U.S. Department
of Transportation

**Federal Aviation
Administration**

NSP GB

National Simulator Program
FSTD Qualification Guidance Bulletin

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DATE: 05/03/2019

Flight Standards Service
Washington, DC

National Simulator Program Guidance Bulletin (GB)
This Guidance Bulletin contains information intended to clarify regulatory requirements.

Subject: Realistic Gusting Crosswind Profiles for Flight Simulation Training Device (FSTD) Qualification.

Purpose: Provide baseline gusting crosswind model implementation to FSTD sponsors for use as an acceptable means of compliance for Title 14 of the Code of Federal Regulations (14 CFR) part 60[1].

Background: On November 12, 2013, the Federal Aviation Administration (FAA) published a final rule amending air carrier training requirements to include takeoff and landing in a crosswind with gusts. These changes were made in part to address National Transportation Safety Board (NTSB) safety recommendations following the Continental flight 1404 accident in Denver, CO in 2008[2]. The NTSB issued a safety recommendation for the FAA to gather "data to develop realistic, gusting crosswind profiles for use in pilot simulator training programs".[3] To support this, revisions to 14 CFR Part 60 were published on March 30, 2016 requiring implementation of realistic gusting crosswind profiles and a statement of compliance describing the source data used to construct gusting crosswind profiles.

[1] 14 CFR Part 60, Table A1A (General Simulator Requirements), Section 2.d.3.
[2] Runway Side Excursion During Attempted Takeoff in Strong and Gusty Crosswind Conditions, Continental Flight 1404, December 20, 2008, NTSB Final Report, NTSB/AAR-10/04
[3] NTSB Safety Recommendation #A-10-110.

Revision	Description of Change	Effective Date
0	Original Draft.	04/11/2016
1	Updated Compliance Dates and Qualification Process and Implementation and Tuning Considerations section.	02/26/2018
2	Updated to include additional wind gust model implementation guidelines and examples.	05/03/2019

General Information

On March 30, 2016, the FAA published changes to the 14 CFR Part 60 Qualification Performance Standards (QPS) that define technical requirements for the qualification of gusting crosswind-training tasks on Level C and Level D FSTDs. These changes are mandatory for FSTDs that are initially qualified after the effective date of the final rule[4]. The requirements also apply to previously qualified Level C and Level D FSTDs, but only when used to conduct gusting crosswind training tasks. The retroactive requirements for FSTDs initially qualified before the effective date of the final rule are published in FSTD Directive 2. This Directive requires that any FSTD used to conduct gusting crosswind training tasks, must meet the new technical requirements by March 12, 2019. FSTD Directive 2, along with other FSTD directives for airplane FSTDs, are found in Appendix A, Attachment 6 of 14 CFR Part 60.

Compliance Dates and Qualification Process

Initial FSTD Qualifications: Level C and Level D FSTDs that are initially qualified after the effective date of the final rule must meet all gusting crosswind requirements as defined in the Part 60 QPS at the time of initial qualification.

Previously Qualified FSTDs: Sponsors may elect not to qualify FSTDs for gusting crosswind-training tasks. However, after March 12, 2019, any FSTD used to conduct gusting cross wind training tasks must meet the new general simulator requirements as published in FSTD Directive 2. Where qualification for training, testing, or checking credit is requested, each FSTD sponsor is required to perform FSTD modifications under § 60.23 as needed, conduct additional subjective testing, provide required compliance statements and apply for additional FSTD qualification under § 60.16.

The qualification process is as follows:

1. Use NSP Form T011-FD2,[5] to submit notification of intent to qualify the FSTD gusting cross wind maneuvers and describe any modifications to the FSTD. In accordance with §60.23, the NSP and TPAA must be notified. Where scheduling of large FSTD fleets create special considerations for notification, sponsors should contact the NSP.
2. Statement of Compliance shall accompany the notification. The TPAA may or may not wish to receive the validation materials. Sponsors should consult their TPAA. If the supporting documents are not available at the time of notification, submission of these should be made at a time that is mutually agreeable to both the sponsor and the NSP.
3. Once FSTD modifications and a sponsor self-evaluation are completed, submit the confirmation statement that the modified FSTD has been subjectively evaluated by a qualified pilot as described in § 60.16(a)(1)(iii) using NSP form T012.

[4] The final rule became effective on May 31, 2016. Industry has informally coined the revision, Part 60, Change 2.
[5] This form is intended for the notification of intent to use an FSTD for full stall and stick pusher maneuvers, upset prevention and recovery maneuvers, maneuvers conducted in icing conditions, takeoff and landing maneuvers in gusting crosswinds, and bounced landing recovery maneuvers in accordance with FSTD Directive 2.

The NSP will review each submission, determine if requirements have been met, and respond to the FSTD Sponsor as described in § 60.23(c). This response, along with any noted restrictions, will serve as an interim qualification until issuance of a permanent Statement of Qualification (SOQ) following the next NSP conducted FSTD evaluation. Alternatively, the NSP may elect to conduct an update evaluation before the modified FSTD's use in training.

During onsite evaluations, the NSP team may actively exercise the device or observe the execution of the maneuver by the SME. The NSP may also ask for a demonstration of the training profile and an explanation of its usage and how evaluated by the instructor.

Wind and Gust Models

FSTD sponsors may choose to develop their own wind gust models for FSTD qualification or use the FAA models provided in this bulletin (Attachment 1). The FAA provided wind gust models in Attachment 1 were developed to support Part 60 requirements for realistic gusting crosswinds and may be used to comply with FSTD Directive 2. The models were developed from wind estimates computed by the NTSB and based upon parameters extracted from the Continental flight 1404 Flight Data Recorder.[6] The first gust model was developed using a "sum-of-sines" solution to match both the wind magnitude and the wind direction experienced by the accident aircraft. The second uses a simplified linear estimation of the same model as an alternative solution for FSTDs with limited computing power. Experiments conducted by the FAA demonstrated that the two wind gust models presented here are subjectively realistic and beneficial to training.

To be acceptable, gust models should be additive to a constant magnitude and direction "base wind." The base wind and gusts should be sufficient to meet training goals, which is to ensure that together they pose a high workload for the pilot during both takeoff and landing phases. The introduction of turbulence with gust encounters should be included to add realism.

The base wind should be relative to the runway with the gust components superimposed as a function of time. Implementation of magnitude and direction in the wind, relative to the runway, should produce the appropriate randomness. The base wind should be tailored for specific aircraft and training objectives, as well as any known simulation modeling limitations. Plotted representations of the wind profile to the ground, the base winds, and the gust model in use should be presented during evaluation.

If the wind gust models vary with height above ground (including phase-in or phase-out), a description shall be included in the Statement of Compliance.

Contact: Questions or comments regarding this guidance bulletin can be directed to the National Simulator Program, AFS-205, at 404.474.5620.

[6] Crider, D.A., "Determining Ground Winds for Gear-on-the-Ground Accidents Using FDR Data," *2011 AIAA Modeling and Simulation Technologies Conference and Exhibit*, AIAA-2011-6699, Portland, Oregon, 2011.

Attachment 1 – Wind Gust Models

Model 1: Continuous Gust Model

Model 1, hereafter referred to as the "continuous model", was developed through matching the Continental 1404 accident data with a sum-of-sines fit for both wind magnitude and wind direction (after subtracting out a baseline magnitude and direction in order to normalize the gusts). The results are two equations (one for wind magnitude and one for wind direction) composed of nine individual sine/cosine frequency components derived from the following equations with steady state components removed.

Gust model direction = $[A_1*\text{cosine}(f_1*t)+B_1*\text{sine}(f_1*t)+ A_2*\text{cosine}(f_2*t)+B_2*\text{sine}(f_2*t)+\ldots +A_n*\text{cosine}(f_n*t)+B_n*\text{sine}(f_n*t)]$

Gust model magnitude = $[C_1*\text{cosine}(f_1*t)+D_1*\text{sine}(f_1*t)+ C_2*\text{cosine}(f_2*t)+D_2*\text{sine}(f_2*t)+\ldots +C_n*\text{cosine}(f_n*t)+D_n*\text{sine}(f_n*t)]$

Table 1 below provides coefficients and frequencies for each of the terms in the equations provided above.

Table 1: Coefficients for Sine/Cosine Frequency Components – Continuous Gust Model

N	Model direction cosine coefficients (A_n)	Model direction sine coefficients (B_n)	Model magnitude cosine coefficients (C_n)	Model magnitude sine coefficients (D_n)	Model frequencies (rad/sec) (f_n)
1	**5.03**	**-1.08**	**-0.95**	**-0.69**	**0.68**
2	**5.62**	**8.59**	**-4.02**	**-1.75**	**1.36**
3	**7**	**-1.76**	**-4.5**	**2.05**	**2.04**
4	**2.68**	**-0.57**	**-1.5**	**0.3**	**2.72**
5	**2.19**	**-1.33**	**-1.03**	**1.29**	**3.4**
6	**0.87**	**-0.071**	**-0.14**	**-0.33**	**4.08**
7	**1.17**	**-2.11**	**-0.59**	**1.44**	**4.75**
8	**0.11**	**-1.84**	**0.069**	**1.04**	**5.43**
9	**0.056**	**-1.36**	**0.21**	**0.73**	**6.11**

Figure 1 and Figure 2 below are the output of the described wind direction and wind magnitude models over-plotted with the unbiased NTSB data from the Continental 1404 accident.

Figure 1: Continuous Gust Model Magnitude

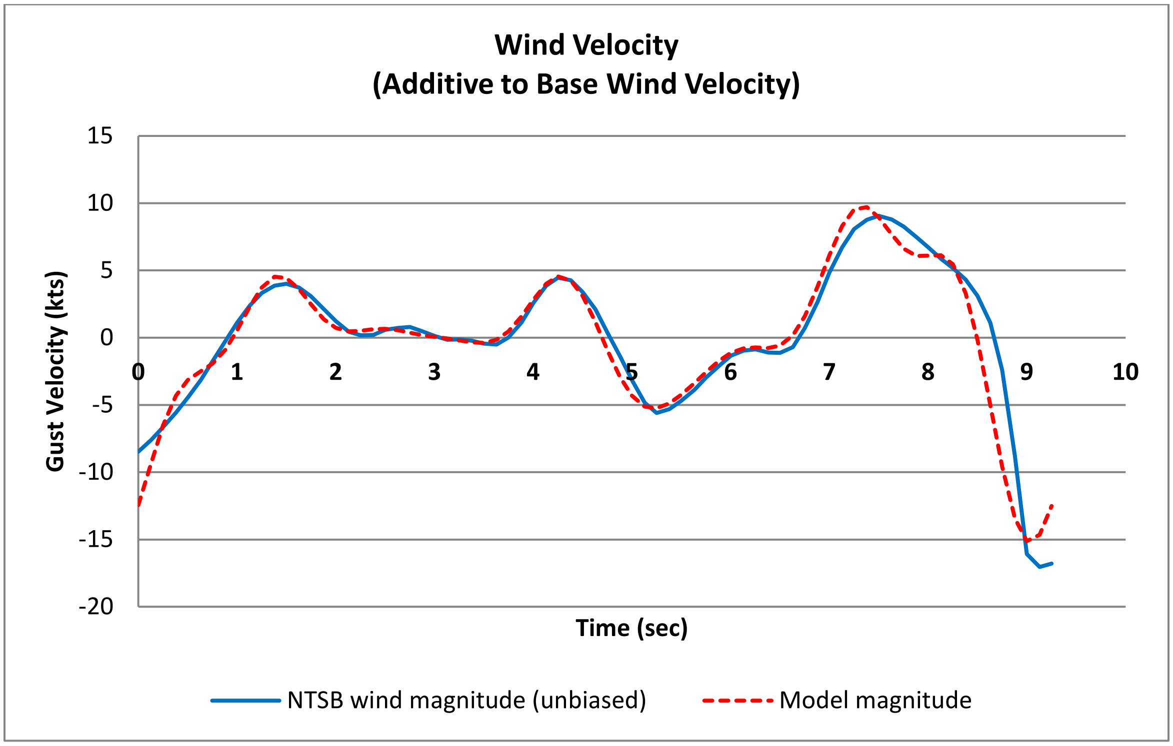
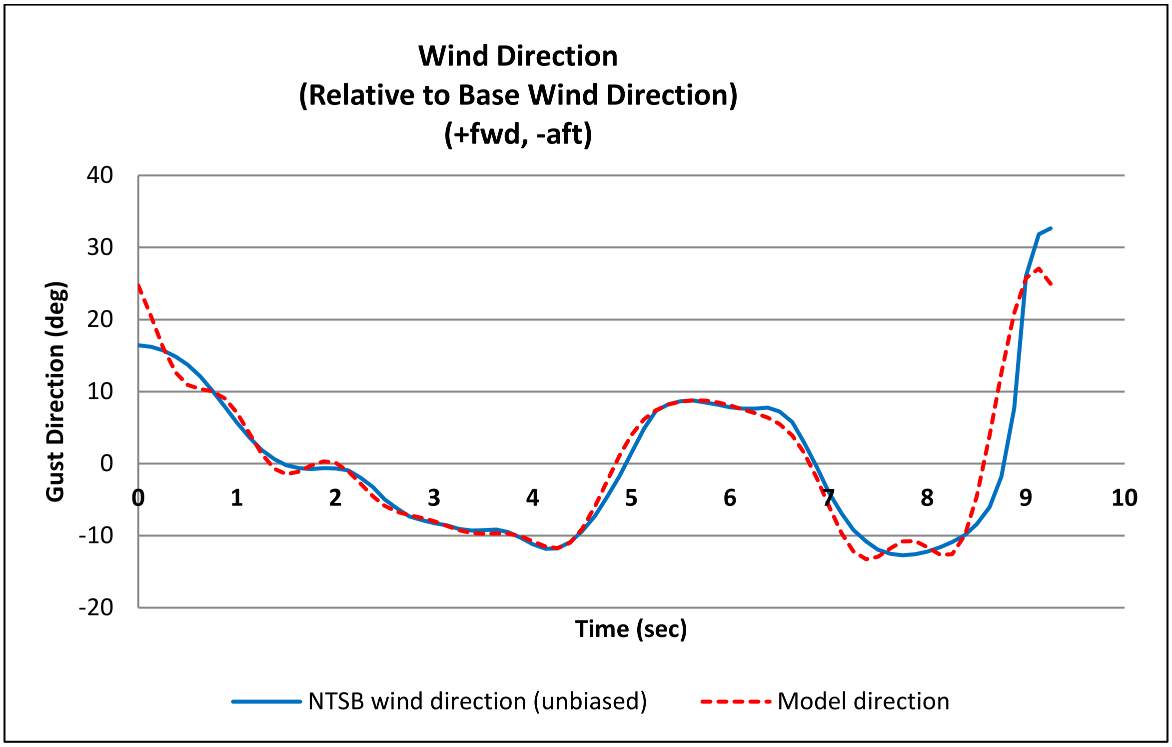


Figure 2: Continuous Gust Model Direction



Model 2: Linear Gust Model

Model 2, hereafter referred to as the "linear model", was developed as an alternate solution that may be easier to implement in legacy simulators.

The tables below provide the breakpoints for both the gust model velocity (Table 2) and the gust model direction (Table 3). Additionally, the slopes of the lines are provided for each segment of the model (wind rate and direction rate).

Table 2: Breakpoints for Linear Gust Model (Velocity)

Model time (sec)	Model_vel. (kts)	Velocity Rate (kts/sec)
0	0	
1.0	0	0
2.5	10	6.666
3.25	5	-6.666
4.25	5	0
5.0	10	6.666
6.5	0	-6.666
8.75	15	6.666
11.0	0	-6.666

Table 3: Breakpoints for Linear Gust Model (Direction)

Model time (sec)	Model_direction (deg) (-aft of direct crosswind)	Direction Rate (deg/sec)
0	0	
1.0	0	0
5.0	-30	-7.5
6.5	-10	13.333
7.5	-10	0
8.5	-30	-20.0
9.5	-30	0
11.0	0	20.0

Figure 3 and 4 below show the linear gust model as compared to the CO 1404 accident data.

Figure 3: Linear Gust Model Magnitude

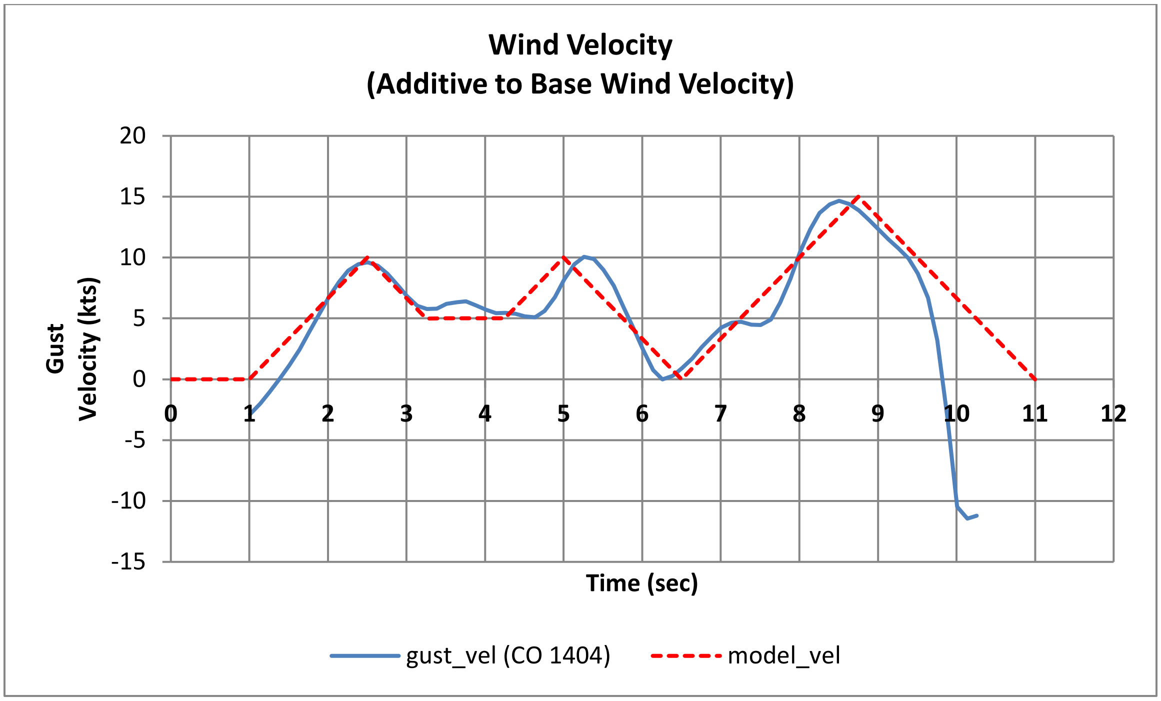
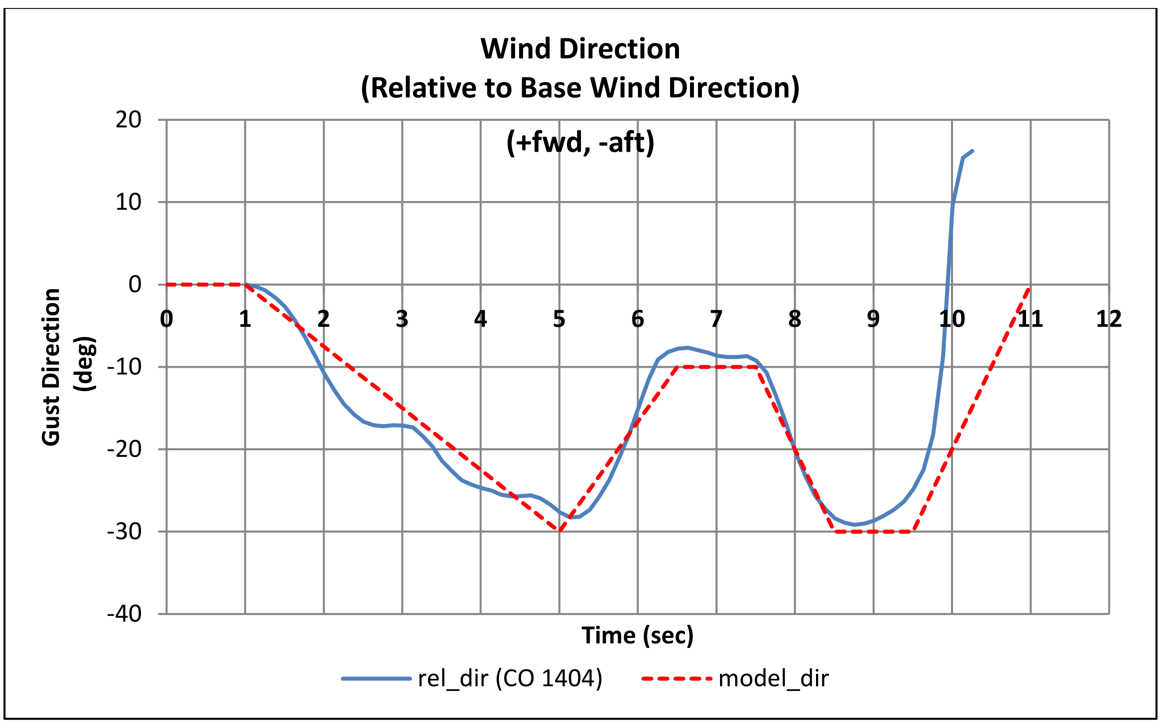


Figure 4: Linear Gust Model Direction



Attachment 2 – Gust Model Implementation Guidelines

- The continuous wind gust model is a periodic sinusoidal function with its bias terms removed. As a result, the output of this model should be summed into the current steady state (base) wind velocity and direction to add gust components that are incremental to the steady state wind condition. Because the gust model can start in a non-zero condition, it may require additional filtering for gradual ramp-in once triggered during the initial approach or while awaiting takeoff.
- The linear wind gust model is a non-periodic function that covers eleven seconds of gust data. Because of this, if continuous gusty conditions are required, the model can be set-up to repeat in continuing intervals. Similar to the continuous wind gust model, the linear model also has its bias terms removed and should be summed into the current steady state winds.
- Before use in training, these gust models should be tuned for the particular aircraft being simulated and the intended training scenarios. The following should be considered in the tuning process:
    - Use a subject matter expert (SME) pilot to provide assistance in tuning and evaluating the gust models for realistic effects during takeoff and landing training tasks.
    - Because the wind magnitude and direction rates of change in the gust models are based upon objective data, any scaling of these terms may affect the realism of the wind gust in training. To adjust the difficulty of wind gust training, steady state wind conditions can be changed to achieve the desired maximum crosswind components after summing-in the wind gusts. Attachment 3 of this guidance bulletin provides example implementations and checkout material in order to tune the gusts for a challenging gusting crosswind takeoff scenario.
    - While the flight crew should never be given the impression that it is acceptable to intentionally disregard company or OEM crosswind limitations, unforeseen wind/gusts may occur in flight. Therefore, there is benefit in demonstrating a wind condition in excess of the normal limits. Setting the conditions to approximate the CO1404 peak 45-knot wind may be a reasonable starting point (see Attachment 3 for more information).
    - When using these gust models for an approach/landing maneuver, some attenuation in peak gust magnitude (e.g. by reducing the base wind magnitude) may be necessary since they can quickly stimulate an unstable approach and go-around.
    - Gusts should be felt during the entire takeoff or landing roll. Runway departure should be expected without pilot corrective inputs.
    - Adding a light-to-moderate turbulence (vertical “chop”), particularly during approach, can enhance realism.
- The capabilities of the FSTD must be considered, including the associated aerodynamic and ground models. The FSTD sponsor should coordinate with the FSTD manufacturer and/or data provider to ensure the wind gust models do not exceed the capabilities of the FSTD.

- In order to demonstrate correct implementation of the gust, it should be possible for the simulator to generate plots of the wind gust magnitude/velocity as well as the total wind (base plus gust) resolved into Headwind and Crosswind components for an approximately 20 second period.
- Facilities should be provided to control the necessary parameters from the IOS.

Attachment 3 –Example Tuned Gust Models

Since the initial publication of this guidance bulletin, evidence suggest that the implementation of these gust models has not produced subjectively challenging gusting crosswind scenarios in some cases. The following information provides additional guidance on how to implement and tune the example gust models (continuous and linear models) to achieve challenging scenarios for crew training.

In Attachment 1 of this guidance bulletin, example gust models are provided in an unbiased format which allows for an operator to integrate them into various steady state wind conditions in order to produce challenging gusting crosswind scenarios. It is important to note that these gust models are based upon a single accident scenario and must use specific baseline (constant) wind velocities and directions to reproduce the gusting crosswinds encountered by the accident aircraft. By integrating these gust models into a baseline headwind with little or no crosswind component, the gust models will not produce a challenging scenario.

- Both the continuous model and the linear model were designed to match the same gusts as experienced by the CO 1404 flight crew; however, the implementations require differing base wind magnitude and direction to achieve these results.
- The gust models provided in Attachment 1 are unbiased and intended to be summed into a steady state wind condition with the gusts essentially "riding" on top of the steady state winds. This provides an ability to apply these gusts to any steady state wind on any runway heading. If adjustments are necessary to make the scenario more or less challenging, we recommend changing the steady state wind direction and magnitude to accomplish this, rather than by changing the gust model itself.
- While these gusts can be summed into any steady state wind direction and magnitude (keeping in mind that a negative gust is "aft" and positive is "forward" of the base direction), to achieve significant gusting crosswind components, the steady state winds should be set up for a significant crosswind relative to the runway heading.
- Because the linear and continuous models are implemented differently (time domain vs frequency domain), slightly different steady state wind conditions are needed to achieve optimal results.
- Table 4 below describes the recommended steady state wind conditions required for each wind gust model to achieve similar gusts as experienced in the CO 1404 accident. These conditions were tuned in magnitude to achieve a peak crosswind gust of approximately 45 knots as experienced by the accident flight crew. Note that the wind directions in Table 4 are specified in terms relative to the runway heading with negative numbers indicating a left crosswind.
- Attachment 4 and Attachment 5 show the total wind profiles generated using the steady state wind conditions from Table 4.

Table 4: Recommended Steady State Wind Conditions

Model	Steady State Wind Velocity (kts)	Steady State Wind Direction (deg)	Peak Gusting Crosswind Component (kts)
Continuous	**35**	**-83**	**44.4**
Linear	**30**	**-60**	**44.6**

Attachment 4 –Continuous Gust Model Recommended Wind Profile

Figure 5: Wind Velocity

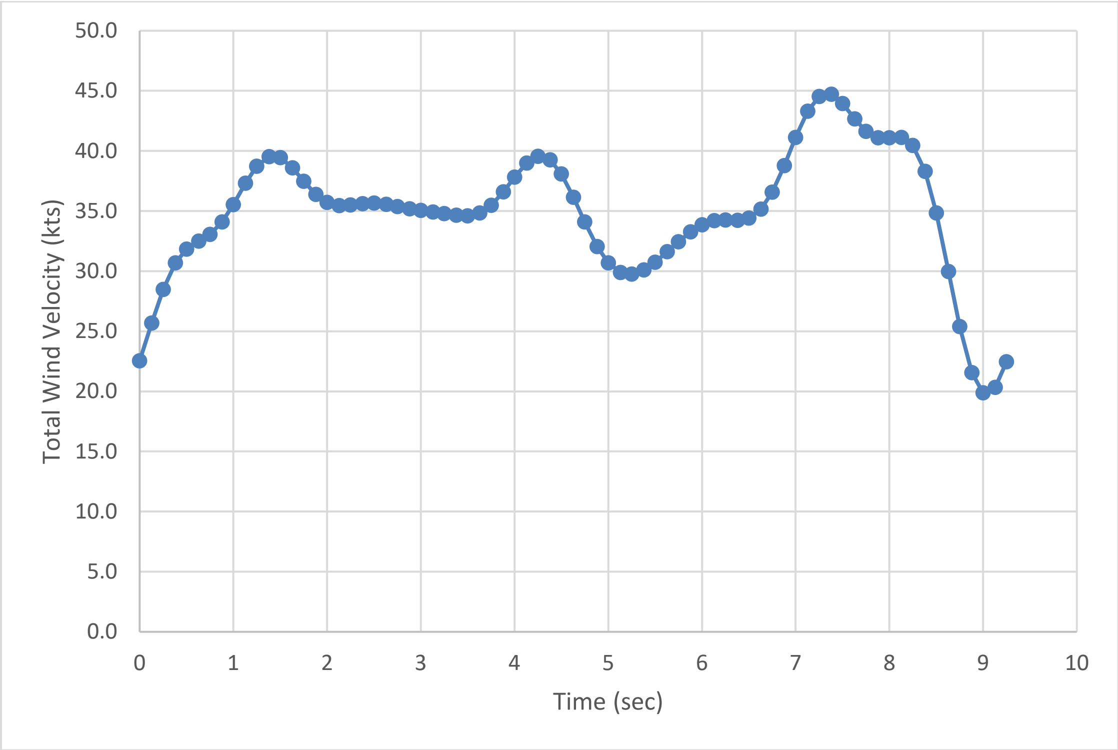


Figure 6: Wind Direction (Relative to Runway Heading)

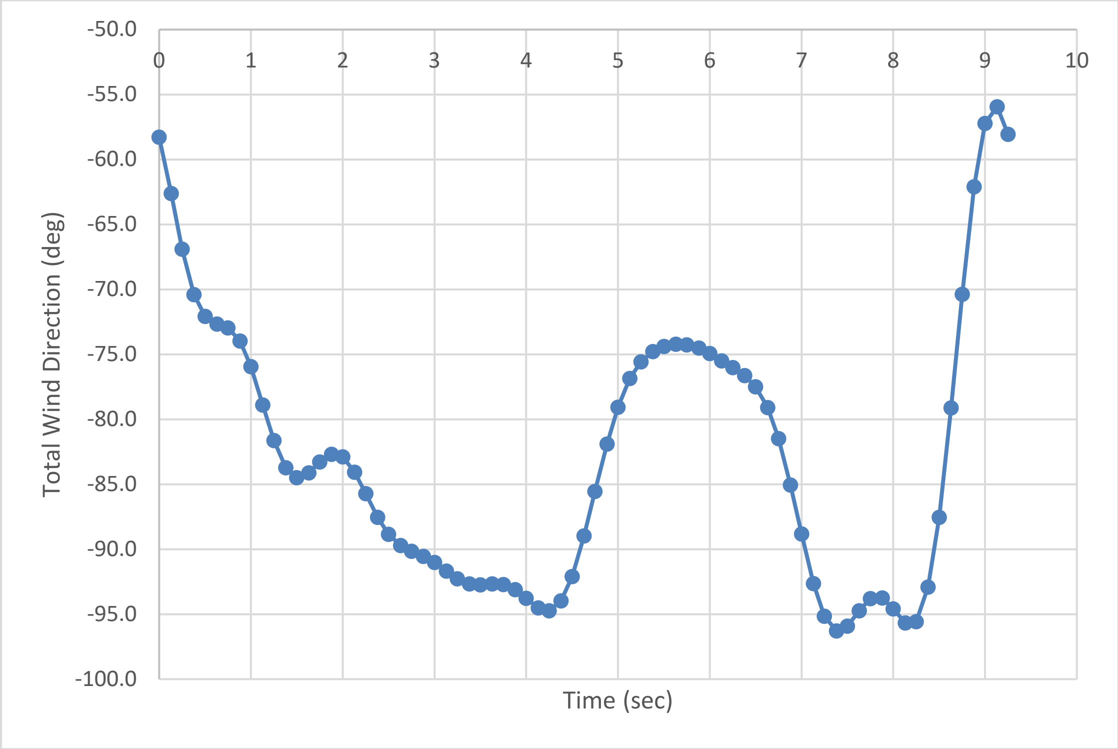


Figure 7: Wind Velocity (Crosswind Component)

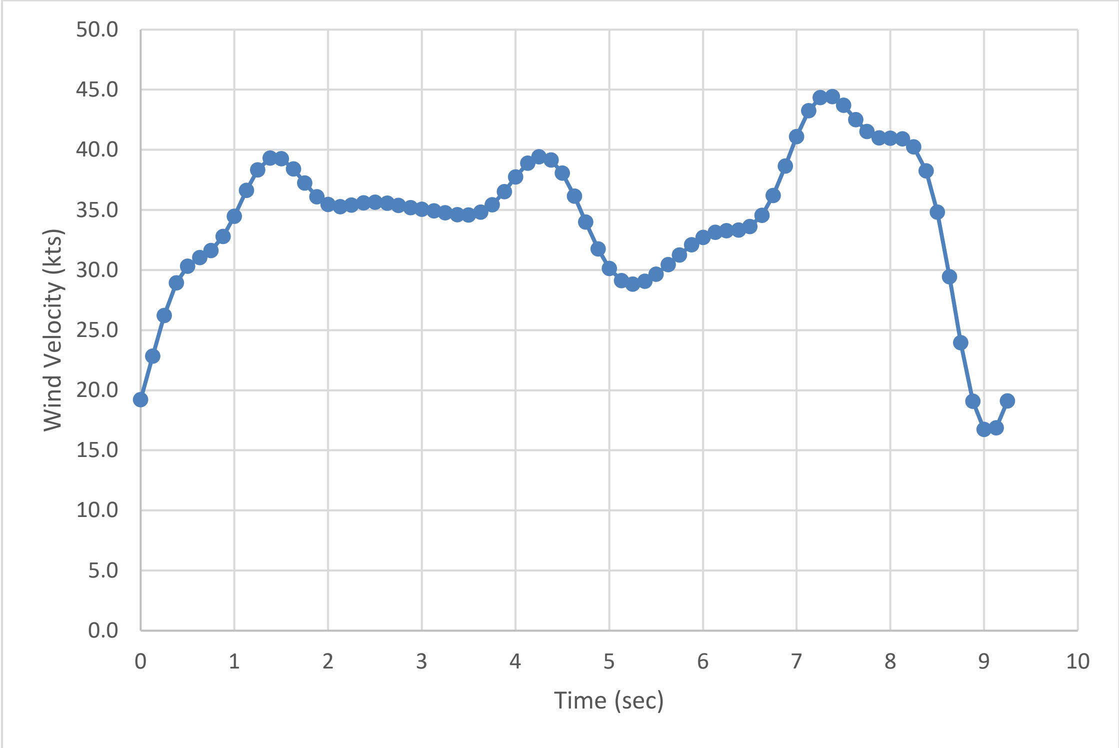
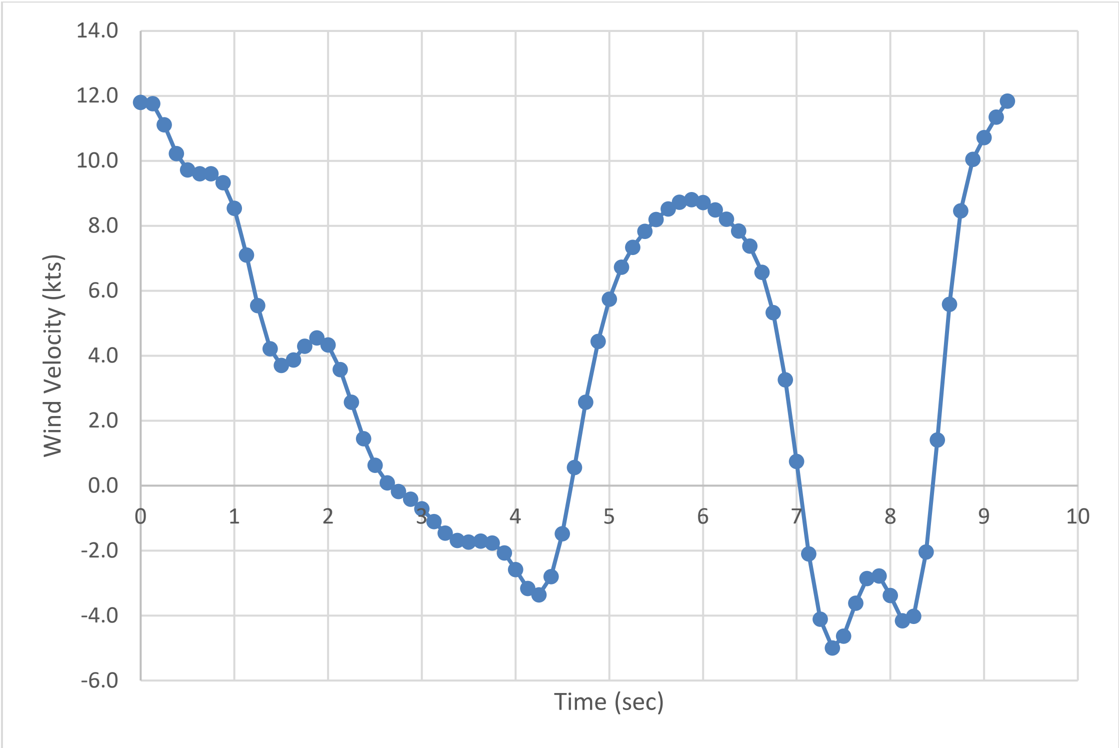


Figure 8: Wind Velocity (Headwind Component)



Attachment 5 –Linear Gust Model Recommended Wind Profile

Figure 9: Wind Velocity

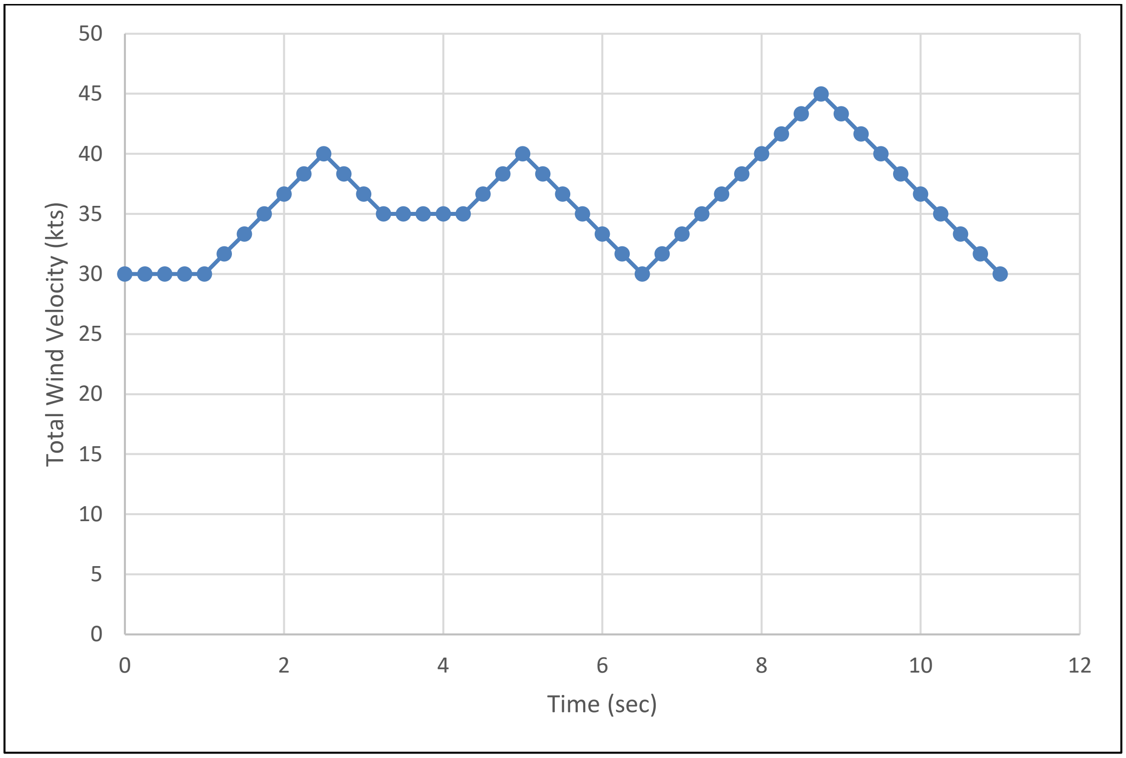


Figure 10: Wind Direction (Relative to Runway Heading)

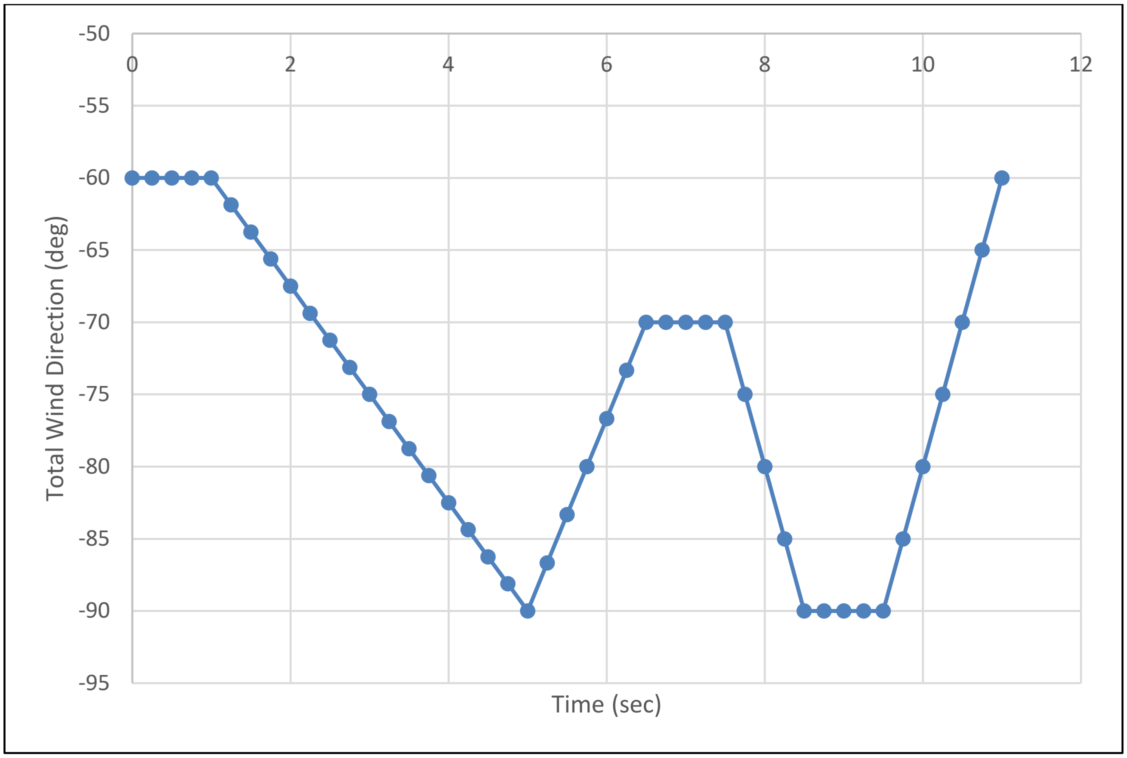


Figure 11: Wind Velocity (Crosswind Component)

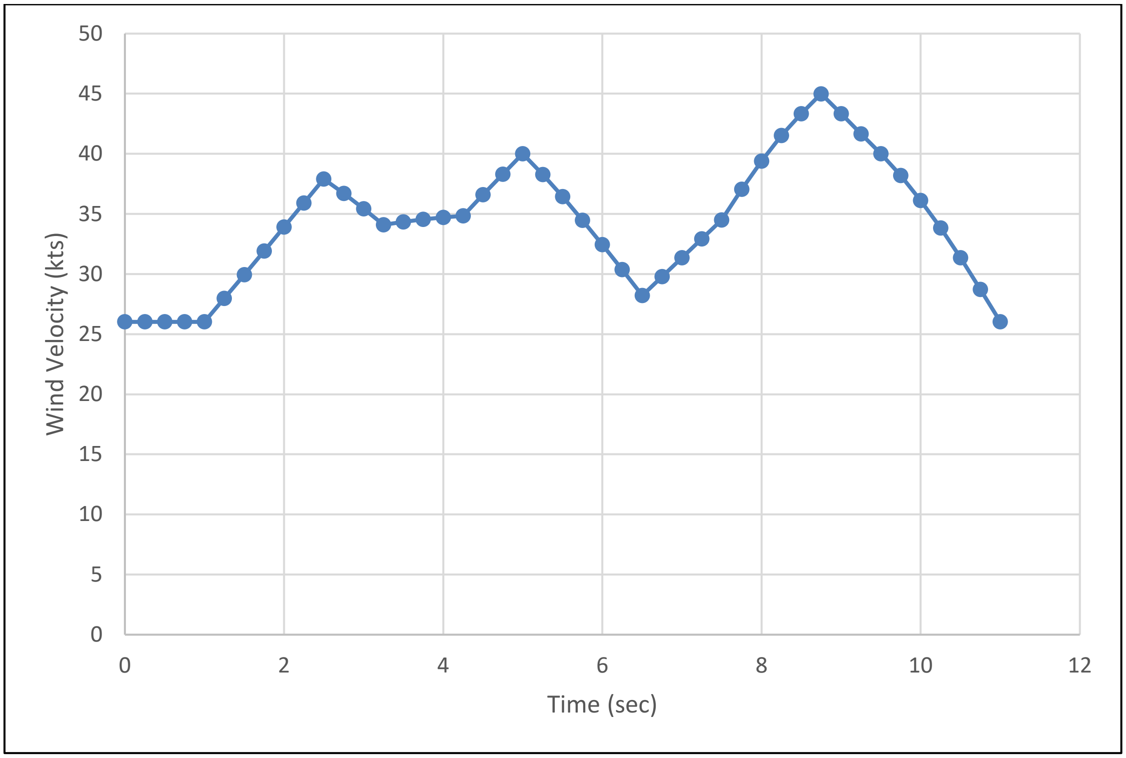


Figure 12: Wind Velocity (Headwind Component)