Results from Ground and Flight Testing of UAS Weather Payload

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Abstract: Prior, during and post atmospheric characterization field campaigns and the data reduction associated with calculating temperature structure constant, C_T^2, from nodal sensors is both well-known and misrepresented. Critical to accurate estimates of is selecting, and what this author refers to as, a Structure Function Window Length from which to base temperature fluctuations on. To best understand the impact of the Structure Function Window (SFW), a set of data taken over 24 hours, that included co-located nodal Differential Temperature Sensor (DTS) systems, nodal miniature Anemoment sonic anemometers, a larger Applied Technologies sonic anemometer, and an integrated path Scintec BLS900 atmospheric characterization system, was used to calculate and compare a variety of moving mean lengths which ultimately build up . The SFW and the methods for estimating the length of the SFW to best estimate is the focus of this presentation.

Refractive Index Structure Coefficient ($C_n{}^2$)

Measurement of refractive-index structure coefficient, Cn^2, by direct measurement of thermal inhomogeneities in the atmosphere. The values of Cn^2 obtained from visible wavelength measurements can be directly related to C_T^2, the temperature structure coefficient. The relationship is defined as:

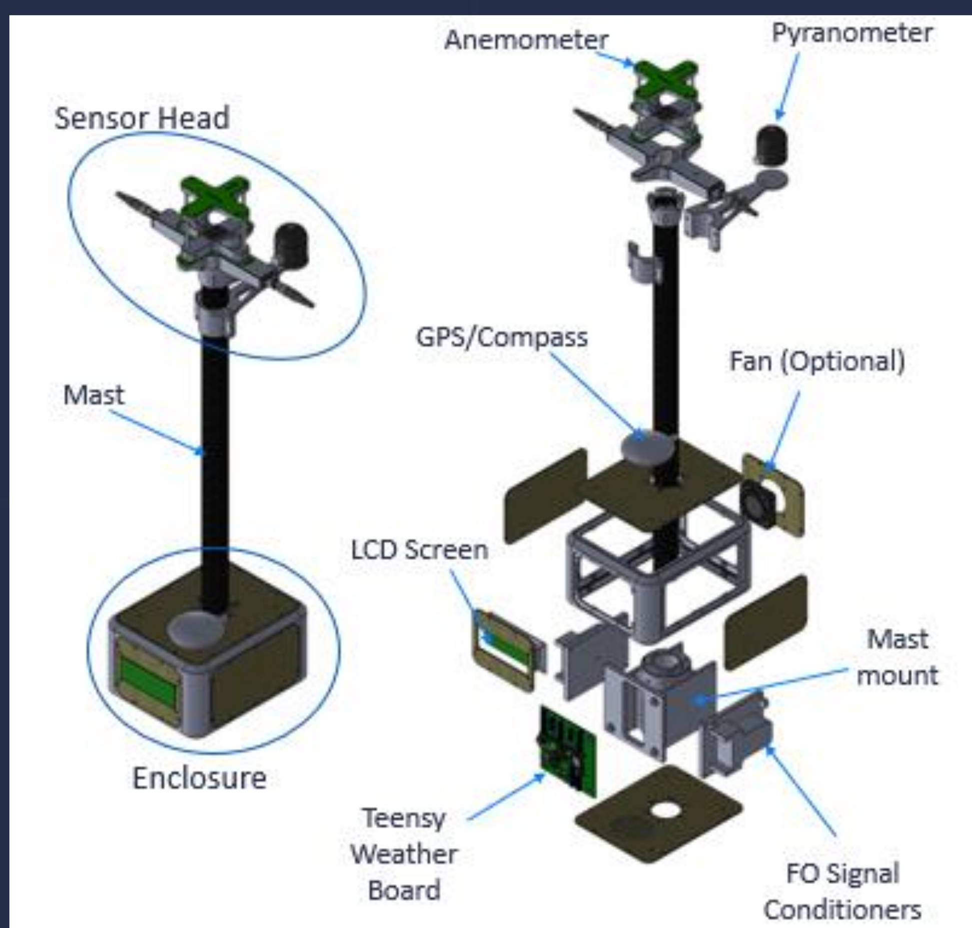
$$Differential\ Temperature\ C_T^2 = \frac{\langle \Delta T^2 \rangle}{r^{2/3}},$$

$$Power\ Spectrum\ C_T^2 = \frac{-8/3\,\Phi\left(2\pi/U_m\right)}{f^{-2/3}},$$

$$C_n{}^2 = \left[79\frac{P}{T^2}\right]^2 \times 10^{-12} C_T^2$$

Where for differential temperature ΔT is the ensemble average obtained from a pair of temperature sensors separated by a distance r, P is pressure in millibars, and T is a temperature in kelvins. Using a power spectrum method Φ is the temperature power spectrum, U_m is the mean wind speed, and f is the spectrum frequency range.

New Buoy/Sea ODTS built for the Navy



UAS Payload System Design

Critical Features:

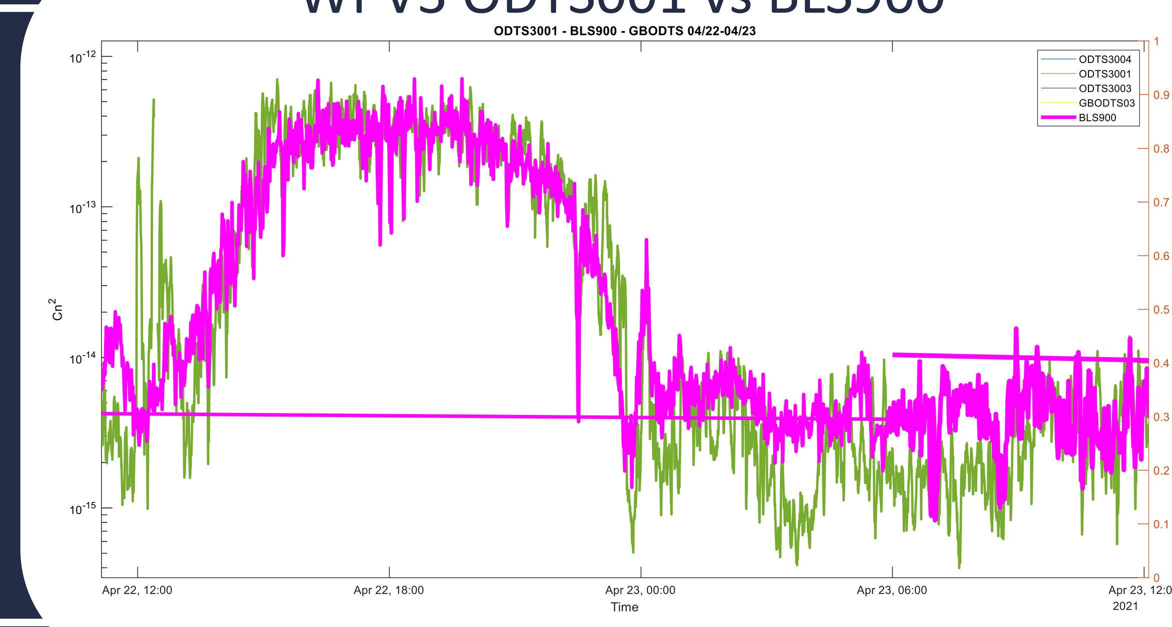
- Rigid Structure
- Sensor Spacing away from Propellers
- Secure Cabling
- Field Replaceable Wear Items
- Quick Health and Status Reference
- Low Size Weight And Power (SWAP)
- On Board Data Storage (SD Card)
- GPS
- Altimeter
- Wide Power Input Range

Platform Support

Ground (Validation) Calibration and Correlation Test Purpose

- Collect atmospheric turbulence data for the updated BlueHalo WPV3 Atmospheric Characterization Payloads
- Collect and compare atmospheric turbulence data from various sensors – WPV3, GBODTS, ATI Sonic Anemometer, and BLS900
- Collect atmospheric turbulence data to support comparison and correlation of ODTS data vs BLS900 data. Correlate minimum Structure Function Window (SFW) with ODTS data reduction using BLS900 data.

WPV3 ODTS001 vs BLS900



UAS Payload Base Specifications

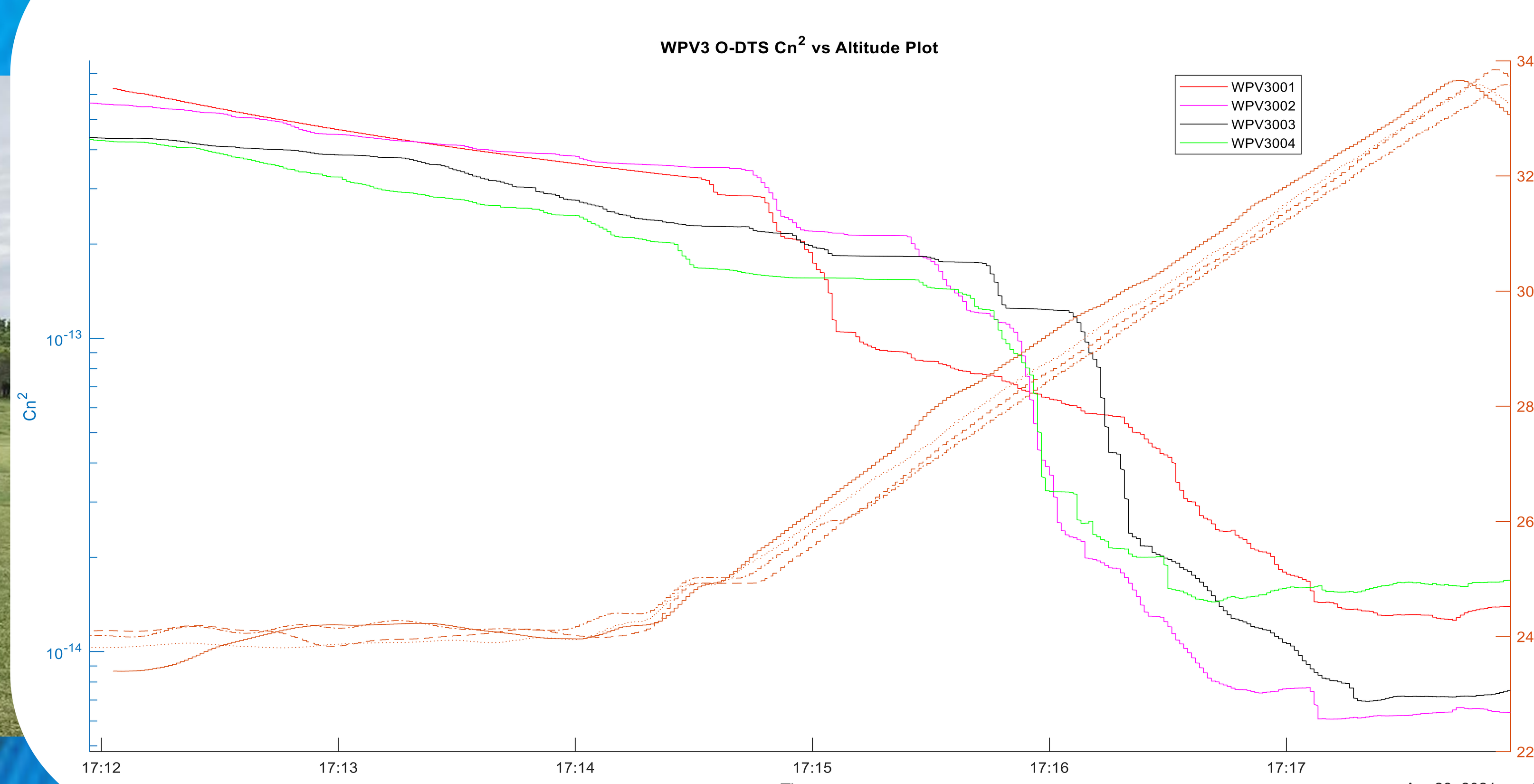
- Trisonica Mini Sonic Anemometer
  - Temperature
  - Pressure
  - Relative Humidity
  - 3D wind Speed
- Barometric Pressure Altimeter
- GPS
- LCD Data Display
- Telemetry Data Link
- SD Card Storage
- 35Hz Sample Rate
- Powered from UAS / 4-12S Battery
- Solar Pyranometer
- DTS Fine Wire Thermocouple
- Optical DTS – **NIST traceable**

Atmospheric Characterization Payload

	Component	Feature	Specification	Unit
Anemometer	Wind Speed	Range	0-50	m/s
		Resolution	0.1	m/s
		Accuracy (0-15 m/s)	+/-0.1	m/s
		Accuracy (15-30m/s)	+/-2	%
	Wind Direction	Range (x,y)	360	Deg
		Range (z)	+/-30	Deg
		Resolution	+/-1	Deg
		Accuracy	+/-1	Deg
	Temperature	Range	-25-80	C
		Resolution	0.1	C
		Accuracy	+/-2	C
	Humidity	Range	0-100	%
		Accuracy	+/-5	%
	Pressure	Range	50-115	kPa
		Accuracy	+/-1	kPa
	Tilt	Pitch and Roll	+/-180	Deg
		Accuracy	+/-0.5	Deg
	Compass	Heading	360	Deg
		Accuracy	+/-5	Deg
DAQ	Data Storage	SD Card	32	GB
	System Speed	Frequency	20	Hz
	Total Weight:		0.75	kg
	Boom Height:		46	cm
	Input Power:		14-50	VDC

UAS Weather Swarm

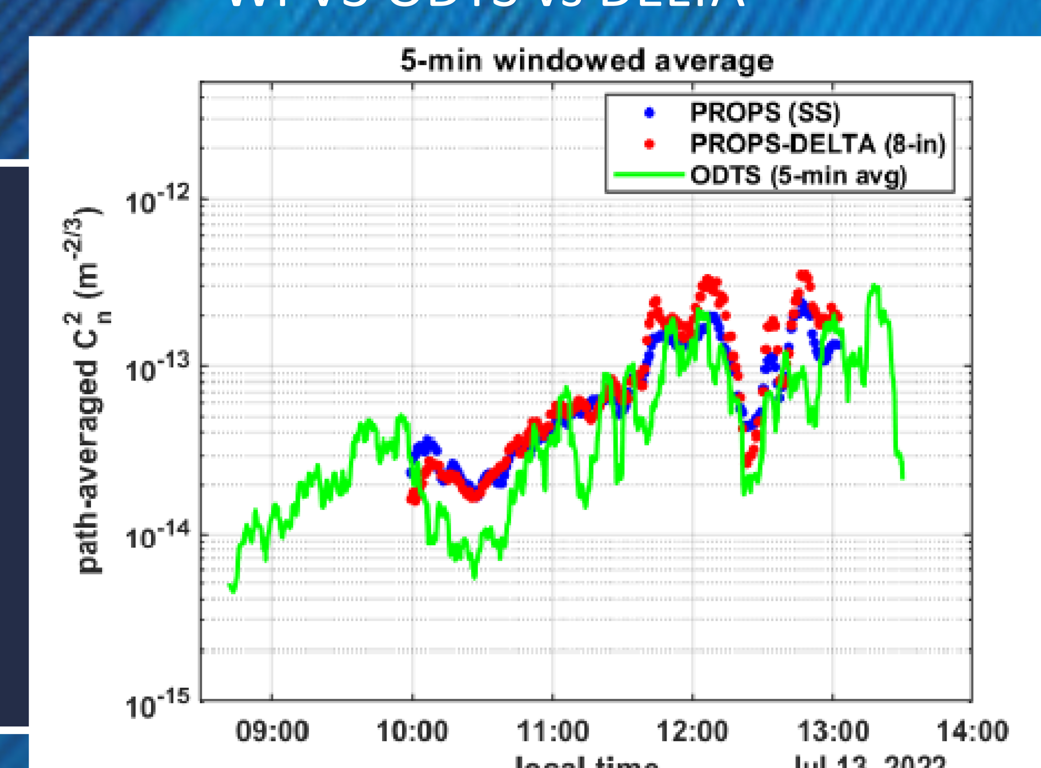
WPV3 UAS SWARM Data



Integrated Path Test

- July 12-13th 2022 – BlueHalo and MZA collected atmospheric turbulence data in combined effort
- A WPV3 ODTS was mounted to a UAS to collect data while MZA's DELTA device was placed on ground
- A target board was mounted on the UAS for the DELTA to observe – this provided an integrated path of $C_n{}^2$ values as opposed to the previous nodal tests
- The maximum distance measured was 750 meters from DELTA to target board (UAS mounted) – maximum altitude of the UAS was 100 meters

WPV3 ODTS vs DELTA



SODAR Data