Aerial photography surveys

Anglian Coastal Monitoring

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This document describes the coastal aerial photography surveys and imagery collected by the Anglian Coastal Monitoring project.

The Survey

How we collect photography data

The Environment Agency has flown an aerial photography survey of our coastline every summer since 1991. We have two aeroplanes equipped with Leica RCD30 multispectral medium format camera systems. These are fixed to the hull of the plane and capture vertical imagery of the coast below.

Figure 1: Camera mounted inside the aircraft

The camera system includes a Position and orientation system (POS) from a GPS receiver and an Inertial Measurement Unit (IMU) from a LIDAR instrument. This calculates the position of the plane in the air with regard to changes in pitch, roll and yaw. Although a relatively stable platform the plane is impacted by turbulence. The accelerometers and gyroscopes in the IMU measure this, and the tilt of the plane as it manoeuvres to achieve the designated flight path. The exterior orientations of the images are calculated from the post-processed GPS trajectory, where images are 'synchronised' to the GPS trajectory using the GPS timings and the camera's calibration files. We then use a process called aerial triangulation (assigning known points of ground features into overlapping images).

Therefore each photograph is spatially referenced and the real world position of each image and the features shown within it are known and can be displayed in a Geographic Information System (GIS) software.

The aeroplane generally captures images while flying at between 1200 and 2000 m above ground level. This provides a ground resolution of less than 20 cm. Meaning one image pixel shows an area of 20 cm on the ground. Images are captured at approximately 5 second intervals and typically flown with 55% forward overlap and 30% side overlap. Each image will show an area of the ground 1.2 km wide and 800 m in length, depending on the flying height. In a typical coastal survey we take about 7,000 photos.

The flight log sheet documents the 'line set up' time giving an approximate flight height. This does not account for changes in topography and so is used as an approximate height. The flight line times and status of the tidal window are also recorded.

Specification

Surveys are conducted according to the latest version of the Environment Agency's *National Standard Contract and Specification For Surveying Services, Standard Technical Specifications*.

Figure 2: The EA Geomatics aircraft in flight.

Survey timing

Our photography is flown in the summer months, with a flying season extending from May to September. The summer months provide a greater number of vital cloud free days, but also allows us to capture vegetation in bloom. We need appropriate weather conditions to be able to fly and capture sufficient photographs. There must be minimal haze, which reduces the light levels and clarity of the image. Low wind conditions, meaning there is less turbidity, and generally also means a calmer and more consistent wave pattern throughout the mosaiced imagery.

Flights are carried out to coincide with the time of Low Water, usually on a Spring tide in order to achieve the required seaward extent and maximum area of exposed beach or mudflat. The time of day is also important to ensure we fly within the tolerances for sun angle relative to the camera. Vegetation absorb blue and red light and reflect green and near infra-red spectral signatures. The angle of the sun impacts on this and so can change how vegetation appears in the imagery, potentially making tasks such as determining zonation of saltmarsh difficult. The sun angle is also important to minimise shadows from tall structures and buildings and to avoid issues such as sun glint which can drastically impact on the colours in the imagery and blurring. Sun glint is the specular reflection of sun from the sea and water surfaces, as the sun angle increase sun glint increases. The window for acceptable sun angle and glint are reduced in the winter months and opportunities to fly in September into October are significantly reduced. Capturing images with an overlap helps compensate for any loss of image from sun glint.

Our aeroplanes are also subject to flight time restrictions, this is especially the case around areas of heavy air traffic such as Southend airport of Ministry of Defence bases and ranges such as in The Wash.

Every five years there is a baseline aerial photography survey. The baseline will include a wider area of the coast, such as the mudflats within The Wash, and the estuaries in Suffolk and Essex.

The Data

Processing

The imagery is orthorectified, a process of using a digital terrain model (DTM) collected by the LIDAR system to distort the photograph vertically so it is accurately referenced relative to a spatial referencing framework. The first step of this process is to 'stitch' together the imagery using the LIDAR elevation data and GPS/IMU positional information to produce a single mosaic image. At this point the spatial accuracy of the imagery is refined by using the aerial triangulation method to place tie points on known ground objects, such as white lines on roads that are seen by multiple images. A minimum of four tie-points per image are used. Heading, roll and pitch errors are adjusted through an iterative process until the misalignments between tie-point objects seen from different images fall within tolerance and a final position for each image is created.

The spatial accuracy of the imagery is checked against an OS MasterMap layer. Each attributed feature in OS MasterMap has an associated accuracy level, typically +/-1 m in urban sites and between +/- 1.5 to +/-2 m in rural coastal areas. Imagery is compared against the OS layer across the survey to ensure spatial precision by checking roads and other identified ground features match against the imagery.

The spatially accurate orthorectified mosaics are radiometrically checked and adjusted for colour, contrast and intensity in inPho Orthovista. Automated seam lines are then generated at image boundaries. A mathematical 'global tilting adjustment' performs radiometric adjustments to compensate for intensity/colour differences between adjacent/overlapping images. A reflections removal function, where required, may also be applied to check for sun reflections within an area of interest (e.g. from the North Sea) and to attempt to eliminate them. We then apply a final algorithm to blend all the individual images into 1 km tiled mosaics.

The data are manually checked and geometric and radiometric anomalies, such as areas where overlaps from images are visible or parallax on surface features such as buildings, are removed or reduced as much as possible.

Mosaic tiles are adjusted for white balance, contrast and exposure in Adobe Photoshop CC before an atmospheric sharpening filter is applied and the Geotiff files are compressed into .ecw files using Erdas Imagine.

Data outputs

The camera has four channels capturing full colour (Red, Green, Blue) and Near Infra-red (I) imagery. The photo mosaic is delivered as 1 km tiles referenced to the National Grid. Each photo tile is in an .ecw file format. More recently we have been supplying a low compression and a high compression .ecw file from the Geotiff files. The low compression file is comparable to our standard product. The higher compression files are of a lower quality but have a significantly smaller file size.

Prior to 2005 our imagery was captured using film cameras. Some of these films have been scanned and orthorectified or georectified. Similar to orthorectification, the georectification process rectifies each image to geographic coordinates in the horizontal plane in relation to a standard spatial georeferencing framework such as WGS84 latitude and longitude. It can therefore be used in GIS and overlaid with our current imagery. However the georectified imagery does not contain elevation information or account for changes in elevation. All film photography was captured with a sufficient overlap to ensure stereoscopic imagery was available and the images could be used as an overlapping mosaic to be viewed as a three dimensional image. From 1991 to 1999 the film imagery was captured in black and white. After this time we collected RGB colour imagery and then RGBI imagery from 2011.

Figure 3: Left: Mosaic image of the Knolls, Suffolk captured in 2015. Right: a scanned georectified photo taken in 2004.

The projects films are archived by the National Collection of Aerial Photography (NCAP): http://ncap.org.uk/.

On occasion oblique aerial photography is collected through the use of a DSLR camera fixed on an arm to the side of the aircraft. Such imagery can be captured and processed quickly and may be obtained during floods or storms to show the extent of flooding and areas impacted. The imagery can also be used to monitor geomorphological change such a channels, spits and saltmarsh. It allows us to view features such as cliff faces not visible in the vertical imagery. It also serves well to put the coastal features or locations in a context and show them in relation to each other in a more understandable perspective.

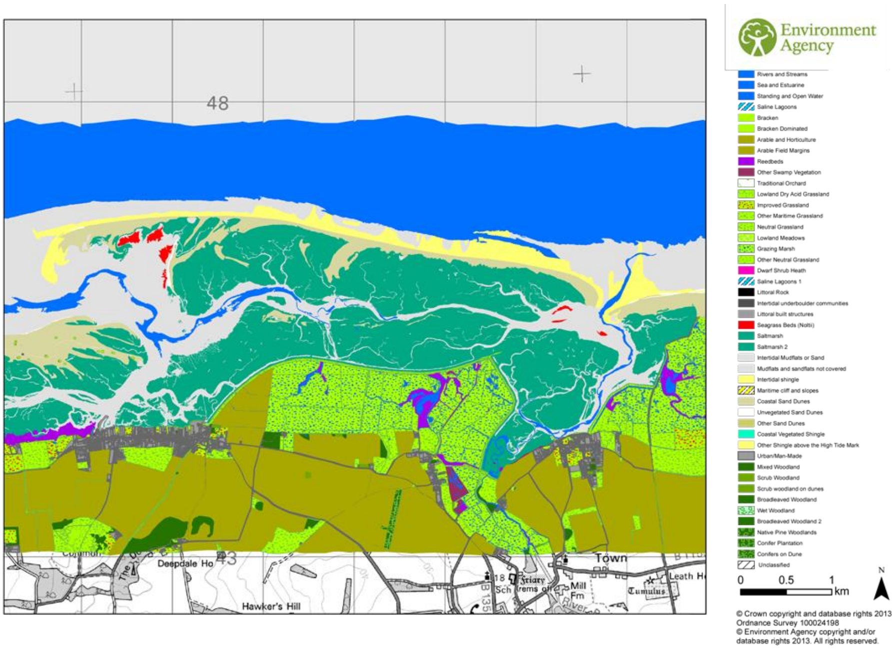
Figure 4: Oblique aerial photography. Left: Seals at Blakeney, Norfolk. Right: The cliffs at Weybourne, Norfolk.

Resolution

All images have a resolution of 20 cm. This means in an image one pixel represents a 20 cm area of the land or sea.

Analysis

The photography provides an annual record of change on our coast, and allows an assessment of these environmental changes and the impacts and damage caused by coastal processes and storm events. For example the annual images are used as a time series to assess the erosion rates of cliffs, the development of vegetation within managed realignment sites, or following a flood event we may fly an emergency survey to map the extent of the flood water.



We use the photography as a basis for mapping, in particular we map coastal habitats such as those listed in the Biodiversity Action Plan (BAP) and for assessing fragmentation of saltmarsh. The infra-red imagery is particularly valuable in identifying and determining the extent of vegetation. The imagery is also used for site planning and operational tasks such as building defences or restoring relict creek systems in formally reclaimed land.

Figure 5: Habitat map of Scolt Head Island, Norfolk produced from aerial photography.

Data considerations

The position of features in orthorectified imagery is subject to error, this is more so at the edges of an images where the aircraft is not in nadir but at an angle to the surface area being captured. This can lead to the sides of features like cliffs and buildings being visible.

Imagery can contain shadow and cloud cover which can make delimitating edges and boundaries such as saltmarsh extent or zonation more difficult.