Coupled Ion-Neutral Dynamics Investigation

The Coupled Ion-Neutral Dynamics Investigation **(CINDI)** is a NASA sponsored Mission of Opportunity conducted by the University of Texas at Dallas (UTD). CINDI will discover the role of ion-neutral interactions in the generation of small and large-scale electric fields in the Earth's upper atmosphere. Ion-neutral interactions are a key process in controlling the dynamics of all planetary atmospheres and their understanding is important to describing the electrodynamic connections between the Sun and the Upper Atmosphere.

The CINDI investigation is carried out as an enhancement to the science objectives of the Communication/Navigation Outage Forecast System (C/NOFS) undertaken by the Air Force Research Laboratory (AFRL) and the Space and Missile Command Test and Evaluation Directorate (SMC/TEL). This program will utilize satellite and ground-based data to develop and evaluate a real-time system for forecasting the presence of radio scintillation caused by equatorial ionospheric plasma structure. The C/NOFS satellite will provide measurements of ionospheric electric fields and particle drifts, the total plasma density, and radio diagnostics. In addition the CINDI instruments will provide measurements of the 3-D neutral winds and ion drifts. The C/NOFS satellite will be operated continuously for at least 1 year. During that time the CINDI science investigations will be undertaken and will provide essential input to real-time specification and prediction models being developed by C/NOFS. This synergistic relationship optimizes the productivity and resources for the CINDI mission.

Science Goals

Question: What are the relationships between the behavior of *F*-region neutral winds and the daily variability of ExB drifts ?

Background: Neutral winds in the ionosphere are responsible for dynamo induced electric fields that cause the ions to move. The redistributed ions change the ion-drag force and thus the neutral winds that are responsible for the electric fields. The behavior of *F*-region neutral winds near the terminator is of fundamental importance to the appearance of plasma irregularities and their subsequent evolution.

CINDI Measurements

Parameter	Dynamic Range	Accuracy	Sens.	Sample Rate
Total Ion Conc.	50 - $5x10^6$ cm^{-3}	50 cm^{-3}	1 %	16 Hz
Ion Drift				
x-trk	+ to - 1000 m/s	2 m/s	1 m/s	16 Hz
in-trk		10 m/s	5 m/s	2 Hz
Neut. Drift				
x-trk	+ to - 500 m/s	5 m/s	2 m/s	16 Hz
in-trk		10 m/s	5 m/s	2 Hz

Approach: By combining the neutral and ion drift measurements with electric field and total density measurements it is possible to determine the local-time behavior of the winds and drifts and their relationships to the appearance of ionospheric irregularities.

Question: How do *F*-region neutral winds and ExB drifts influence the evolution of ionospheric structure ?

Background: The intensity of plasma structure as a function of scale-size is critically important in deciding their impact on radio signal propagation. Neutral winds may affect the development of structures in several ways. First they provide an additional source for instability growth through the gradient drift instability. They also modulate the growth of instabilities from other drivers, by affecting the flux-tube integrated conductivity.

Approach: By combining neutral wind and drift measurements with high-resolution measurements of ion density it is possible to determine the dependence of the intensity of irregularities on the background winds and drifts.

Satellite Orbit

Perigee	Apogee	Inc	Period	Precession	Apsidal Rot.
400 km	700 km	13^0	95 min	1 hr LT in 1.8 days	Eq. To Max. Lat in 6.4 days

Instrumentation and Operations

The CINDI sensors, IVM and NWM, will measure the total ion concentration and the ion and neutral velocity vectors. The sensors are mounted to view along the spacecraft velocity vector and are fully integrated into the C/NOFS payload. The C/NOFS spacecraft is supplied to the Air Force SMC/TEL by Spectrum-Astro Corporation. The full complement of instruments, which includes the CINDI sensors, is integrated onto a single payload module. Power is supplied by body mounted solar cells with an additional cylindrical skirt that can be extended along the spacecraft axis in flight. The satellite will be launched from a Pegasus launch vehicle. The Air Force Satellite Control Network will utilize their Space-Ground Link System and TDRSS to supply data to the C/NOFS data center.

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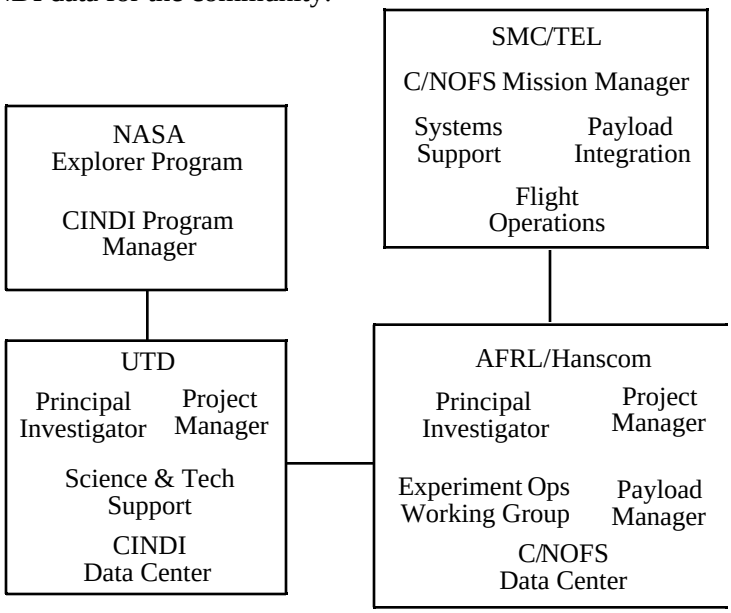
	ION VELOCITY METER	NEUTRAL WIND METER	
		RAM SENSOR	CROSS-TRACK SENSOR
Heritage	AE,DE,DMSP San Marco	Sub sys AE, DE	PIDP, subsys on AE
Dimensions Sensor	25 x 12 x 9 cm.	18 x11x19 cm.	16 dia x 19 cm.
Dimensions Electronics	InSensor Pkg.	22 x 12 x 10 cm.	
Sensor Mass **5.8 Kg**	2.4 kg	1.5 kg	1.9 kg
Electronics Mass **2.2 Kg**	InSensor Pkg.	2.2 kg	
Sensor Power **13 W**	3 W	3 W	7 W
Electronics Power **2.5 W**	InSensor Pkg.	2.5 W	
Inst. Data Rate **3.5 Kbps**	2.0 kbps	1.5 kbps	
Look Direction	Along S/C Ram	Along S/C Ram	
Instantaneous FOV	±45°	±45°	

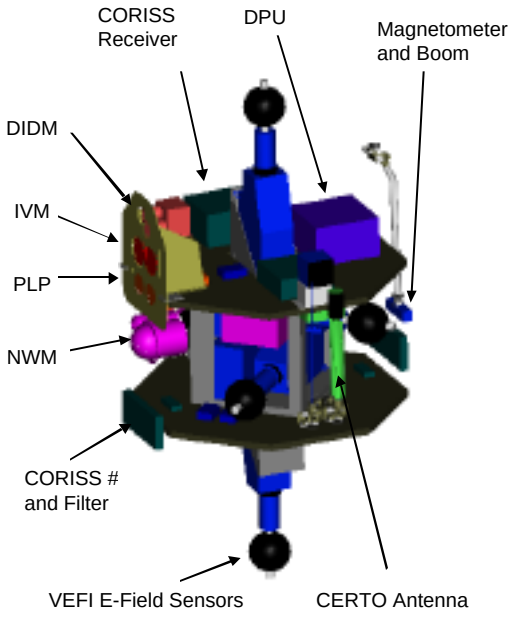
C/NOFS Satellite

Pointing	Control	Accuracy	Stability	Loc. Accuracy
3 axis stabilized 1 rev/orbit	2^0 R,P,Y	0.1^0	$<0.1^0$/min	3 km alt 10 km in-trk 10 km x-trk

Mission Management

The C/NOFS satellite program undertaken by the Air Force is the host mission for the CINDI instruments. The Air Force SMC/TEL is responsible for the spacecraft procurement, payload integration and the execution of flight operations. The C/NOFS science and operations are managed by AFRL from a program office at Hanscom Air Force Base. The PI at UTD manages CINDI operations that are coordinated with the C/NOFS operations through the experimenter's working group. CINDI science is conducted at UTD under direction of the PI. A science data center at UTD will support the CINDI science activity and provide open access to the CINDI data for the community.





C/NOFS Satellite Payload

Schedule

s/c contract	Feb, 2001
Pre. Des. Rev	Aug, 2001
Crt. Des. Rev	Dec, 2001
Payload Int.	Feb, 2003
Launch	Oct, 2003

Budget

Pre-Launch $ 7.7M Post Launch $ 2.9M