Arctic Weather Every 10 Minutes: Exelis ABI on PCW

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Synopsis:

The US, Japanese, Korean, and European meteorological agencies are all upgrading their geostationary weather imagers to provide much more frequent Full Disk Earth images (every 5 to 10 minutes). The Exelis Advanced Baseline Imager (ABI) will fly on GOES-R East, GOES-R West, Himawari (Japan), and GEO-KOMPSAT-2A (Korea), providing these missions the additional capability for interleaved mesoscales delivering storm observations every 30 to 60 seconds. Arctic weather observation, however, is still limited to a few passes a day from low Earth orbit (LEO) satellites, many of which are well beyond their intended operational life.

Arctic weather could obtain the same temporal fidelity as equatorial and mid-latitude weather if Canada's Polar Communication and Weather (PCW) mission flies with ABI imagers. This would provide full images of the Arctic every 10 minutes plus interleaved storm watches every minute, rather than just a swath every 100 minutes. Such coverage would dramatically improve the quality of Arctic weather observation and prediction.

1. Geostationary Imagers Do not Provide High-Quality Arctic Weather Data

Due to the curvature of the earth, the geostationary weather imagers only provide high quality weather data up to ~60°N latitude. This coverage is shown in Figure 1. The purple regions are the coverage currently provided by the Exelis GOES-class imagers and soon to be provided by the Exelis ABI-class imagers. The gray region is the coverage provided by the EUMETSAT imagers. As can be seen, this leaves out the entire Arctic region, including Alaska, northern Canada, Iceland, etc.

2. LEO Imagers Have Many Limitations

Much of the Arctic's satellite weather data comes from LEO satellites. They provide useful data but have critical limitations.

LEO data is collected one swath at a time with an orbital period of ~100 minutes. There is no ability to obtain persistent images, which means evolving weather cannot be observed in the way that it can with a geostationary imager.

The long time gaps between observations means much of the Arctic weather products come from numerical weather models rather than directly from images. However, the images used to initialize and drive the models consist of pixels collected over a wide span of time ("aging pixels"), impacting the accuracy of these models.

VIIRS, the next generation LEO imager, lacks the water vapor bands used for winds – a critical product for Arctic weather.

The LEO imager constellation is aging. Most satellites are already beyond their expected operational life and far fewer satellites are planned for the future (see Figure 2). This will result in less coverage for the Arctic.

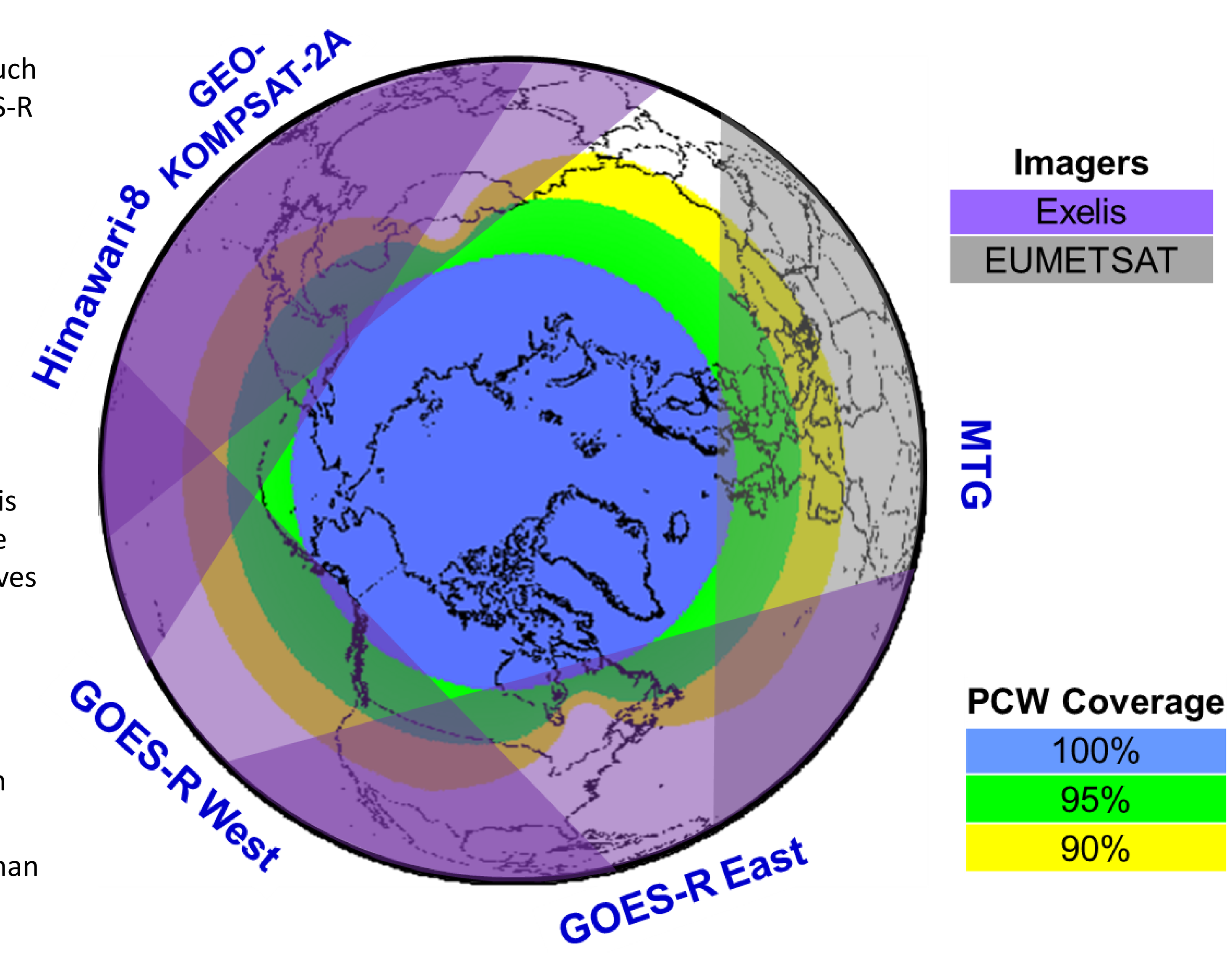

Figure 1: ABI on PCW fills geostationary imager constellation Arctic gap

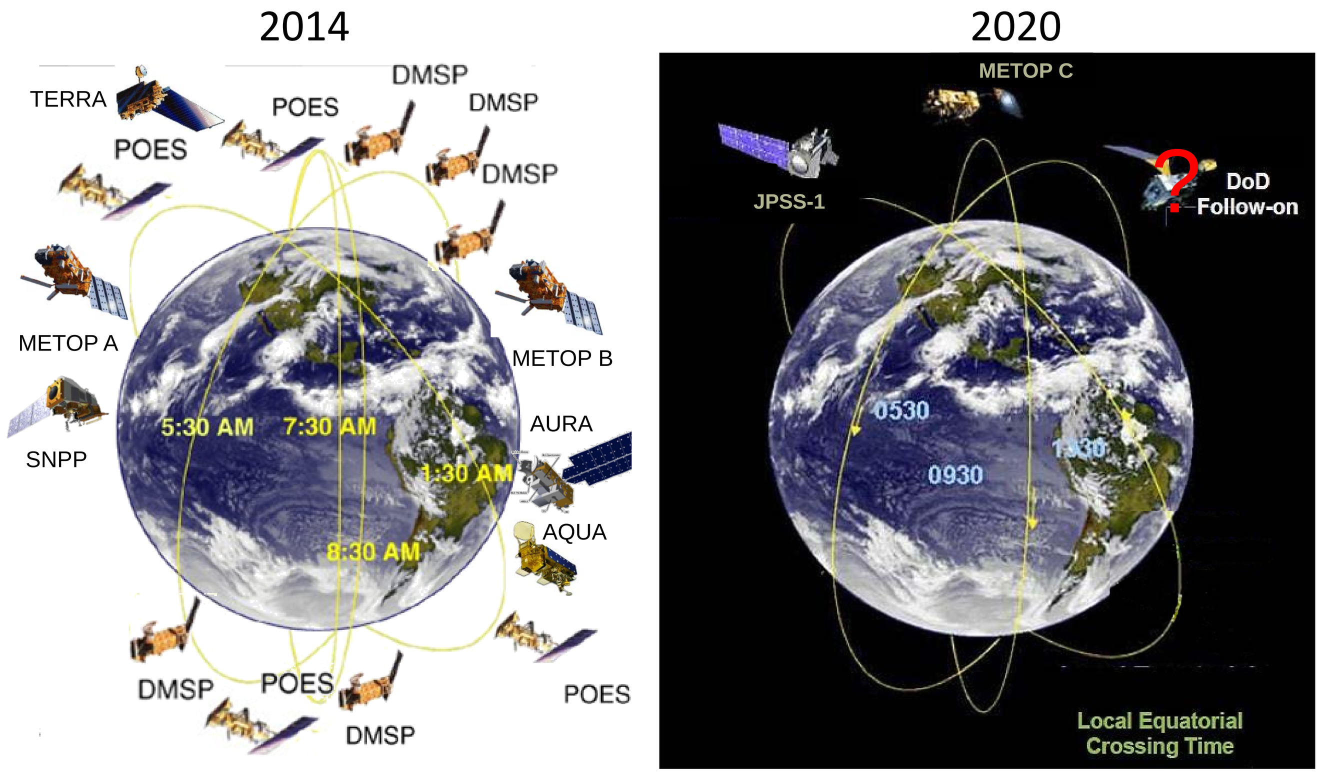

Figure 2: LEO weather imagers are aging, reducing future Arctic coverage

3. PCW Designed for Persistent Arctic Coverage

The 100% coverage region for PCW is shown in blue in Figure 1. PCW will provide continuous coverage of the entire Arctic region, filling the gap left by the geostationary imagers. Continuous coverage is provided for all parts of the earth above 60°N latitude, which includes most of Canada, Alaska, Iceland, Greenland, etc.

With ABI-class imagers on PCW, Full Disk Earth images, including the Arctic, can be collected every 10 minutes and storm watch images can be collected every minute.

There is a distinct trend over the last couple of decades of warmer temperatures in the Arctic. This leads to less ice and greater weather and environmental uncertainty. The frequency and intensity of Arctic cyclones is increasing (1900 storms between 2000 and 2010). Shipping traffic and human habitation is also increasing as the ice melts.

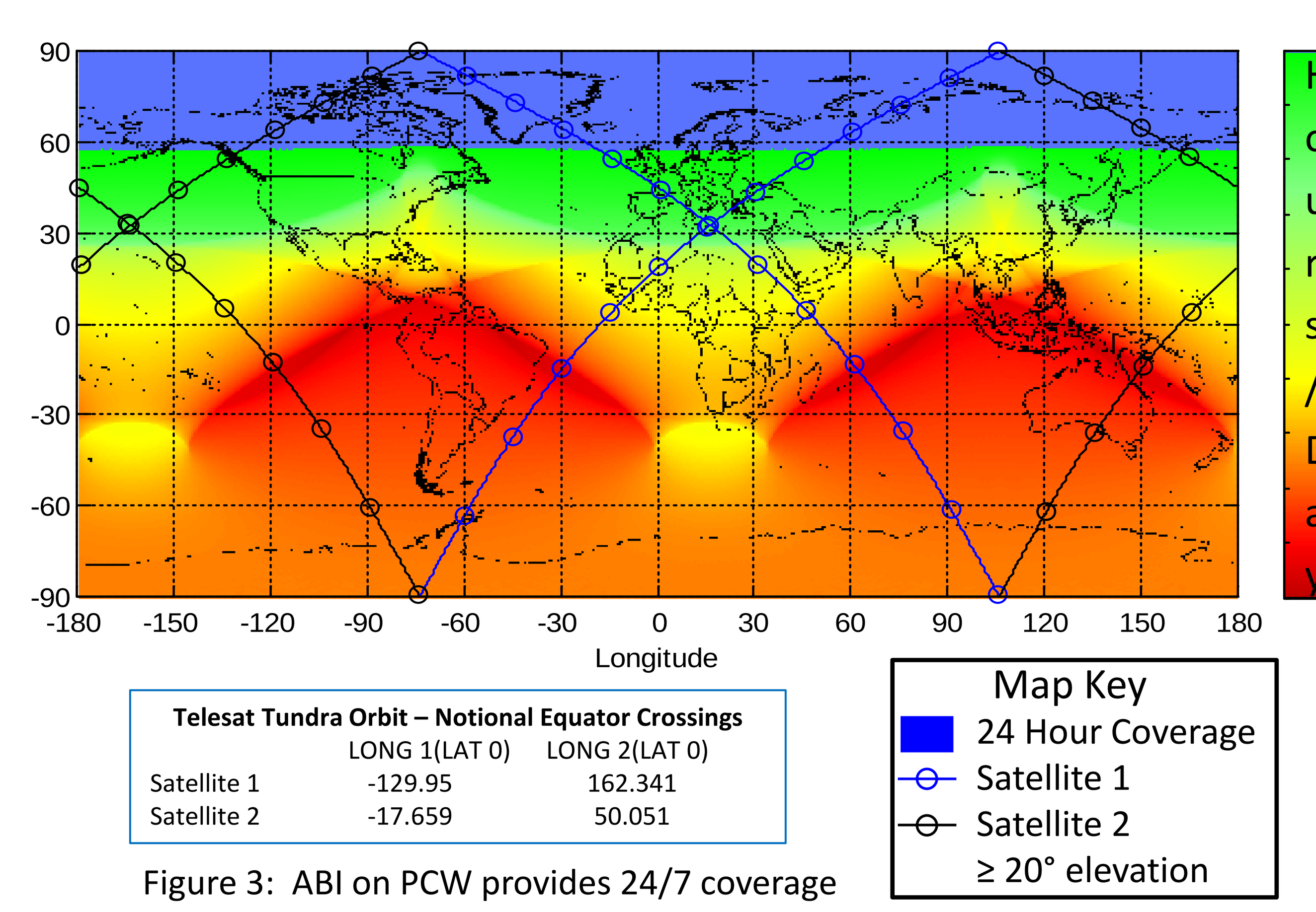

Figure 3: ABI on PCW provides 24/7 coverage of Arctic with updated images every 10 minutes

4. Tundra Orbit Provides Global Coverage

Like a LEO instrument, PCW will provide coverage for the entire globe. Unlike a LEO instrument, it can provide persistent coverage of the Arctic. Figure 3 shows the global coverage for PCW when flying in a Tundra orbit. The blue region is 24 hours of coverage per day and every spot on the earth is observed for more than 4 hours per day. Antarctica is observed for more than 8 hours per day. PCW will also provide significant coverage in the Indian Ocean region which will be of particular importance with the planned retirement of Meteosat 7 in 2016.

The Tundra orbit is a moderately eccentric orbit, as shown in Figure 4. Apogee is ~20% higher than a geostationary orbit and perigee is ~20% lower. The orbital period is twenty-four hours. Two satellites are used, orbiting twelve hours apart. One possible set of ground tracks for these satellites is shown in Figure 3.

The view of the earth from one satellite over the course of the orbit is also shown in Figure 4. The red circle is ABI's field-of-regard (FOR). At perigee the earth is close enough to overfill the FOR but for most of the orbit ABI will see the entire Earth plus space.

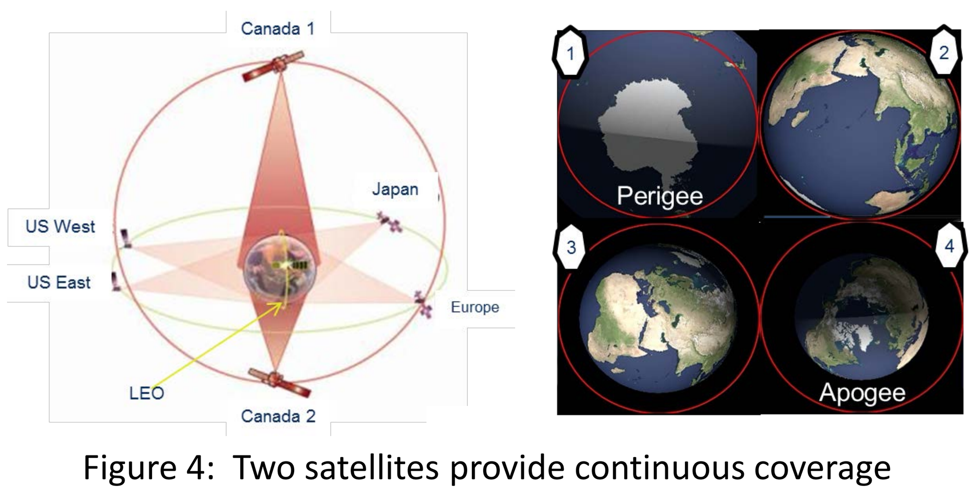

Figure 4: Two satellites provide continuous coverage

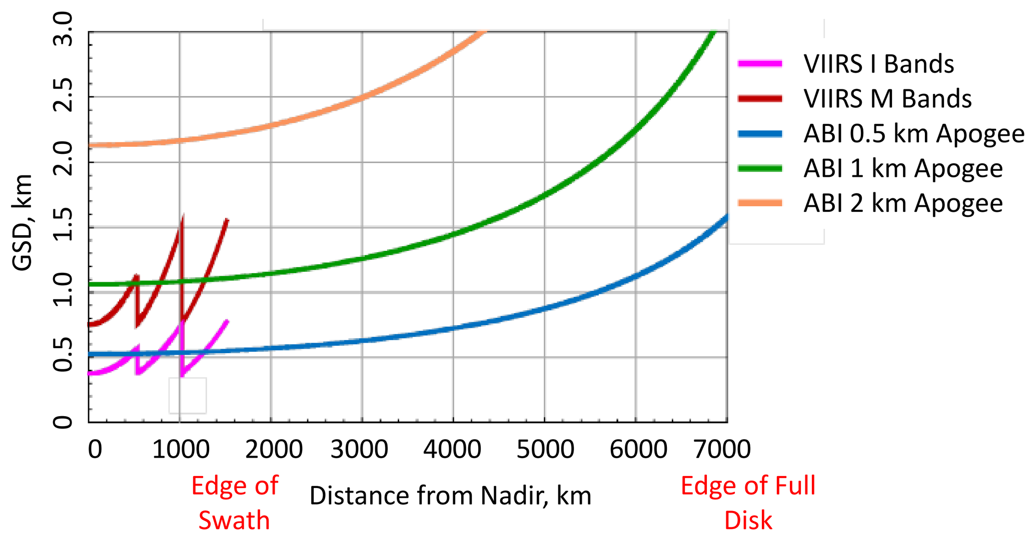

Figure 6: PCW delivers similar resolution as VIIRS

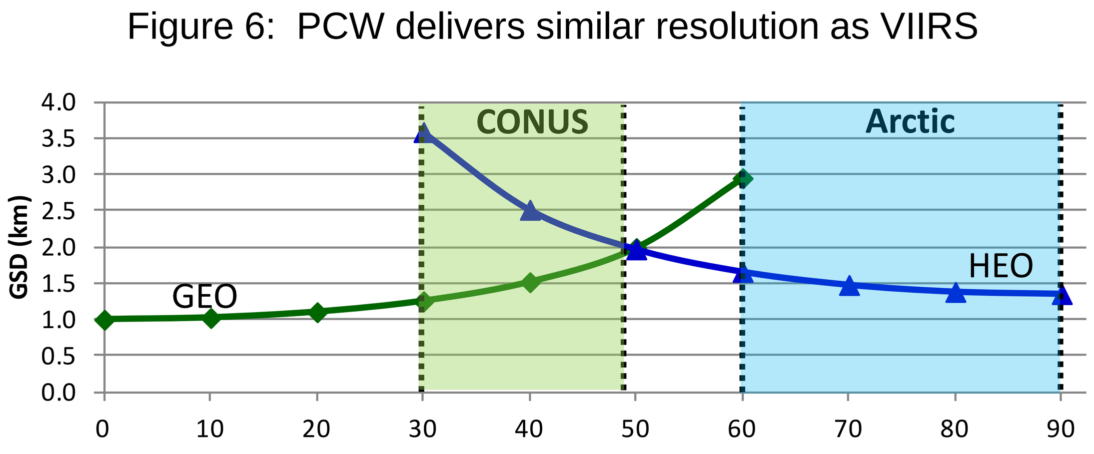

Figure 7: Resolution of Arctic images from PCW will be similar to CONUS images from GOES-R

5. PCW Imagery Will Improve Arctic Weather Knowledge and Forecasts

ABI provides sixteen channels selected for weather data products (listed in Table 1). They include the water vapor channels used for assessing winds as well as channels for identifying fires and tracking volcanic ash.

Although located at a much higher orbit than the LEO constellation, the resolution of an ABI on PCW is comparable (see Figure 6) and offers the advantage of being uniform (no distortion caused by abrupt resolution changes). The resolution is compatible with the current numerical weather models. The resolution is also as good as or better than that obtained for CONUS imagery from GOES-R because the area of interest is directly beneath the satellite (see Figure 7).

The ability to collect an entire image within 10 minutes will significantly improve knowledge of current Arctic weather. It will also improve the models by eliminating the "aging pixels" issue. One minute updates for severe weather events will provide one hundred times the temporal fidelity of current LEO imagers.

PCW & ABI Will Deliver Next Generation Arctic Weather

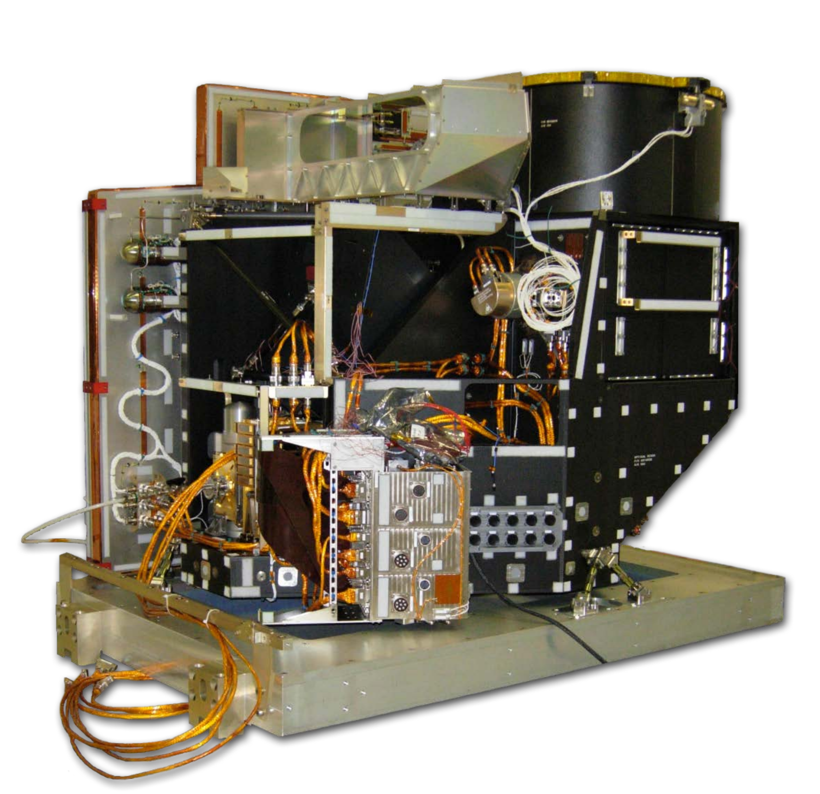

Figure 5: Exelis delivered two ABI-class imagers in 2013 and five more are currently in production

Table 1: ABI spectral channels selected for weather data products

Wavelength (μm)	GSD (km)†	Main Applications
0.47	1.1	Surface, clouds, aerosols
0.64	0.5	Wind, clouds, ice mapping
0.87	1.1	Wind, aerosols, vegetation
1.38	2.0	Cirrus detection
1.61	1.1	Snow-cloud distinction, ice cover
2.25	2.0	Aerosol, smoke, cloud phase
3.9	2.3	Fog, fire detection, ice/cloud separation, wind
6.185	2.3	Wind, high level humidity
6.95	2.3	Wind, mid level humidity
7.34	2.3	Wind, low level humidity,SO_2
8.5	2.3	Total water, cloud phase
9.61	2.3	Total ozone
10.35	2.0	Cloud, surface, cirrus
11.2	2.0	Cloud, Sea Surface Temperature (SST), ash
12.3	2.0	Ash, SST
13.3	2.0	Cloud height

†Nadir GSD at PCW reference altitude (apogee ±3 hours)

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