Crew Earth Observations: Twelve Years of Documenting Earth from the International Space Station

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Introduction: The Crew Earth Observations (CEO) payload was one of the initial experiments aboard the International Space Station, and has been continuously collecting data about the Earth since Expedition 1. The design of the experiment is simple: using state-of-the-art camera equipment, astronauts collect imagery of the Earth's surface over defined regions of scientific interest and also document dynamic events such as storms systems, floods, wild fires and volcanic eruptions (e.g. Stefanov et al, 2012, Evans et al. 2011). To date, CEO has provided roughly 600,000 images of Earth, capturing views of features and processes on land, the oceans, and the atmosphere. CEO data are less rigorously constrained than other remote sensing data (Green and Lopez, 2009), but the volume of data, and the unique attributes of the imagery provide a rich and understandable view of the Earth that is difficult to achieve from the classic remote sensing platforms Stefanov et al 2012). In addition, the length-of-record of the imagery dataset, especially when combined with astronaut photography from other NASA and Russian missions starting in the early 1960s, provides a valuable record of changes on the surface of the Earth over 50 years. This time period coincides with the rapid growth of human settlements and human infrastructure.

Equipment: Crew members use handheld cameras (currently only digital) and high definition video, and a variety of lenses (including a 400 mm lens with a doubling attachment, equivalent to 800 mm lens) to take Earth observation photographs. The imaging equipment is periodically updated to take advantage of the rapidly changing camera technologies. The CEO payload may use any available window on the Space Station, but are today conducted primarily from the windows in the Russian Zvezda service module and the Cupola. Prior to installation of the Window Observational Research Facility, or WORF in 2010the nadir-viewing, optical-quality window in the U.S. Destiny laboratory module was also used for CEO operations.

Operational support: The crew receives daily lists of viewing opportunities of sites or dynamic features, such as storm systems. These lists are compiled using updated ISS trajectory information, including the ISS orbital location, the local solar illumination, and the local sun reflection point (over water). Other considerations that factor into the daily compilation of targets include specific site requirements for successful documentation, such as time of year. In addition, the sites are vetted with weather information, and crew sleep periods. The crew has navigational software that support their observations. The data (images and metadata, including timestamp, camera settings, lens) are downlinked to the ground, processed, and assimilated into the Gateway to Astronaut Photography Database (http://eol.jsc.nasa.gov). The time stamp is processed against historical state vectors for the ISS so that the nadir position and solar information becomes part of the

image metadata. High priority images that are part of a designated scientific campaign are manually reviewed and augmented with additional descriptive information.

In addition to the planned and requested observations, astronauts independently observe and collect data of features and regions of the Earth that interest them. Crew innovation has resulted in new and unique sets of data.

Imagery campaigns and accomplishments: Since 2000, Crew Earth Observations has supported several specific imagery campaigns. There has been a continued focus on repeated photography of long term ecological sites, small coral reefs and island nations in the remote parts of the world's oceans, upper atmospheric phenomena such as aurora and Polar Mesospheric (or noctilucent) Clouds, detailed photography of cities and their growing footprint, and changes along coastlines. To support planetary studies, crew routinely observe features that are common on different planets in the solar system , including impact craters, volcanoes and large dune systems. Specific campaigns include support to the International Polar Year (2008-2009) through polar observations of features like sea ice, icebergs, and upper atmosphere phenomena. Another observational campaign supported the Beagle Project, a collaboration and international celebration of Charles Darwin's 200th birthday and his explorations on the HMS Beagle. The images are frequently used as educational tools. Because of its popularity with students and educators, CEO has participated in a wide variety of formal and informal educational activities, e.g. the Expedition Earth and Beyond program (http://ares.jsc.nasa.gov/ares/eeab/index.cfm).

Recently, advances in camera sensitivity have enabled low light photography of urban areas at night at higher spatial resolutions than available from comparable Defense Meteorological Satellite Program (DMSP) data. . City lights help outline the most populated areas in settlements around the world, and can be used to explore relative population densities, changing patterns of urban/suburban development, transportation networks, spatial relationship to geographic features, and more. The night time astronaut photographs of urban areas can serve as a "zoom lens" for the lower resolution DMSP data for select urban areas. In addition, the capability to obtain time-lapse imagery from fixed cameras has been exploited to produce dynamic videos of both changing surface patterns around the world and atmospheric phenomena.
http://eol.jsc.nasa.gov/Videos/CrewEarthObservationsVideos/.

Finally, over the years CEO has routinely captured the Earth's dynamic events, resulting in unique views of volcanic eruptions, tropical storm systems, and tsunami damaged coastlines. Today CEO places a new emphasis on observations of large events, both natural and man-made, and supports the international effort to use ISS data for humanitarian purposes, including response to disasters.

References

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