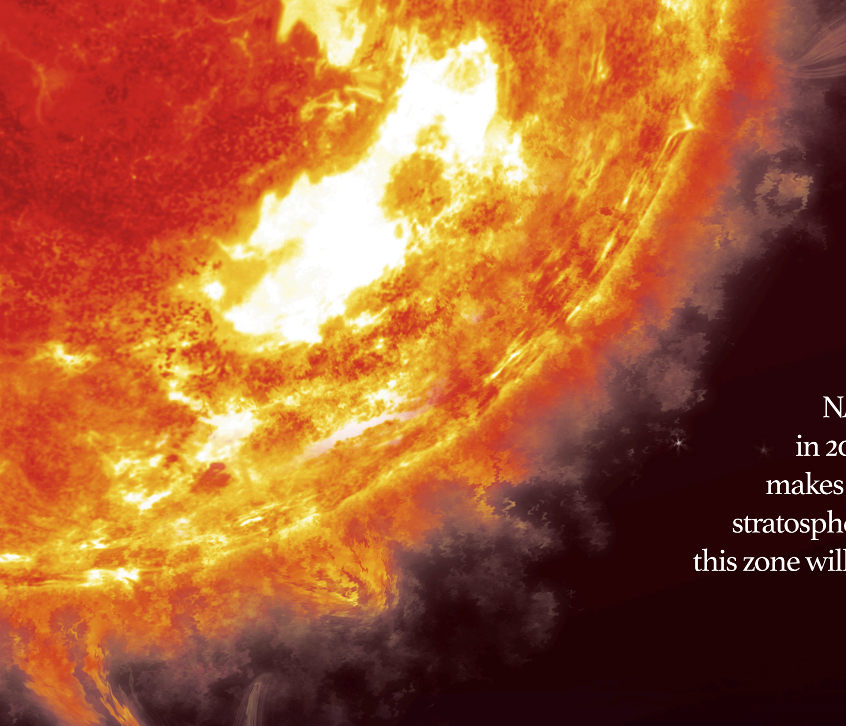


Understanding the Ionosphere: NASA'S ICON MISSION

Poster designed by Mark Belan (www.artscistudios.com)

NASA is gearing up to launch its latest space mission, the Ionospheric Connection Explorer, otherwise known as ICON, in 2018. The spacecraft will investigate the characteristics of the ionosphere - a unique region of Earth's atmosphere that makes radio and GPS communications possible. Space and Earth weather events, like coronal mass ejections and stratospheric warming events, drive extreme and unpredictable variability in this region. Understanding the forces at play in this zone will offer insight to the types of disturbances that interfere with radio communications and GPS signaling.

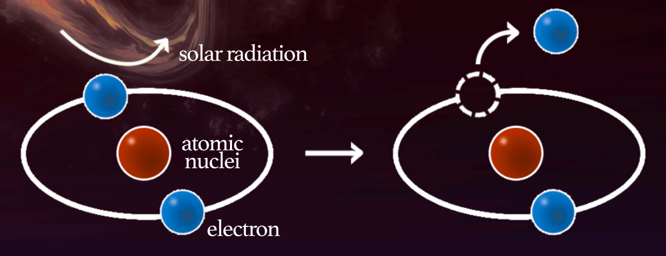


Figure adapted from http://ecetutorials.com/photo-electric-effect-and-photo-ionization/

IONIZATION

When solar radiation and/or cosmic rays enter the Earth's atmosphere, atoms and molecules can lose electrons to form positively charged ions. This process, known as ionization, creates a unique region in the Earth's atmosphere called the ionosphere, which contains a variety of ionized gas species, including ions of oxygen, hydrogen, nitric oxide, and others. These ions co-exist alongside the liberated electrons until they recombine through collisions.

IONOSPHERE

The ionosphere is a region of Earth's upper atmosphere, from about 60 km (37 miles) to above 1, 000 km (620 miles) altitude. It owes its existence primarily to ultraviolet radiation and x-rays from the Sun, which ionize particles over a range of altitudes. The structure and composition of the neutral atmosphere that is ionized by the sun at these altitudes leads to a distinct set of layers in the ionosphere which vary in both ion species and total number of ions (right; Figure 1). Since ionization depends primarily on the Sun and its activities, the amount of ionization in the ionosphere is controlled by diurnal and seasonal effects (Figure 2).

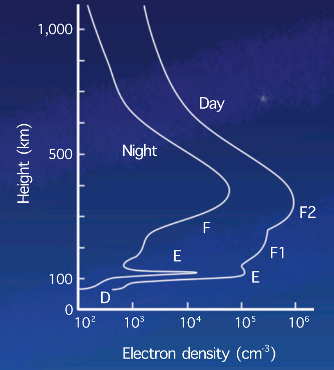


Figure 1: The density of electrons changes with altitude in daylight and nighttime. The F layer is generally the most dense ionospheric layer.

Figure adapted from http://encyclopedia2.thefreedictionary.com/ionosphere.

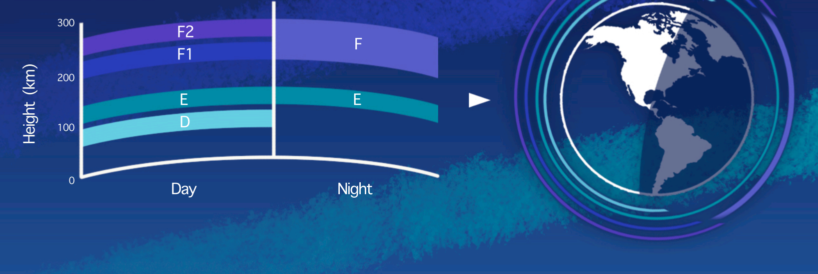
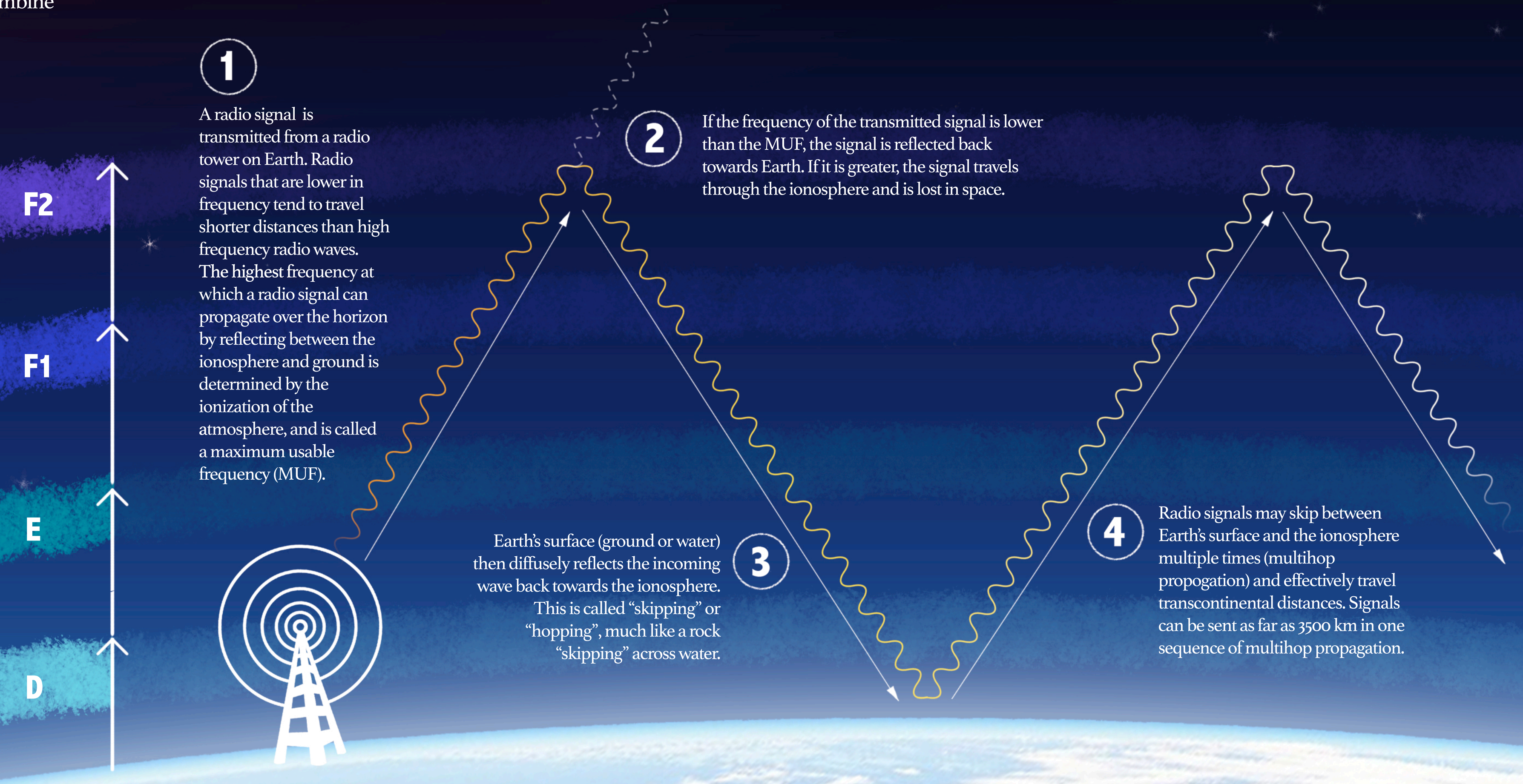


Figure 2: The ionosphere separates into different layers depending on the amount of sunlight available. Generally, the ionosphere is separated into four distinct layers during the daytime, and combines into two during the night.

Left figure adapted from the Naval Postgraduate School, http://www.weather.nps.navy.mil/~psguest/EMEO_online/module3/module_3_2.html. 22 October 2003.
Right figure adapted from the University of Waikato, https://www.sciencelearn.org.nz/resources/243-space-plasma.

SKYWAVE PROPAGATION

Skywave propagation is the behavior of radio waves when they are transmitted through, or reflected from, the ionosphere back toward Earth's surface. Because low-frequency radiowaves (near the AM radio band and below) can reflect from the ionosphere, it is possible to send signals far beyond the horizon, traversing intercontinental distances. (This is how ham radio operators in the United States can contact operators in, say, Japan). However, since the ionosphere is a continuously changing region influenced by the sun and the neutral atmosphere, radio communications can change from one day to the next, and sometimes even from one hour to the next. Generally, layers with higher electron densities can reflect signals at higher frequencies, up to ~10 MHz for the densest portions of the ionosphere. The variation of the peak height of the ionosphere between day and night can often allow signals to propagate farther at night.



1. A radio signal is transmitted from a radio tower on Earth. Radio signals that are lower in frequency tend to travel shorter distances than high frequency radio waves. The highest frequency at which a radio signal can propagate over the horizon by reflecting between the ionosphere and ground is determined by the ionization of the atmosphere, and is called a maximum usable frequency (MUF).

2. If the frequency of the transmitted signal is lower than the MUF, the signal is reflected back towards Earth. If it is greater, the signal travels through the ionosphere and is lost in space.

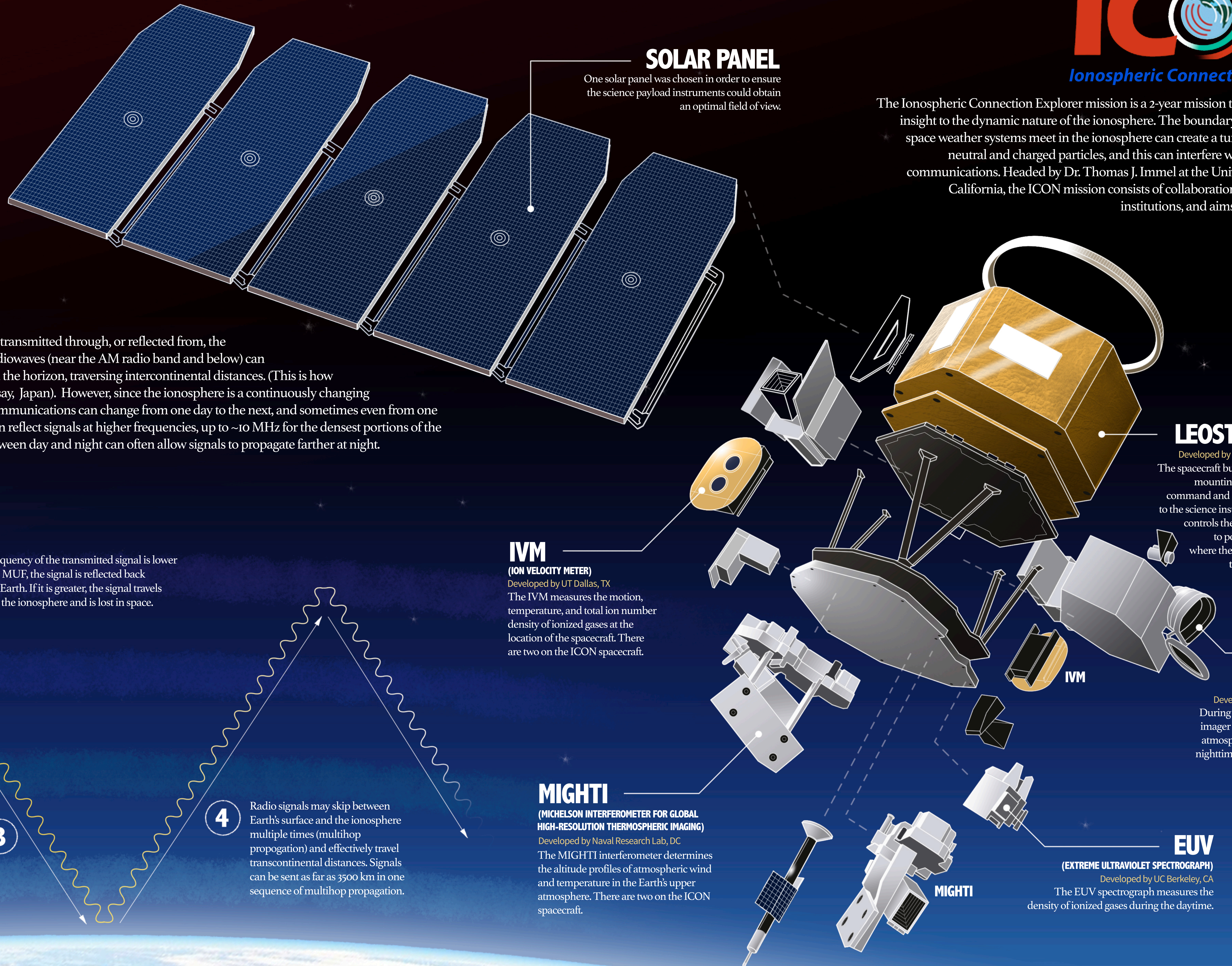
3. Earth's surface (ground or water) then diffusely reflects the incoming wave back towards the ionosphere. This is called "skipping" or "hopping", much like a rock "skipping" across water.

4. Radio signals may skip between Earth's surface and the ionosphere multiple times (multihop propogation) and effectively travel transcontinental distances. Signals can be sent as far as 3500 km in one sequence of multihop propagation.

ICON

Ionospheric Connection Explorer

The Ionospheric Connection Explorer mission is a 2-year mission that will bring new insight to the dynamic nature of the ionosphere. The boundary where Earth and space weather systems meet in the ionosphere can create a turbulent mixture of neutral and charged particles, and this can interfere with radio and GPS communications. Headed by Dr. Thomas J. Immel at the University of Berkeley, California, the ICON mission consists of collaborations between several institutions, and aims to launch in 2018.



SOLAR PANEL

One solar panel was chosen in order to ensure the science payload instruments could obtain an optimal field of view.

LEOSTAR-2 BUS

Developed by Orbital/ATK in Sterling, VA

The spacecraft bus provides mechanical mounting, electrical power, and command and data telemetry services to the science instruments. The bus also controls the spacecraft orientation to position the instruments where they need to be to observe the Earth's atmosphere.

IVM

(ION VELOCITY METER)

Developed by UT Dallas, TX

The IVM measures the motion, temperature, and total ion number density of ionized gases at the location of the spacecraft. There are two on the ICON spacecraft.

FUV

(FAR ULTRA VIOLET IMAGING SPECTROGRAPH)

Developed by UC Berkeley, CA

During the daytime, the FUV imager determines the upper atmospheric composition. At nighttime, it measures altitude profiles of ion density.

MIGHTI

(MICHELSON INTERFEROMETER FOR GLOBAL HIGH-RESOLUTION THERMOSPHERIC IMAGING)

Developed by Naval Research Lab, DC

The MIGHTI interferometer determines the altitude profiles of atmospheric wind and temperature in the Earth's upper atmosphere. There are two on the ICON spacecraft.

EUV

(EXTREME ULTRAVIOLET SPECTROGRAPH)

Developed by UC Berkeley, CA

The EUV spectrograph measures the density of ionized gases during the daytime.

References: 1) Garner, Rob. "ICON Mission Overview." NASA. NASA, 31 Mar. 2016. Web. 03 Apr. 2017. 2) "How Electromagnetic Waves Propagate in Atmosphere?" The Bigger. N.p., n.d. Web. 03 Apr. 2017. 3) "ICON - EoPortal Directory - Satellite Missions." ICON - EoPortal Directory - Satellite Missions. N.p., n.d. Web. 04 Apr. 2017. 4) "Ionosphere." The Free Dictionary. Farlex, n.d. Web. 04 Apr. 2017. 5) "Ionospheric Modification." Ionospheric Radio (n.d.): 506-37. Web. 6) "Layers of the Ionosphere." Science Learning Hub. University of Waikato, 29 Apr. 2014. Web. 4 Apr. 2017. 7) "Photo Electric Effect and Photo Ionization." ECE Tutorials. N.p., n.d. Web. 04 Apr. 2017. 8) "Science Overview." ICON - Ionospheric Connection Explorer. N.p., n.d. Web. 03 Apr. 2017. 9) "Tracking Solar Flares." Tracking Solar Flares. N.p., n.d. Web. 03 Apr. 2017.

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