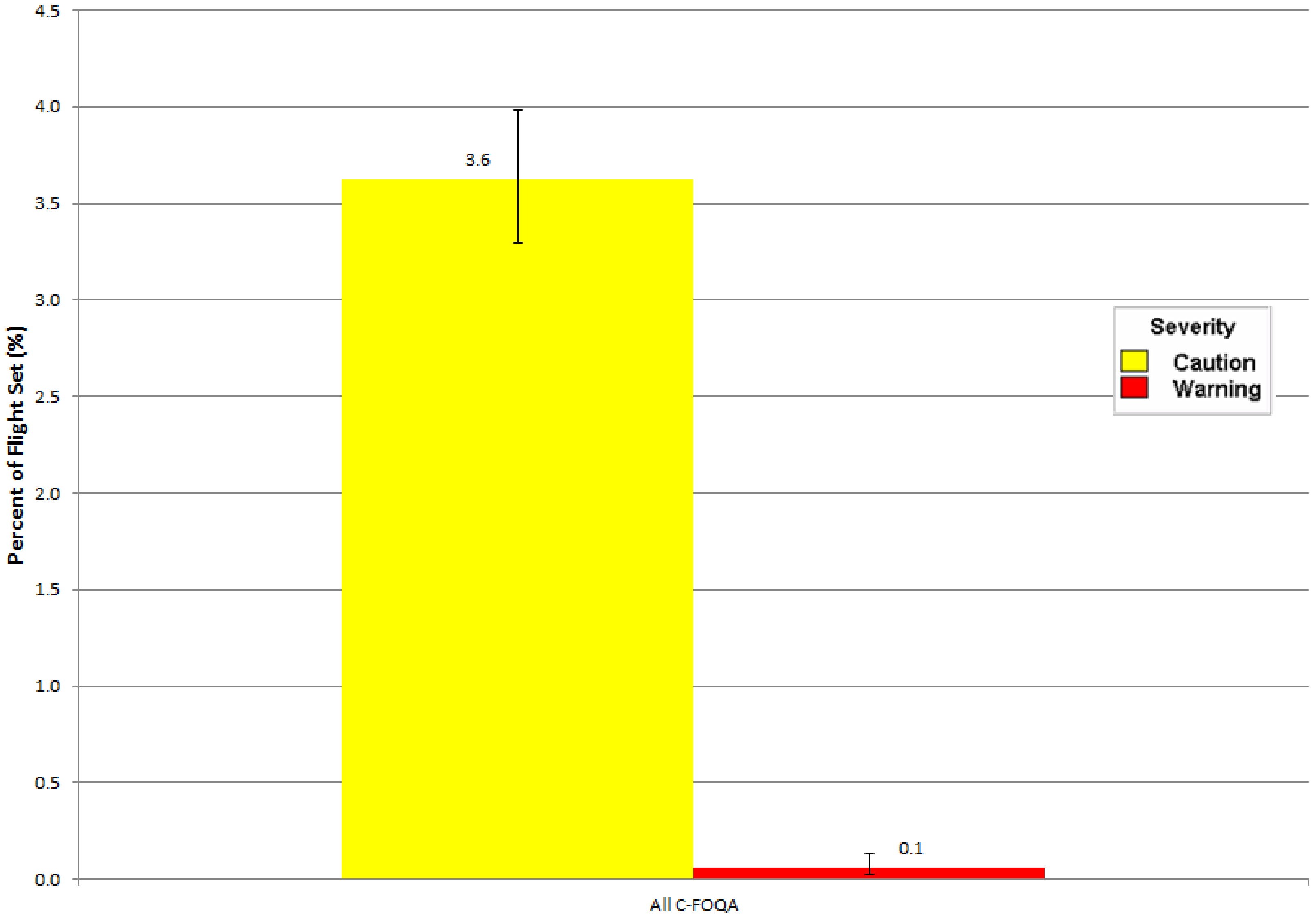
*Error Bars Calculated with 90% confidence interval

Unstable Approach Rates by Runway Length - Comparison to Group (2010)



***Error Bars Calculated with 90% confidence interval**

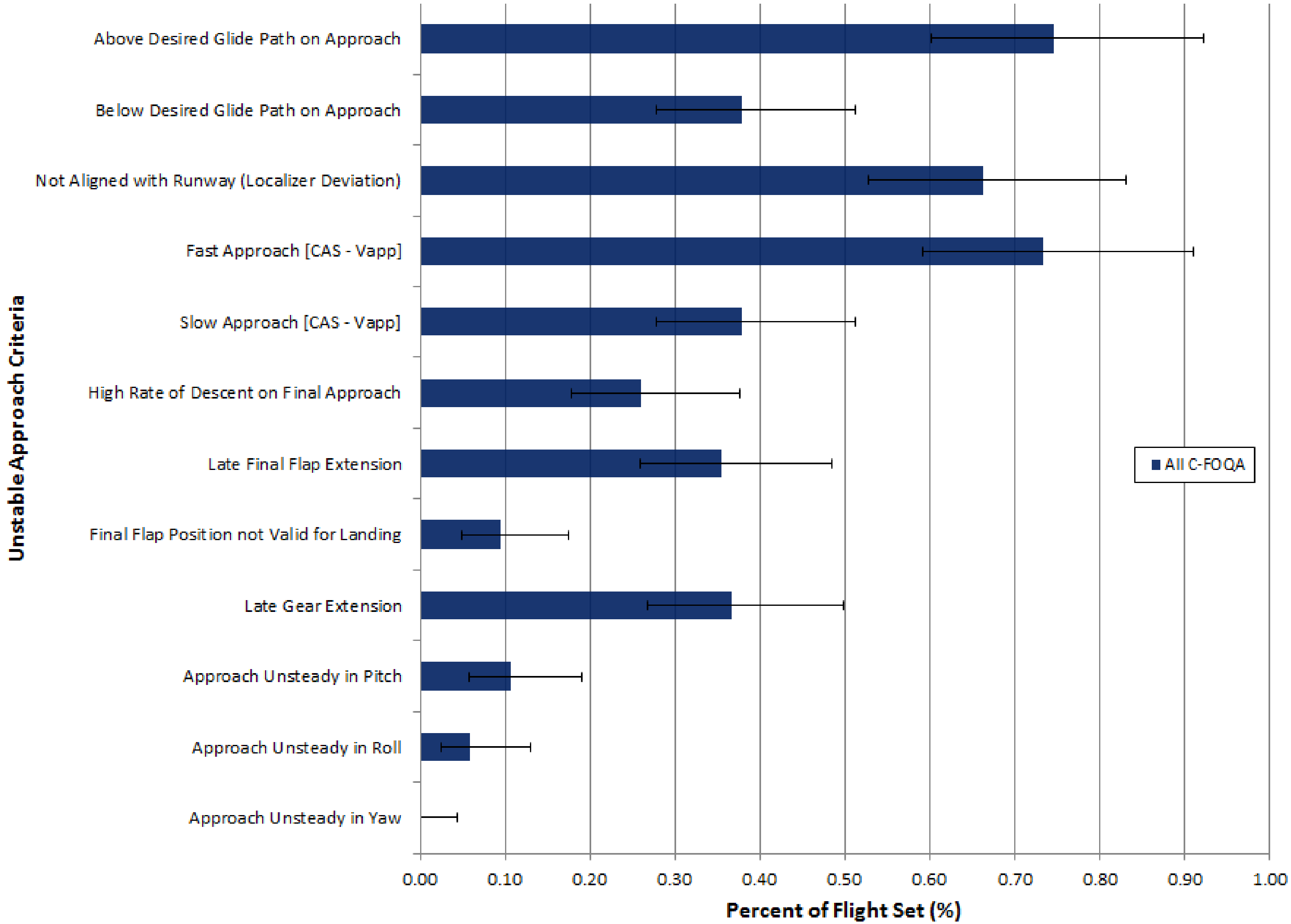
Unstable Approach Event Rates and Severity- Comparison to Group (2010)



*Error Bars Calculated with 90% confidence interval

**Rates are computed using the total number of valid flights for 2010

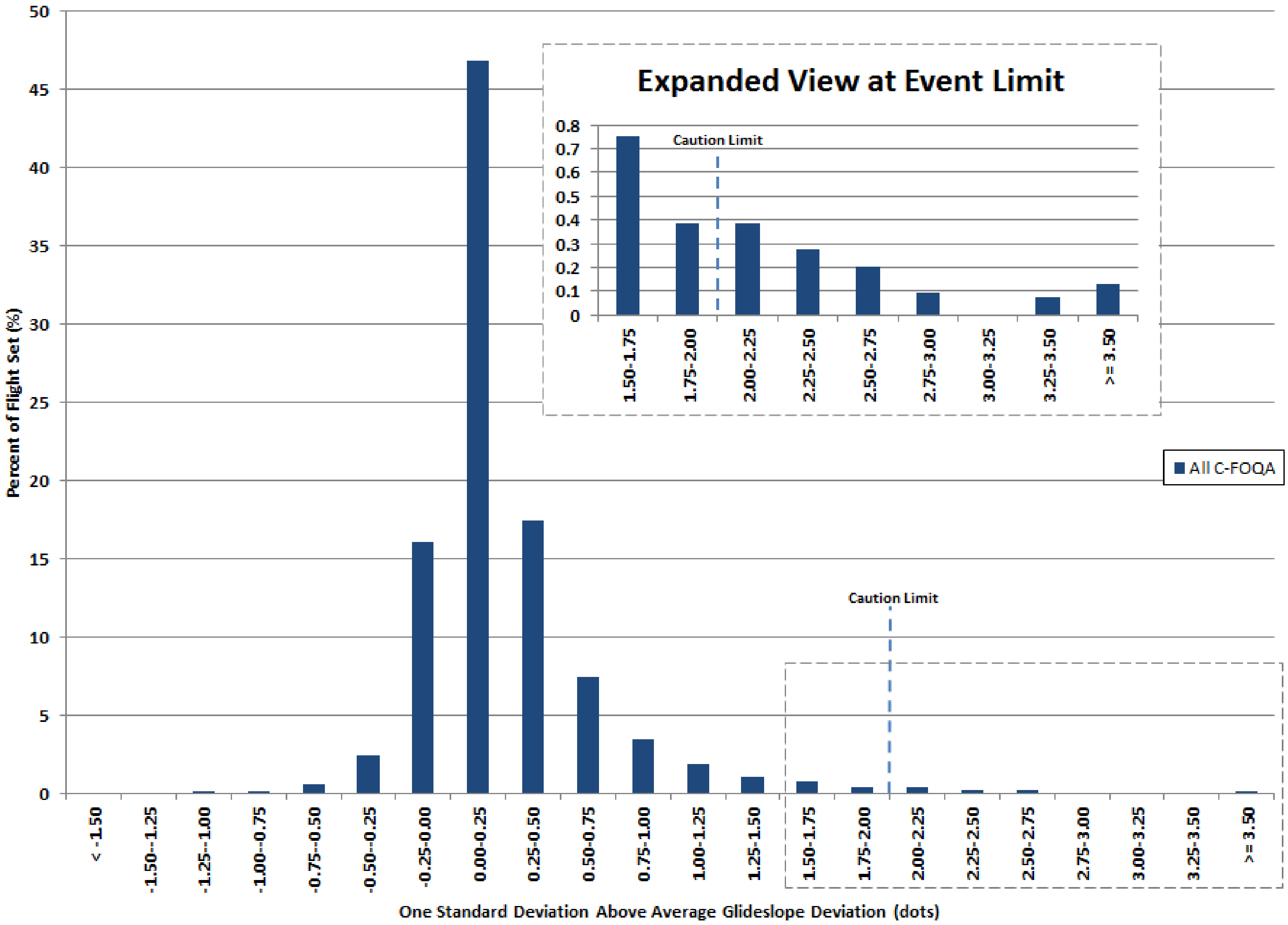
Unstable Approach Rates by Cause - Comparison to Group (2010)



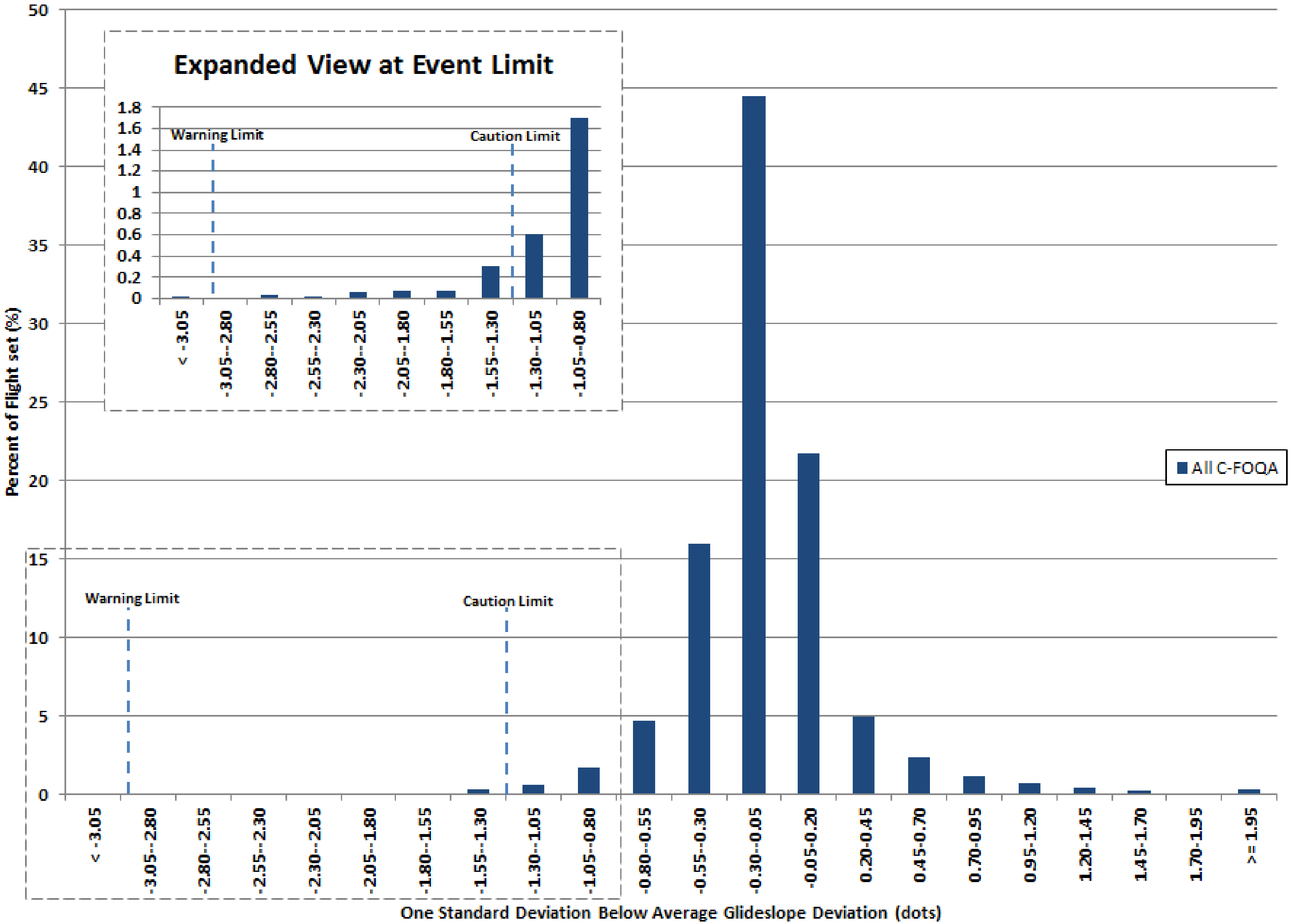
*Error Bars Calculated with 90% confidence interval

**Rates are computed using the total number of valid flights for 2010

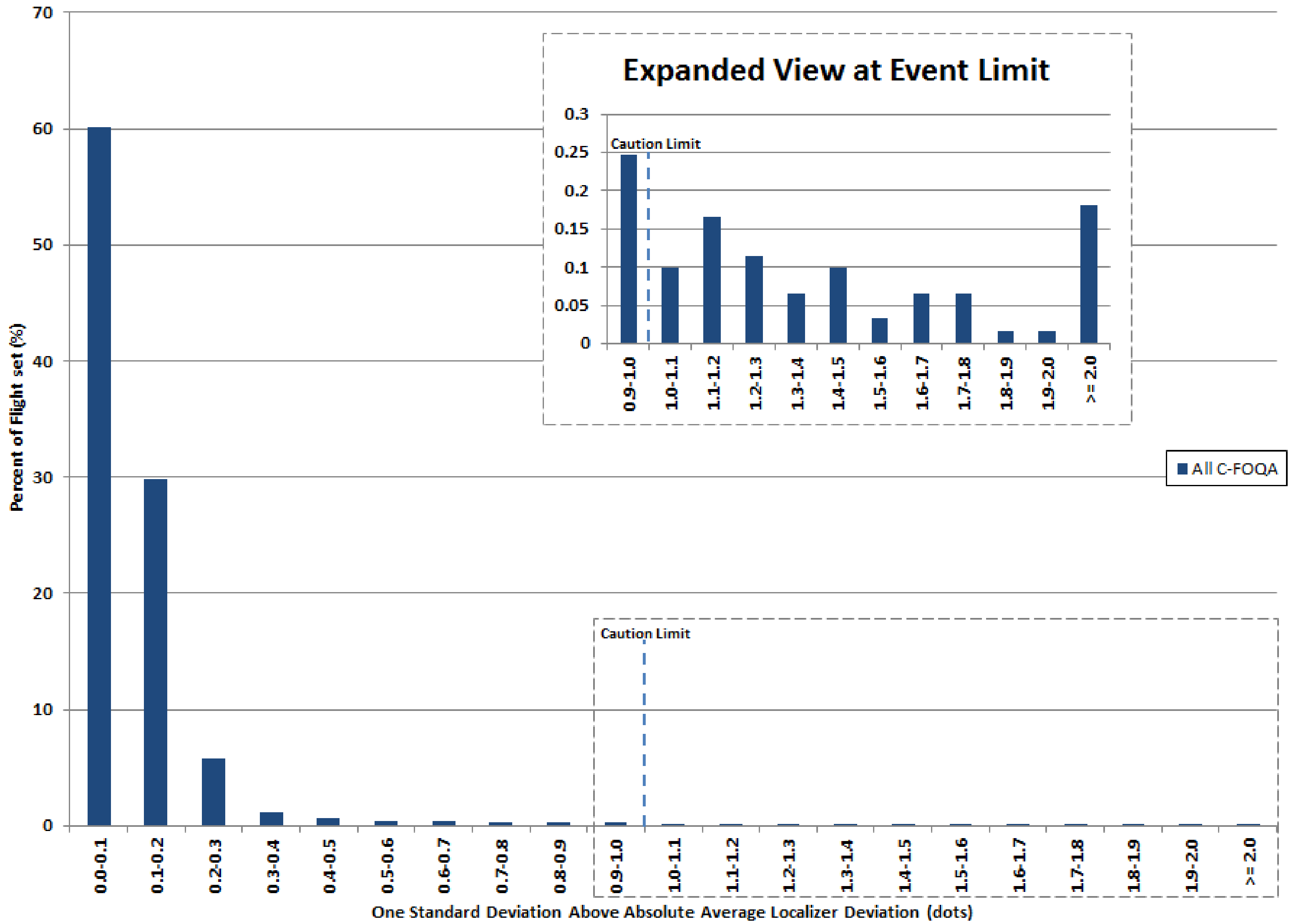
Above Desired Glide Path Distribution (2010)



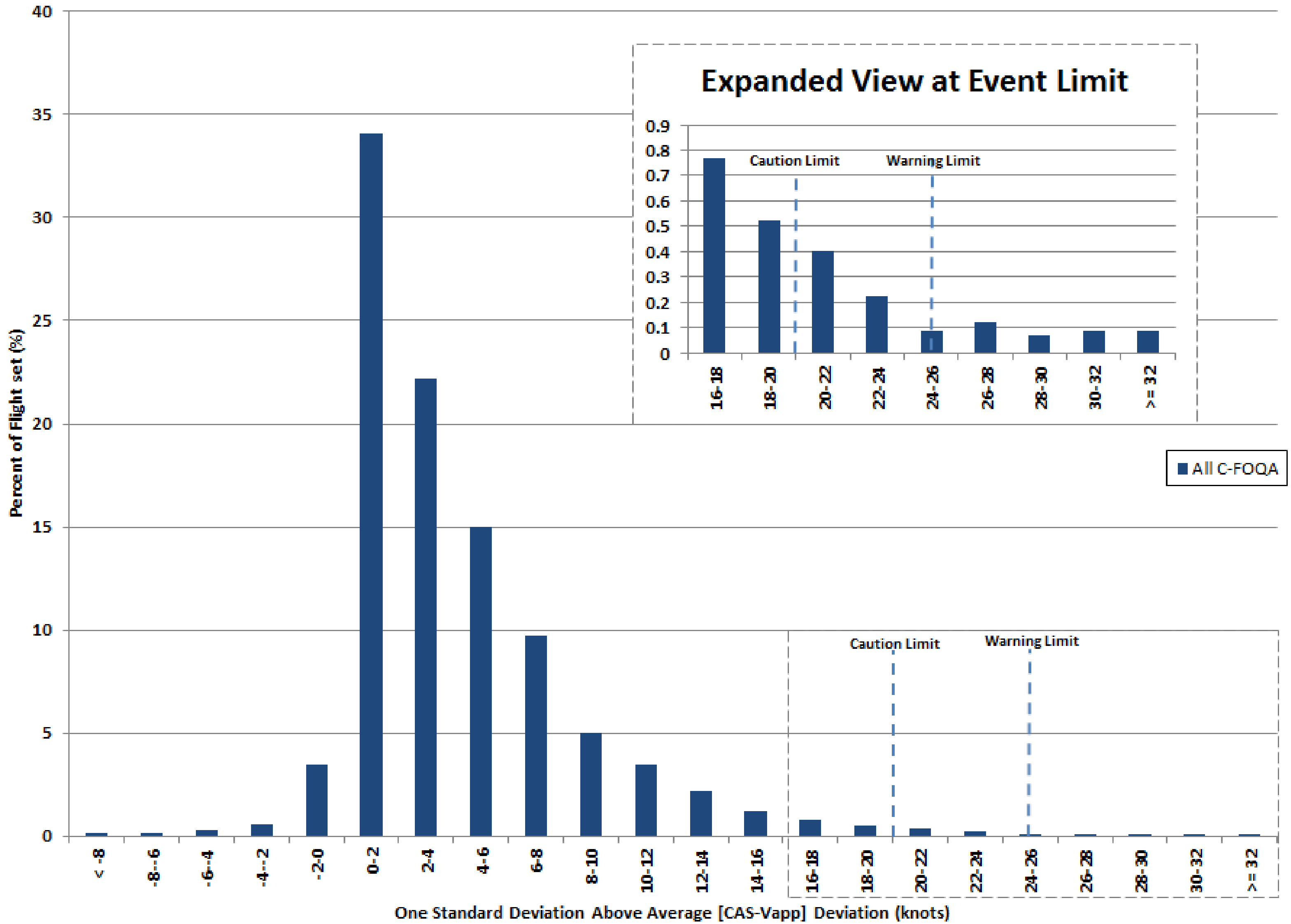
Below Desired Glide Path Distribution (2010)



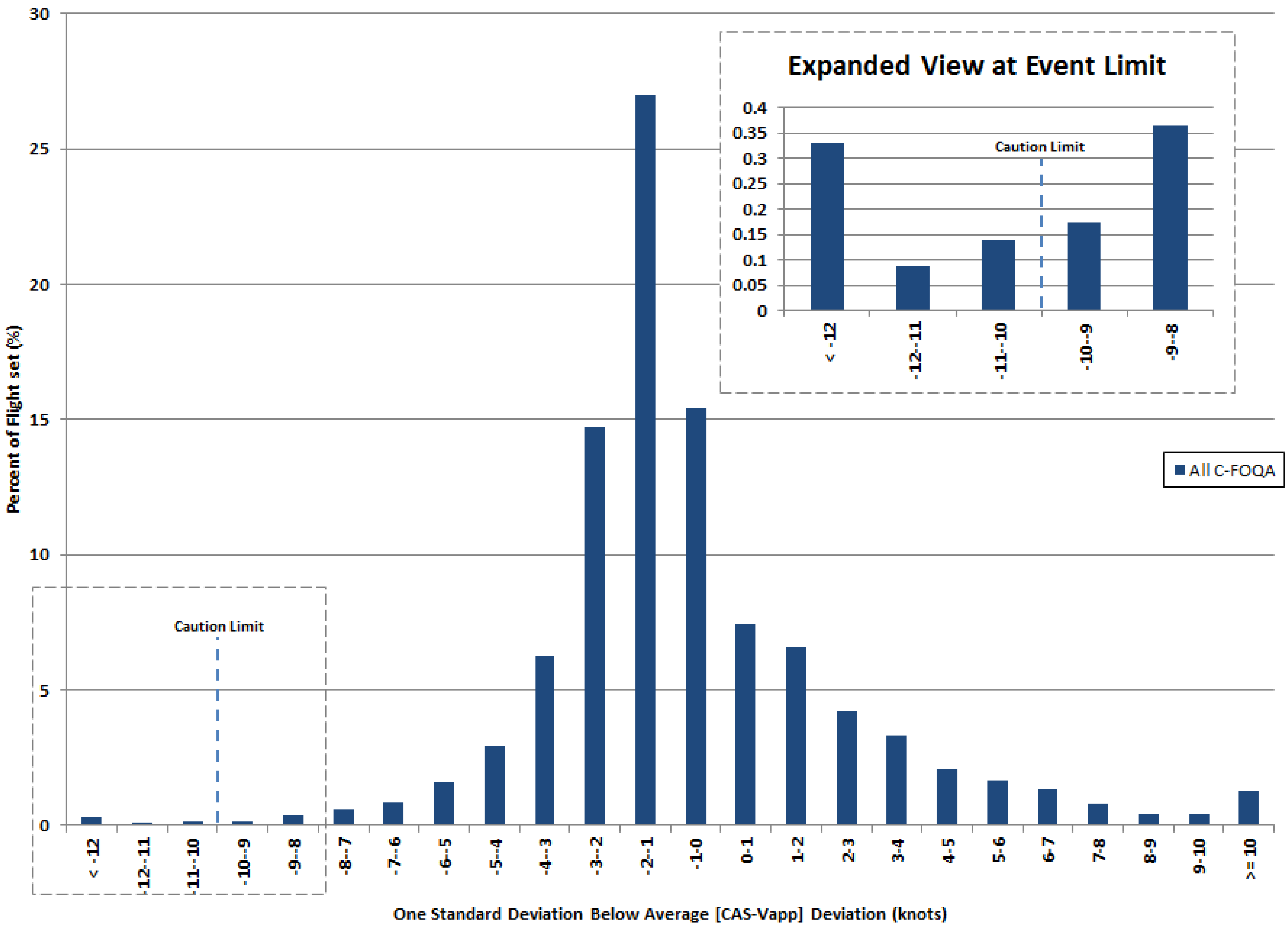
Not Aligned with Runway Distribution (2010)



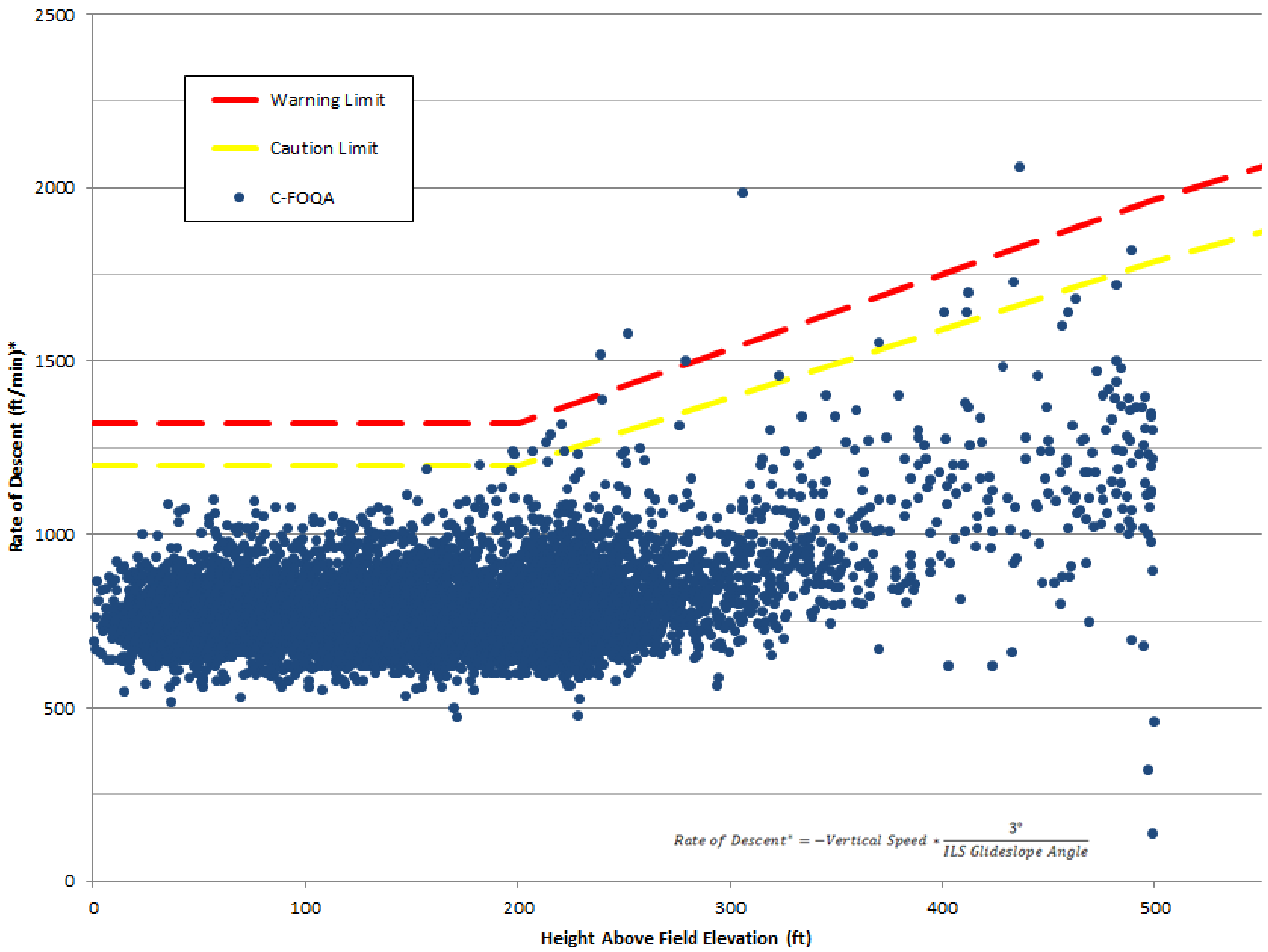
Fast Approach [CAS-Vapp] Distribution (2010)



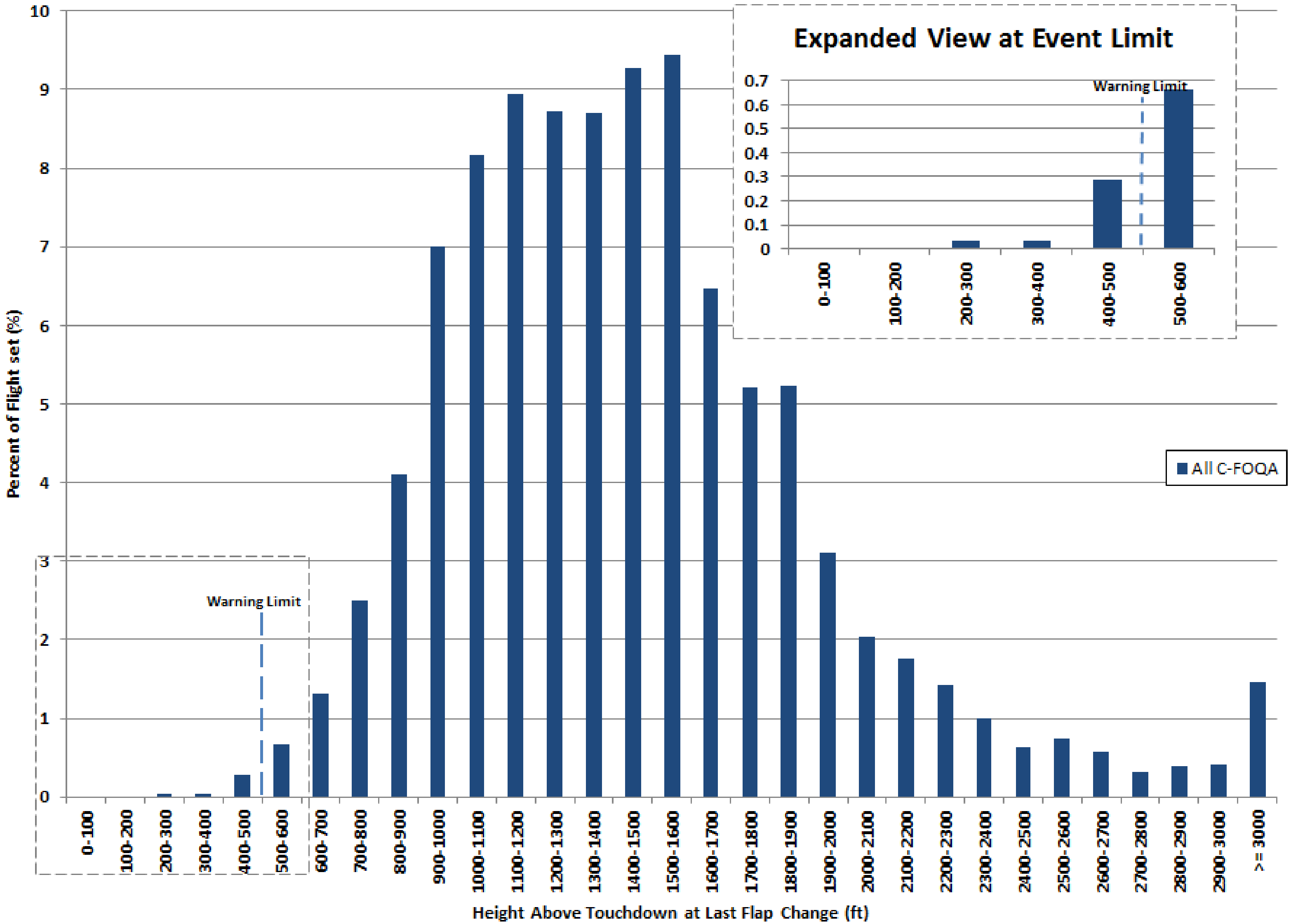
Slow Approach [CAS-Vapp] Distribution (2010)



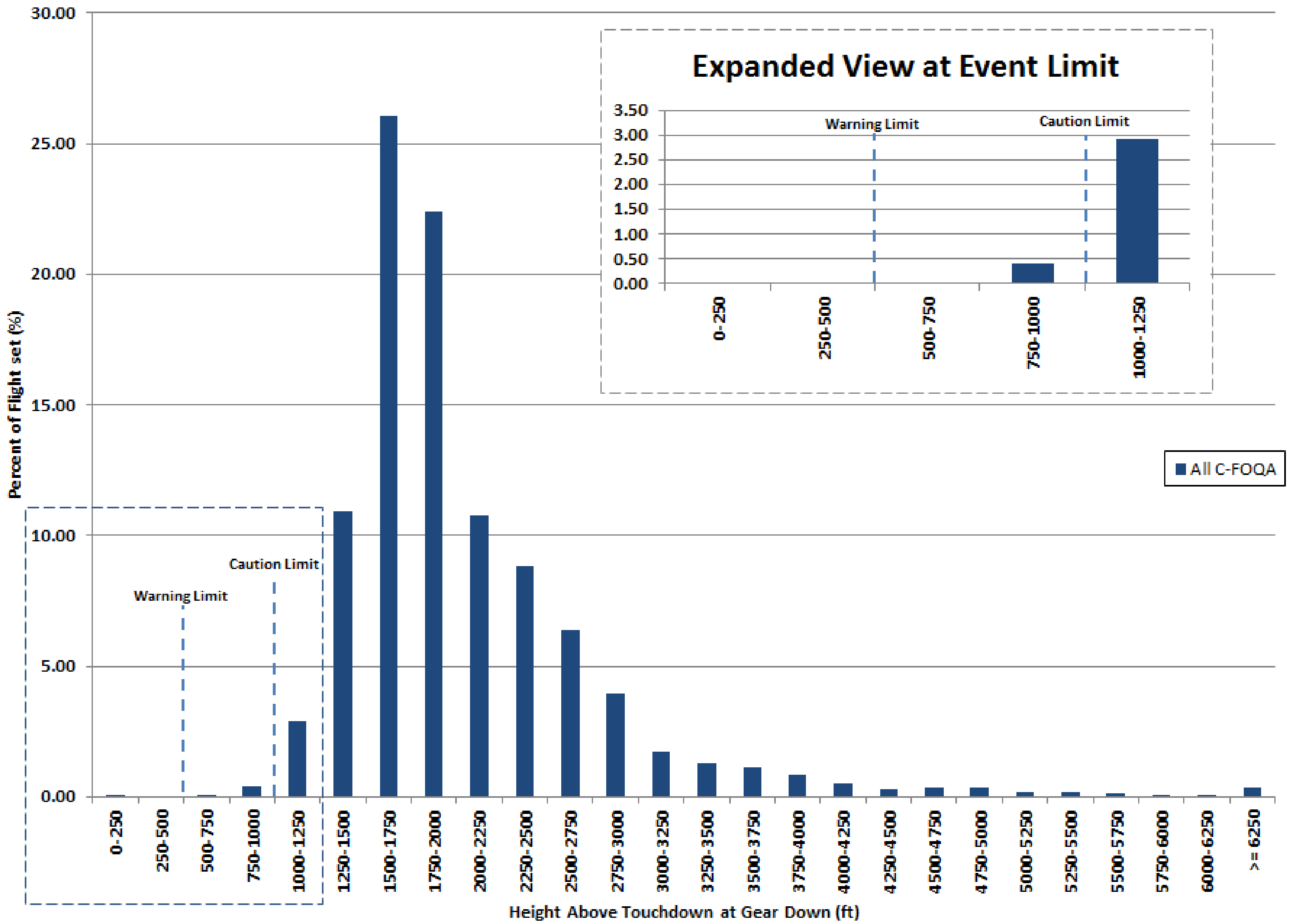
High Rate of Descent Distribution (2010)



Late Flap Extension Distribution (2010)



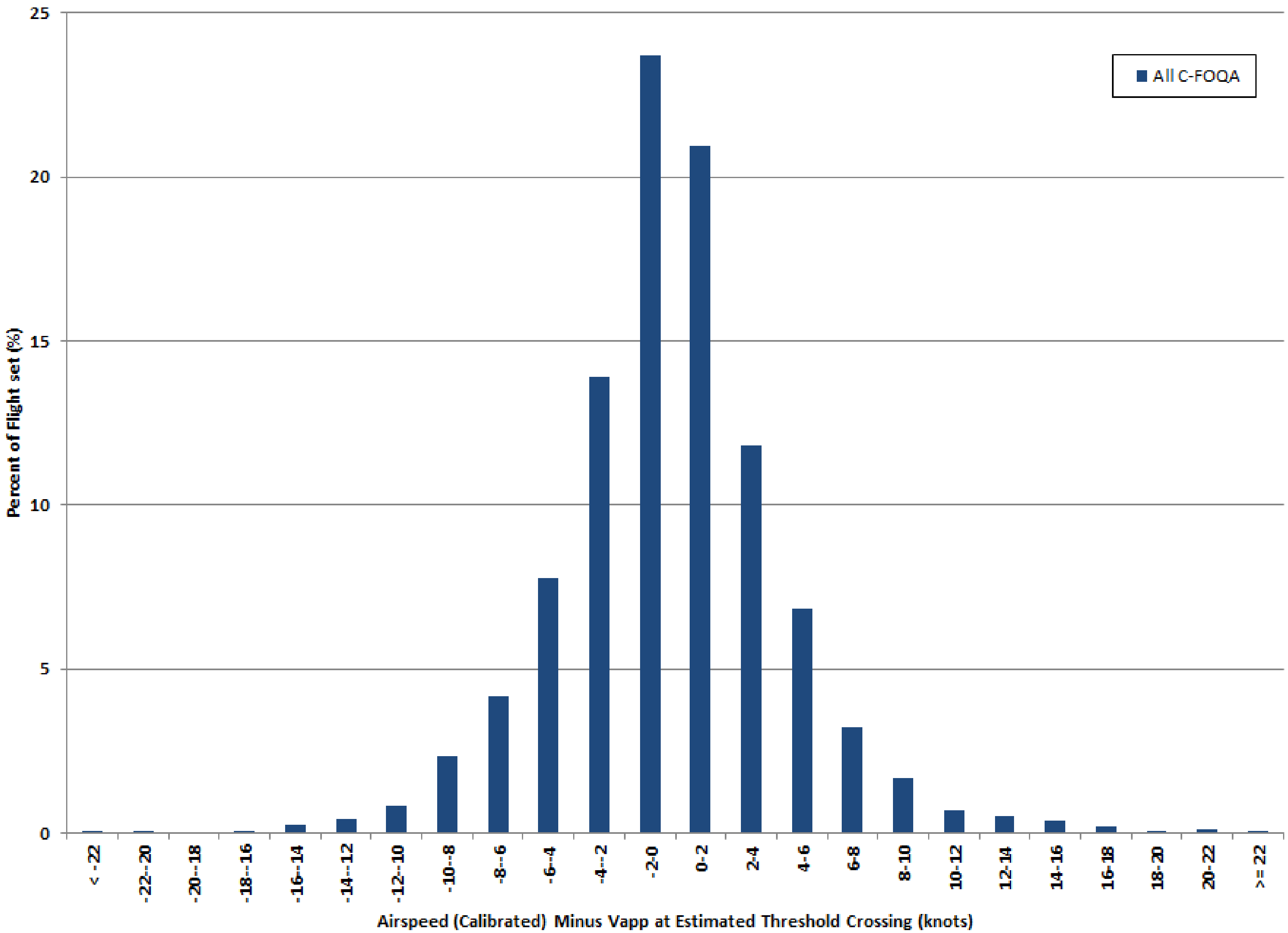
Late Gear Extension Distribution (2010)



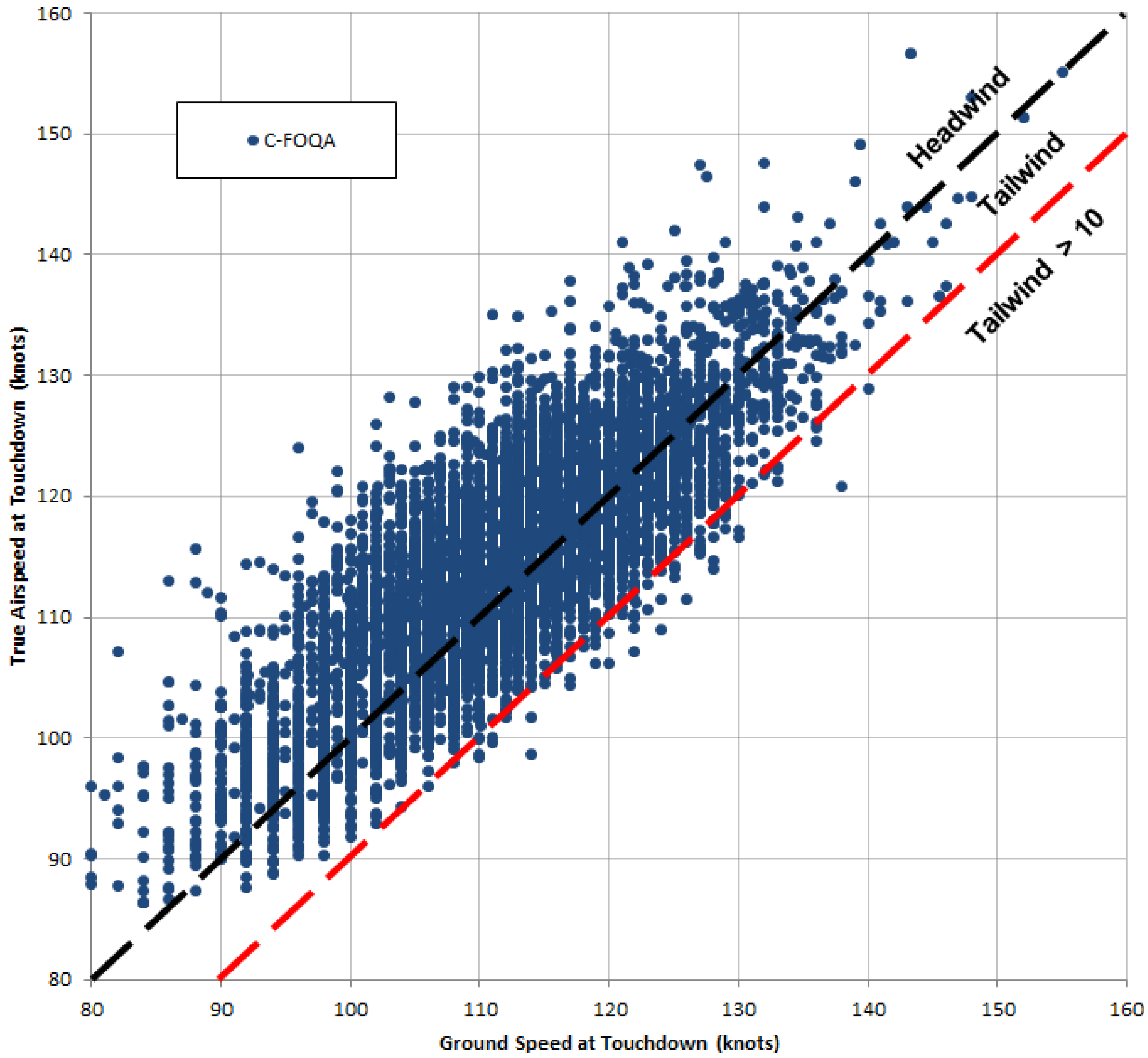
Section IV: Landing Performance

C-FOQA's landing performance from the combined data-set.

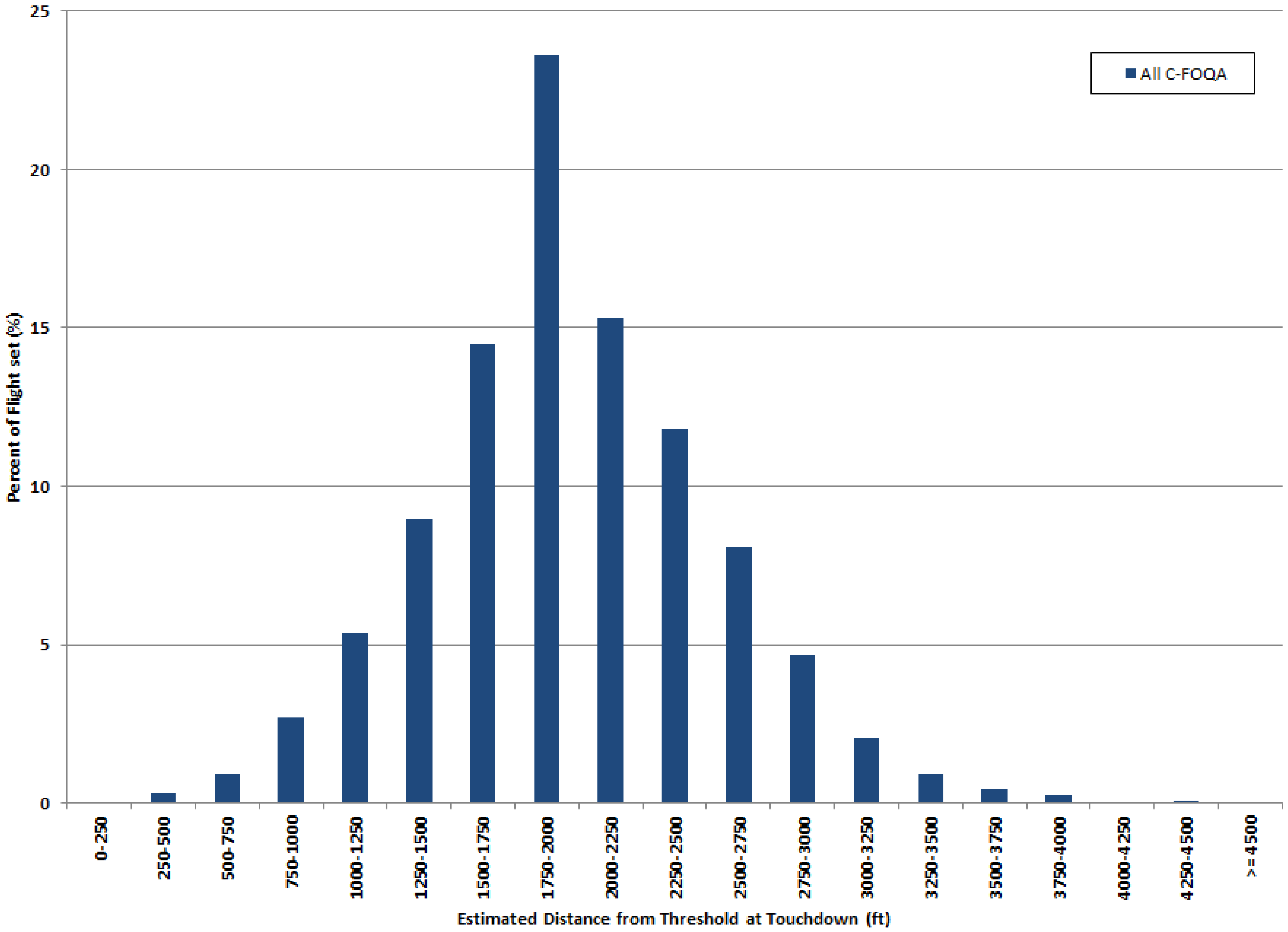
Distribution of (Airspeed – Vapp) at Threshold (2010)



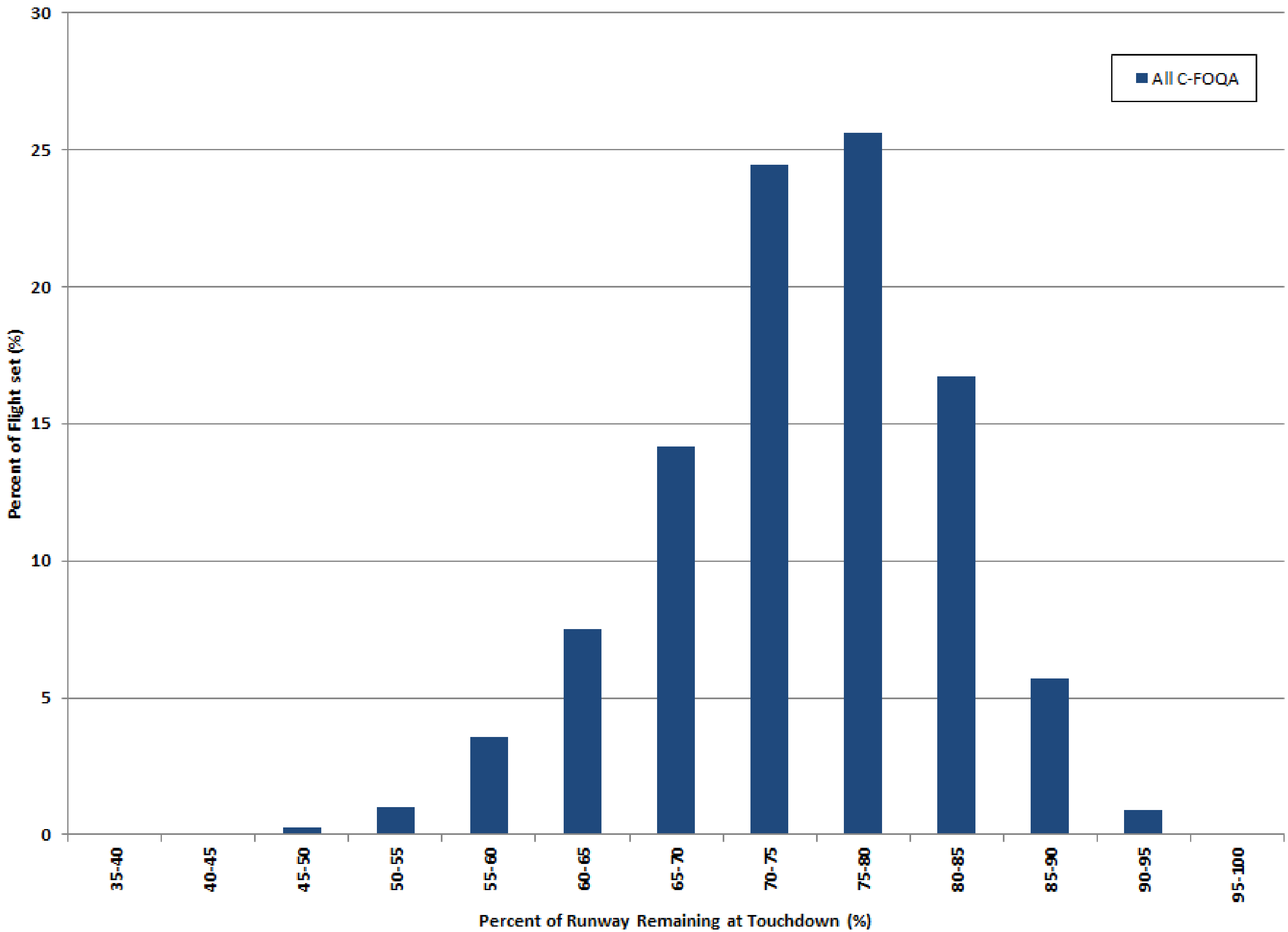
Ground Speed vs. Airspeed at Touchdown (2010)



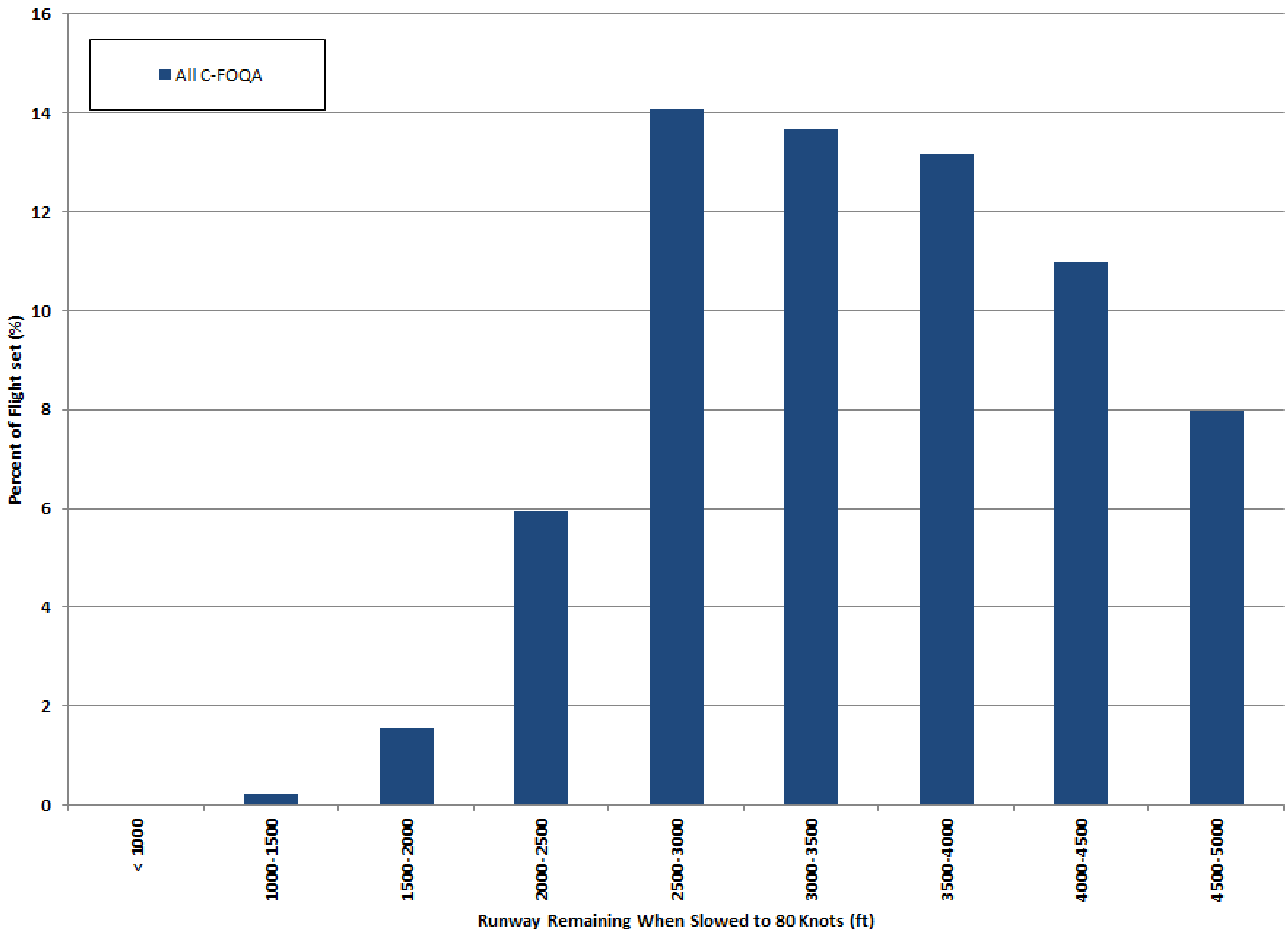
Distribution of Distance from Threshold at Touchdown (2010)



Distribution of Percent of Runway Distance Remaining at Touchdown (2010)



Runway Remaining When Slowed to 80 Knots (2010)



*> 5000ft Not Shown

**Only includes flights for which this measurement could be computed

Appendix

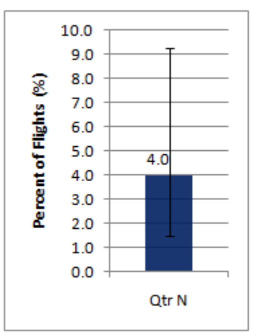
Rate Error Bars Explained

Rate Error Bars (Wilson Confidence Intervals)

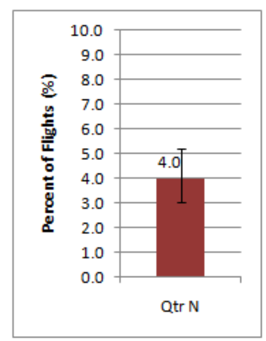
When event rates are calculated we are computing binomial proportion confidence intervals along with the raw proportions. This allows us to confirm whether or not a trend is relevant. Event rates can be thought of as a binomial population in most cases (either the flight does or does not have an event). Unfortunately, this will not work if more than one event per flight is expected.

Imagine there is a bag of 1,000 marbles with 10% red and 90% percent blue. If one were to draw only two marbles out of the bag and then use the results to make an estimation of the bag's true population, then it stands to reason that some estimations will better reflect reality than others. For example, there is an 18% chance of drawing one red and one blue. It would, however, be incorrect to say that the true population in the bag is 50/50 red and blue despite the results of the draw. This small sample size introduced a sampling bias that should be noted. One way to illustrate this sampling bias when presenting the estimate of the true population is with error bars.

The same goes for estimating populations of flights and this report will use Rate Error Bars (calculated with the Wilson Confidence Interval) to indicate instances of possible sampling bias. The two examples below will help to explain how to interpret these Rate Error Bars.



For this example, there are 4 events in 100 flights (4.0%), however, due to the large sample bias, we can only say with 90% confidence that the 'true' rate is between 1.5% and 9.3%.



For this example, there are 40 events in 1000 flights (still 4.0%), however, because the sample population has been dramatically increased, we can say with 90% confidence that the 'true' rate is between 3.1% and 5.2%.

It is expected the Rate Error Bars will decrease over time as the C-FOQA program matures and the sample size increases.

Mean ± One Standard Deviation Explanation

In event-based testing, two kinds of errors are possible:

1) Missed Detection: An event is not triggered and the event actually occurred.
2) False Positive Alarms: An event is triggered and the event actually did not occur.

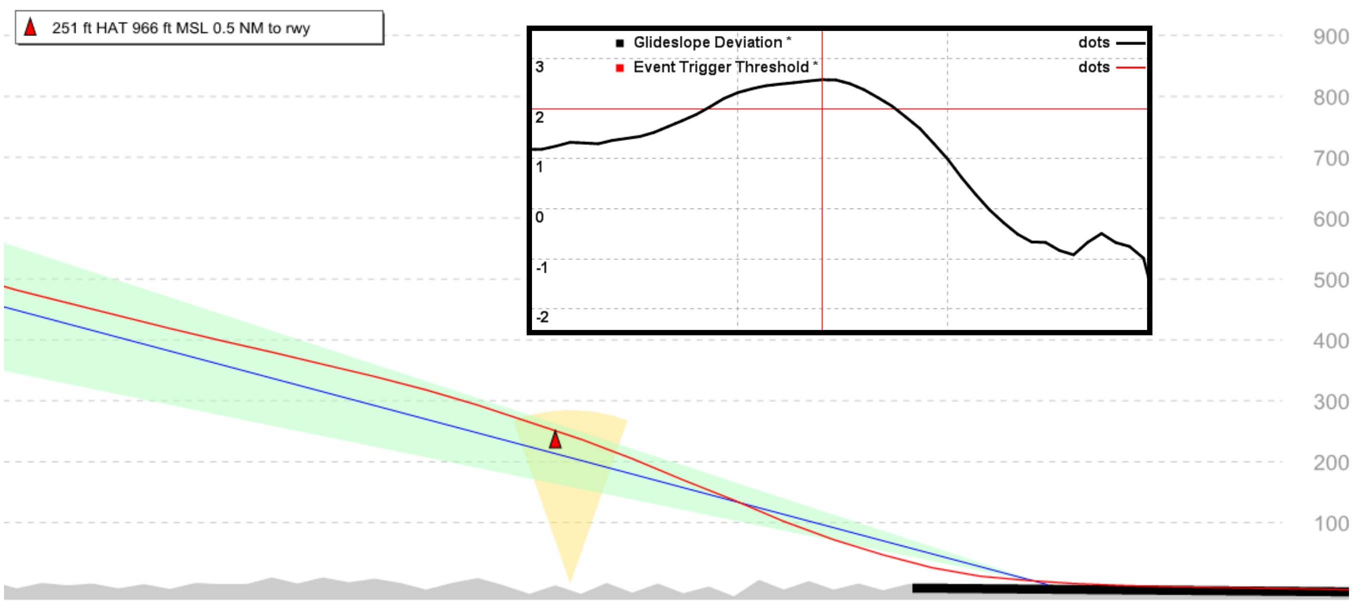
The design of an event trigger represents a trade-off between Missed Detections and False Positive Alarms. Event triggers are often defined by looking at a set of measurement samples accumulated during an interval of interest and requiring a function of these samples to exceed an established limit. Since individual samples can be prone to data error, it is beneficial to evaluate multiple samples in order to minimize False Positive Alarms. Specifically, when it is determined that a sufficient number of valid recorded samples exceed an established limit, then an event can be reliably triggered.

Comparisons Against the Mean ± 1 Std Dev (μ ± 1σ)

Some events lend themselves naturally to simple "exceedance" type triggers, for others our approach is to design an event which would trigger when more than 15.8% of the total recorded samples exceed the established limit. It has been determined that this approach is less prone to Missed Detections and yet still requires a sufficient number of samples exceeding the limit that False Positive rates are low. Assuming that the sampled data set has Gaussian properties, the usage of the MEAN + 1 STD DEV (for upper limit events) and the MEAN - 1 STD DEV (for lower limit events) can be used to identify the limiting value separating the outlying 15.8% from the rest of the samples.

It is important to note that, for event monitoring, this is the mean and standard deviation of the parameter of interest within a single flight, not the mean and standard deviation of measurements across a population of flights.

Below is an example for an Above Desired Glide Path on Approach Event:



μ GS Deviation = 1.90 dots
σ GS Deviation = 0.55 dots
μ + σ = 2.45 dots

Unstable Approach Events
C-FOQA Standard Event Limits

Unstable Approach Events	Phase of Flight	Measurement Criteria		C-FOQA SEL		units
Runway Alignment				**Caution**	**Warning**	**-**
1) Above Desired Glide Path	500 ft HAT - 200 ft AGL	One Standard Deviation above Average Glideslope	>	2	-	dots
2) Below Desired Glide Path	500 ft HAT - 200 ft AGL	One Standard Deviation below Average Glideslope	<	-1.3	-3	dots
3) Not Aligned with Runway (Localizer)	500 ft HAT - TD	One Standard Deviation outside Average Localizer	>	1	-	dots
Airspeed						
4) Fast Approach (Airspeed vs. Vapp)	500 ft HAT - 50 ft AGL	One Standard Deviation above Avg (Airspeed - Vapp)	>	20	25	knots
7) Slow Approach (Airspeed vs. Vapp)	500 ft HAT - 50 ft AGL	One Standard Deviation below Avg (Airspeed - Vapp)	<	-10	-	knots
Rate of Descent (ROD)						
9) High Rate of Descent	500 ft HAT - TD	ROD ÷ ROD Limit*	>	0	10	%
Configuration						
11) Final Flap Change is Late	Descent & Approach	HAT at Last Flap Change	<	-	500	feet
12) Final Flaps Not Valid for Landing	Descent & Approach	Final Flap Setting	<	Landing Flaps	-	degrees
13) Gear Extension is Late	Descent & Approach	HAT at Gear Extension	<	1000	500	feet
Aircraft Body Rates						
14) Unsteady in Pitch	500 ft HAT - 100 ft AGL	Standard Deviation of Pitch Rate	>	1.5	-	deg/sec
15) Unsteady in Roll	500 ft HAT - 50 ft AGL	Standard Deviation of Roll Rate	>	4	-	deg/sec
16) Unsteady in Yaw	500 ft HAT - 100 ft AGL	Standard Deviation of Yaw Rate	>	3	-	deg/sec

*Rate of Descent Limit Changes with Altitude and Glide Path Angle and has a Lower Limit of 1200 ft/min