Fall 2017 IceBridge P-3 Flight Plans
29 September 2017 Draft

compiled by

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Introduction to Flight Plans

This document is a translation of the NASA Operation IceBridge (OIB) scientific objectives articulated in the Level 1 OIB Science Requirements, at the June IceBridge Arctic planning meeting held at the University of California at Irvine, through official science team telecons and through e-mail communication and iterations into a series of operationally realistic flight plans, intended to be flown by NASA's P-3 aircraft, beginning in late October and ending in late November 2017. The material is shown on the following pages in the distilled form of a map and brief text description of each science flight. Google Earth (KML) versions of these flight plans are available by email.

For each planned mission, we give a map and brief text description for the mission. The missions are planned to be flown from Ushuaia, Argentina. A careful reader may notice that some of the mission maps in the main part of the document highlight flightlines in green, yellow, and red colors, while other only show the black lines. The colors are a refinement added to the flight plans at a late stage of design which help the field team navigate the aircraft properly to achieve specific science goals. The colors represent the degree of “straightness” of each flight segment, where straight segments are steered using an automated technique and curved sections using a specialized manual method. Not all of the flight plans shown here have necessarily reached that mature stage of design.

In fact, as a general rule the flight plans depicted here are all at varying stages of completeness. For each mission we note “Remaining Design Issues” to be resolved, if any exist. In most cases these are minor. Spacecraft underflights are a major exception, since these usually have to be re-planned for each potential flight day (for sea ice) or within a window of several potential flight days (for land ice).

Note that this document shows 18 planned land ice and 7 planned sea ice missions, which is more than we expect to fly this year. The extra flight plans give us operational flexibility to fly as much as possible, and scientifically productive, while we are in the field. The entire suite of 25 flight plans is depicted in the introductory material following this text, with each flight prioritized as described next.

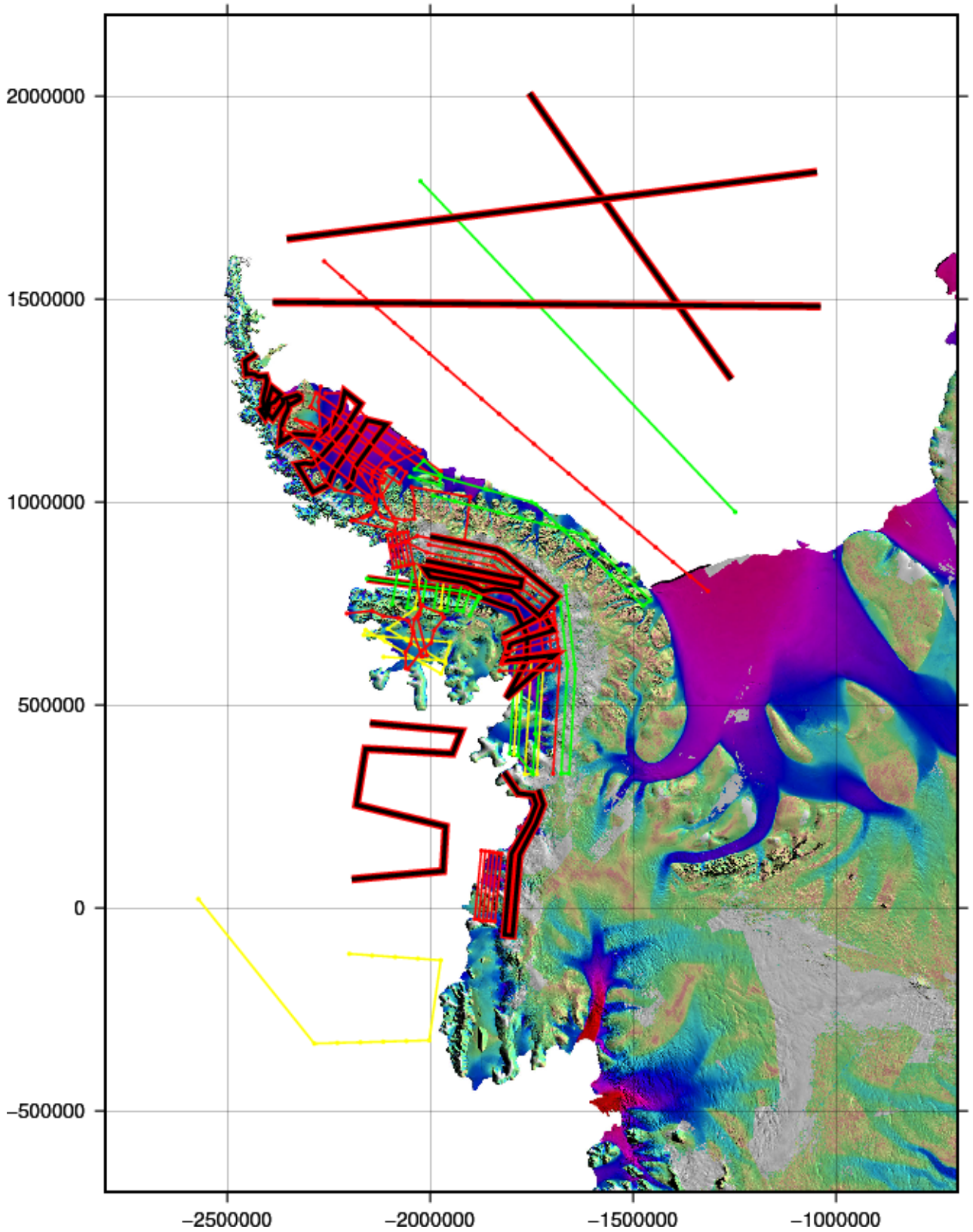
For previous Operation IceBridge campaigns, this document included composite maps, showing how multiple flight plans related to each other in specific regions. With the exception of the composite map of the entire study area given near the top of this document, we no longer include such maps. Instead, the KMZ files (link shown above) provide similar visual information in a more versatile form.

Each flight has a priority assigned to it by the OIB science team, either baseline, high, medium or low, and these are listed below with each mission. The team also instituted a new strategy for the 2014 season, which emphasizes the need to conduct comprehensive dh/dt monitoring over a multi-year time scale. Twenty-three flights have been identified as being suitable for inclusion into this strategy, and these are labeled as such in the text descriptions. In general the flights in this category which have not been flown recently are prioritized highest, while those flown last year are prioritized lowest. These priorities will be revisited each year, with the goal being to ensure all of these flights will be flown on a rotating basis. Several new flights are also shown, as well as several flights designed for previous years but never flown.

Avoidance of overflights of known Antarctic wildlife colonies and designated protected areas is a high priority for NASA. We include an Appendix at the end of this document which details our approach for doing so.

Prioritized 2017 OIB P-3 Antarctic Flights

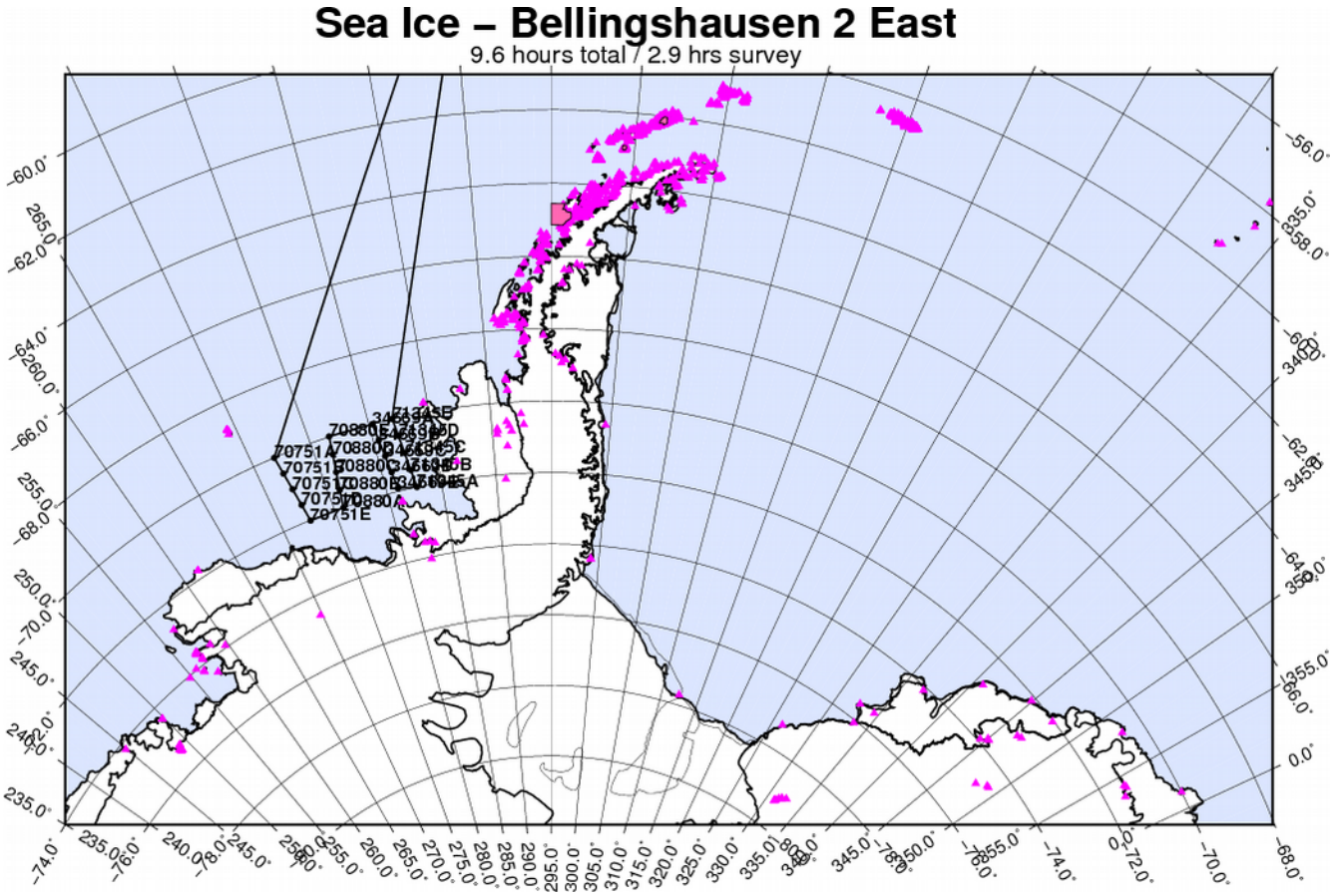
Red/Black=Baseline(8); Red=High(9); Yellow=Medium(3); Green=Low(5)



Sea Ice – Bellingshausen 2 East

This mission is similar to the eastern 2/3 of the 2016 Bellinghsausen 2 flight, and is made up mostly of IceSat-2 ground tracks. Of medium priority on this mission is the opportunity for a coordinated under flight of a CryoSat-2 orbit along one of the north-south legs. This opportunity should not dictate the decision to fly the mission. Instead, the coordinated under flight should only be flown if, on the day selected for the mission, there is a CryoSat-2 ground track that is well-located relative to one of the planned grid lines and well-timed (plus or minus 2 hours). This mission should be flown as early as possible, preferably before mid-October, because of the relatively early onset of melt of in this region. As a low priority, this flight (and any other sea ice flight) can be usefully repeated after the passage of an appropriate amount of time.

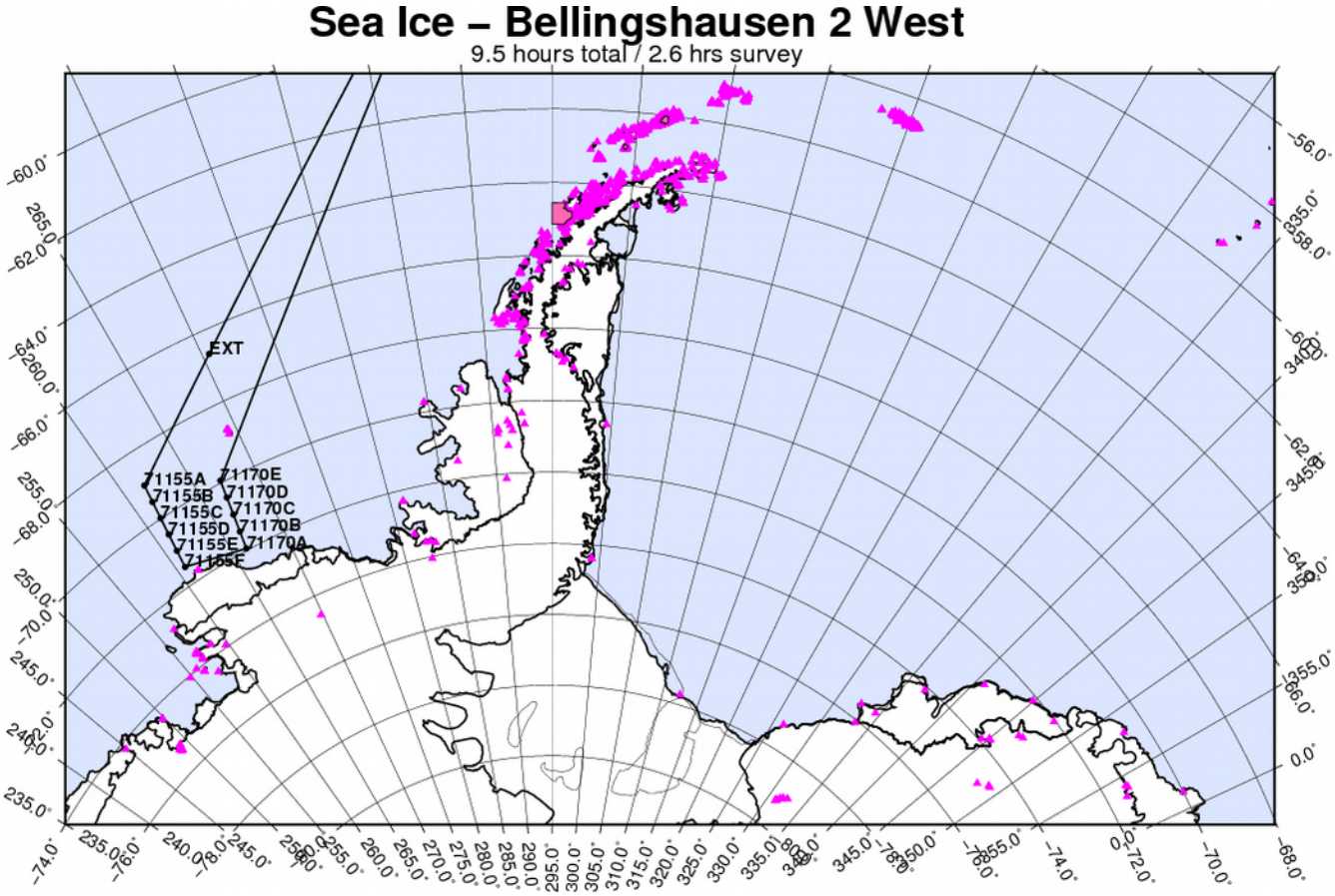
Flight Priority: BASELINE
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: create latlon file



Sea Ice – Bellingshausen 2 West

This mission is similar to the western 1/3 of the 2016 Bellinghsausen 2 flight, and is made up mostly of IceSat-2 ground tracks. We extend the line inbound to Ushuaia to cross the ice edge, if the edge lies far enough south for fuel to allow this. Of medium priority on this mission is the opportunity for a coordinated under flight of a CryoSat-2 orbit along one of the north-south legs. This opportunity should not dictate the decision to fly the mission. Instead, the coordinated under flight should only be flown if, on the day selected for the mission, there is a CryoSat-2 ground track that is well-located relative to one of the planned grid lines and well-timed (plus or minus 2 hours). This mission should be flown as early as possible, preferably before mid-October, because of the relatively early onset of melt of in this region. As a low priority, this flight (and any other sea ice flight) can be usefully repeated after the passage of an appropriate amount of time.

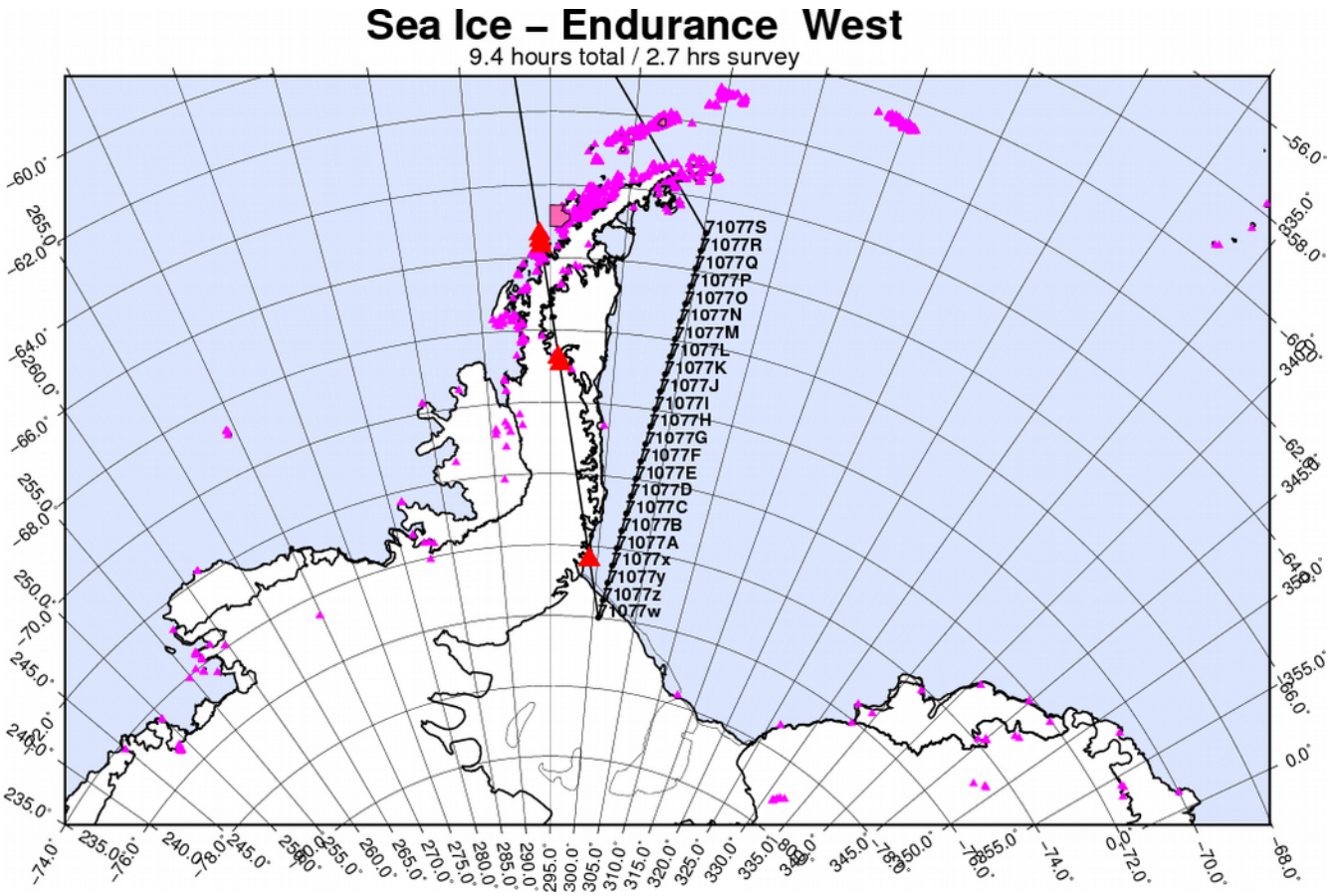
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: create latlon file



Sea Ice – Endurance West

This mission represents a continuation of the IceBridge time series, nearly repeating the near-shore flight line flown in 2009 and 2010 and the Endurance flight line from many OIB Antarctic campaigns. It typically crosses rough sea ice. For 2016 onward we replaced the near-shore line with a nearby IceSat-2 ground track covering the central beam pair. As a low priority, this flight (and any other sea ice flight) can be usefully repeated after the passage of an appropriate amount of time.

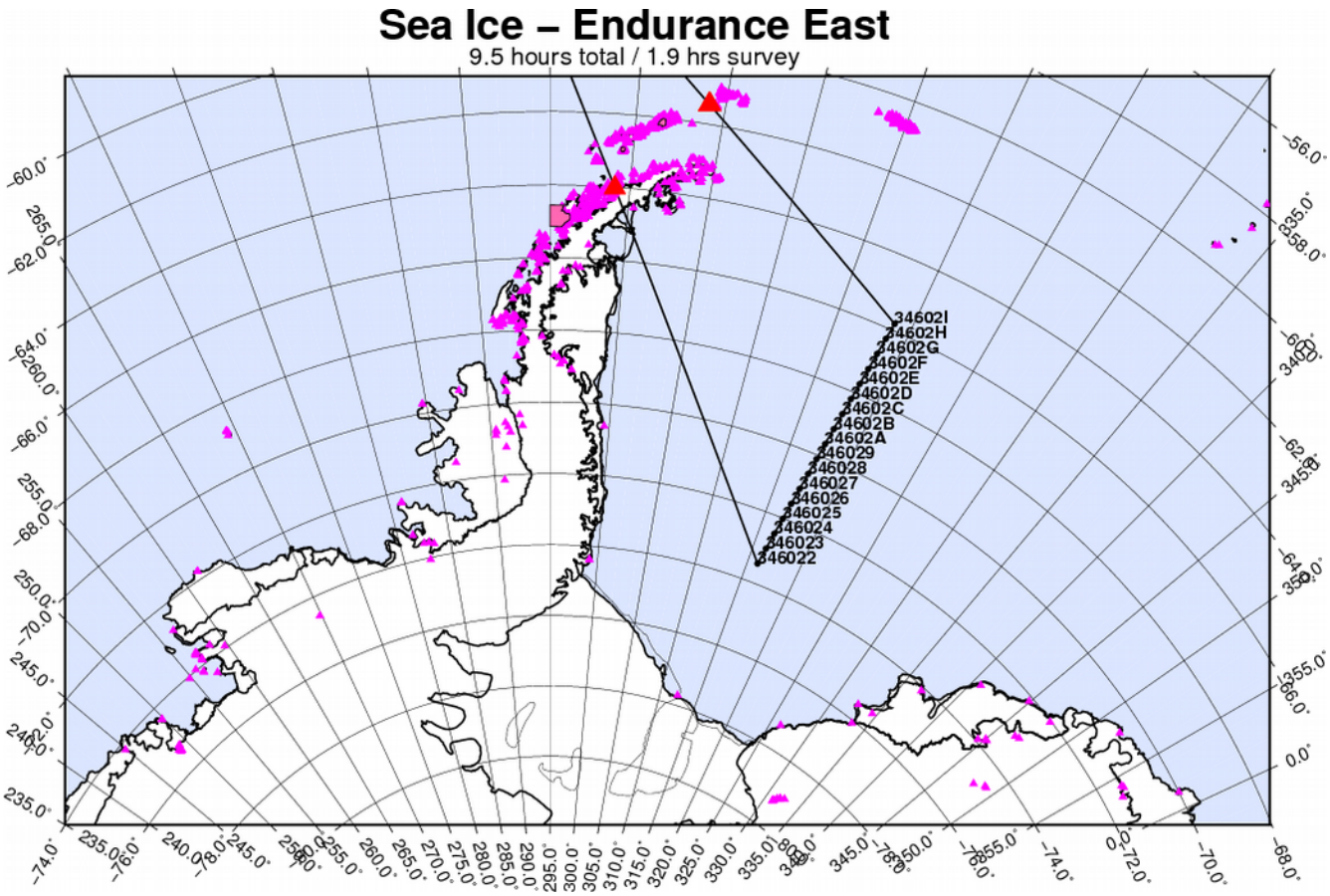
Flight Priority: high
Spacecraft Tracks: 1077 IS-2
Last Flown: 2016
Remaining Design Issues: create latlon file



Sea Ice – Endurance East

This mission represents a continuation of the IceBridge time series, nearly repeating the central Weddell Sea flight line flown in 2009 and 2010 and the Endurance flight line from many OIB Antarctic campaigns. It typically crosses rough sea ice. If possible we will arrange this line to coincident with a CryoSat-2 ground track, preferably timed to occur within ~2 hours of the spacecraft's overflight. As a low priority, this flight (and any other sea ice flight) can be usefully repeated after the passage of an appropriate amount of time.

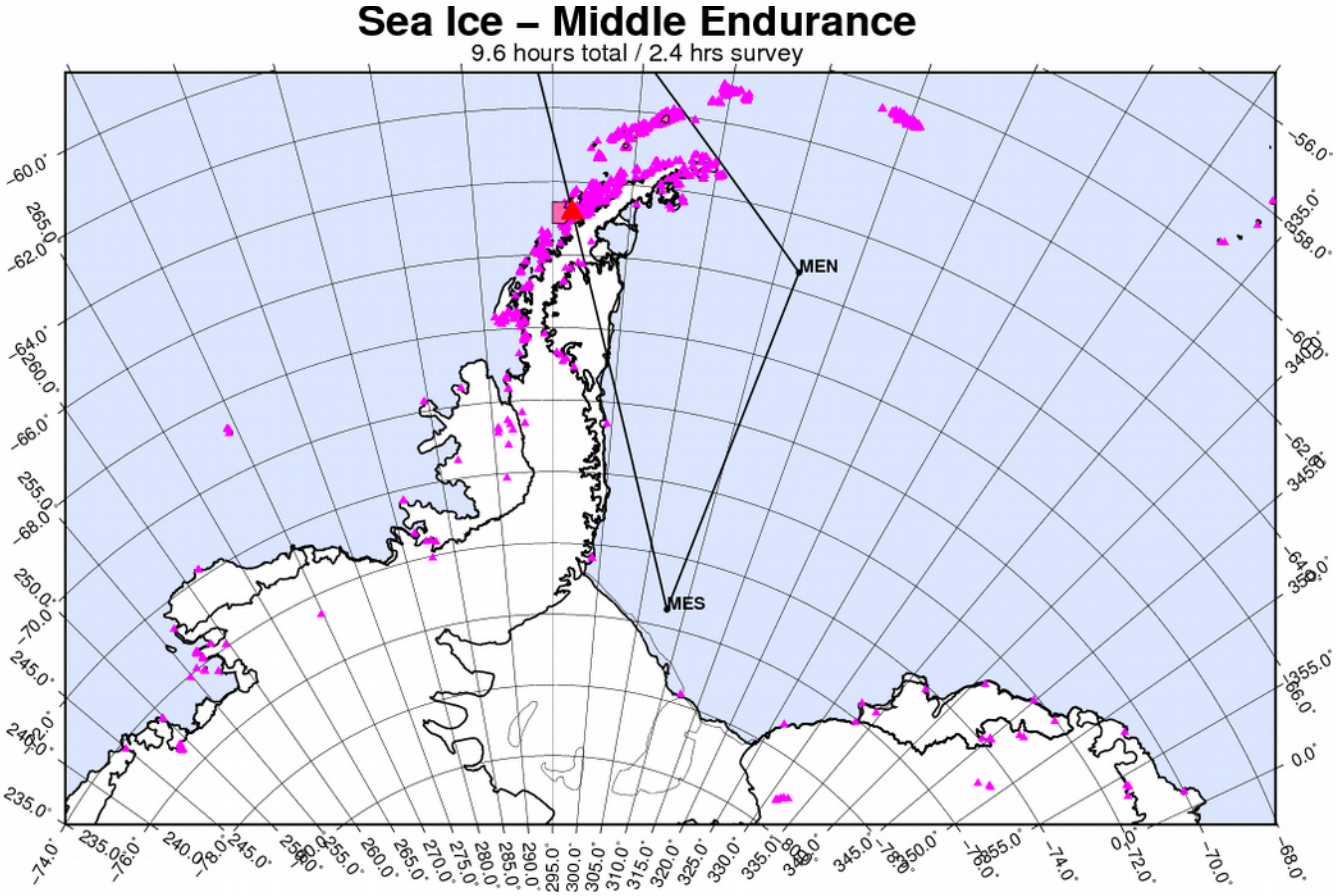
Flight Priority: BASELINE
Spacecraft Tracks: CryoSat-2 track to be determined
Last Flown: 2016
Remaining Design Issues: use time-coincident TanDEM-X track; create latlon file



Sea Ice – Middle Endurance

This is a new mission, designed to cover the area of the western Weddell Sea between the two legs of the Endurance mission or missions. If possible we will arrange this line to coincident with a CryoSat-2 ground track, preferably timed to occur within ~2 hours of the spacecraft's overflight.

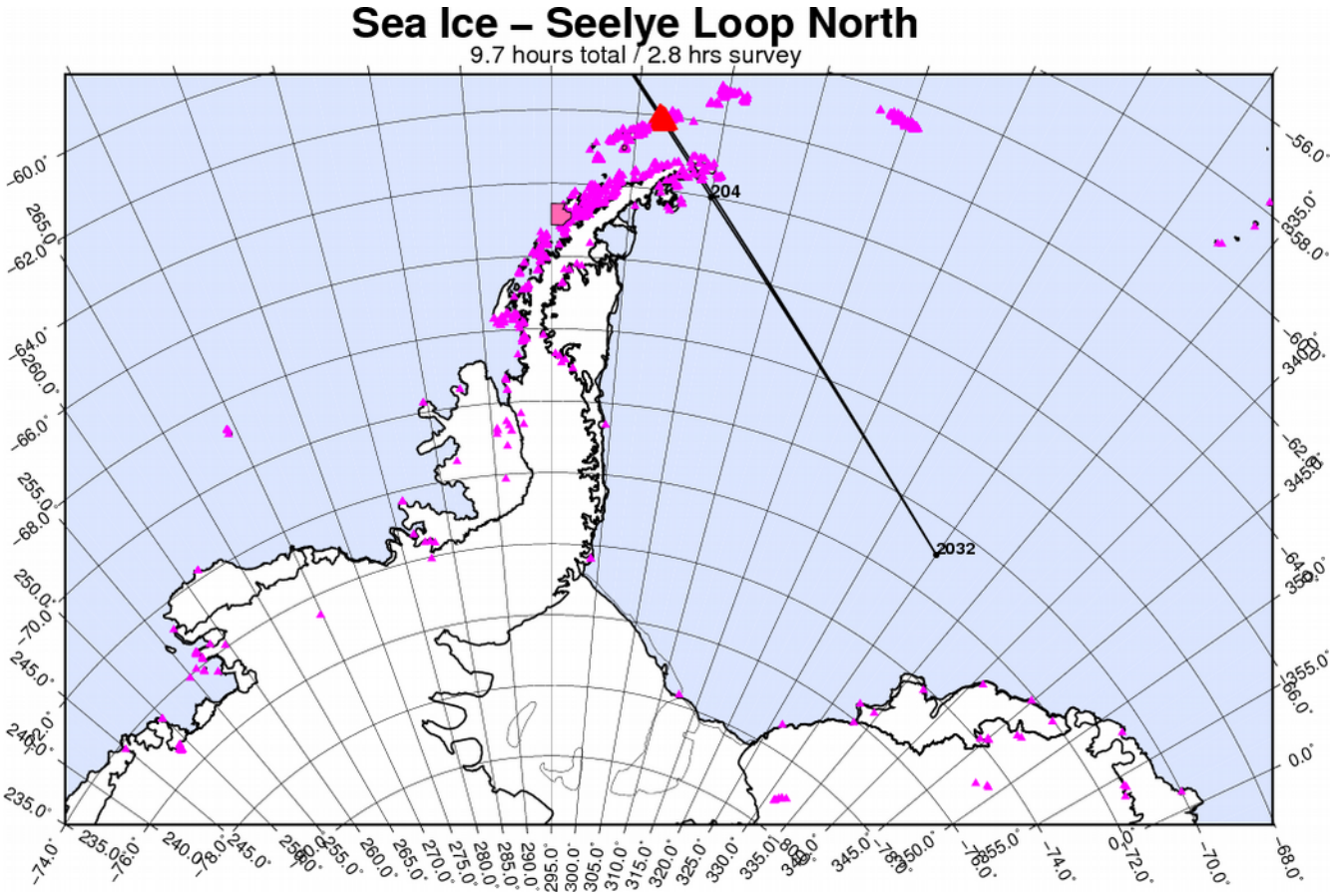
Flight Priority: low
Spacecraft Tracks: CryoSat-2 track to be determined
Last Flown: new flight
Remaining Design Issues: use time-coincident CS-2 track if one exists, create latlon file



Sea Ice – Seelye Loop North

This mission represents a continuation of the IceBridge time series, repeating the northern portion of the same mission flown almost every year of Operation IceBridge. It was not flown in 2012 due to persistent poor weather that year. It targets gradients in sea ice freeboard and thickness along the "gate" connecting the tip of the Antarctic Peninsula with Cape Norvegia – although we cannot reach all the way to Cape Norvegia in 2017 due to range constraints. For either this mission or the Seelye Loop South flight, we intend to orient this flight line to be coincident with an ascending TanDEM-X spacecraft ground track, in cooperation with Dr. Son Nghiem's OTASC experiment. As a low priority, this flight (and any other sea ice flight) can be usefully repeated after the passage of an appropriate amount of time.

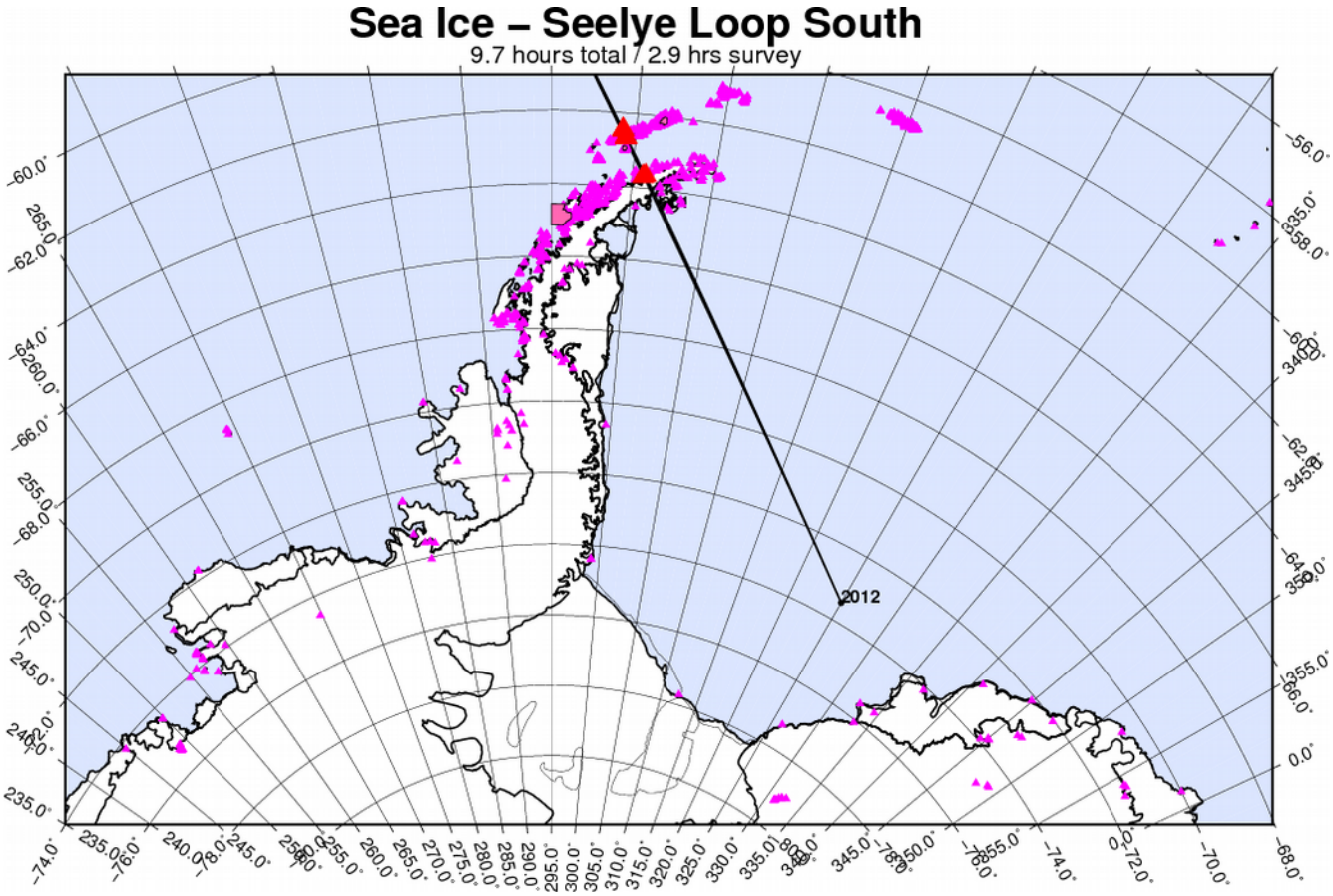
Flight Priority: BASELINE to get either of Seelye Loop legs; high for the other
Spacecraft Tracks: possible TanDEM-X track to be determined
Last Flown: 2016
Remaining Design Issues: create latlon file



Sea Ice – Seelye Loop South

This mission represents a continuation of the IceBridge time series, repeating the southern portion of the same mission flown almost every year of Operation IceBridge. It was not flown in 2012 due to persistent poor weather that year. It targets gradients in sea ice freeboard and thickness along the "gate" connecting the tip of the Antarctic Peninsula with Cape Norvegia – although we cannot reach all the way to Cape Norvegia in 2017 due to range constraints. For either this mission or the Seelye Loop North flight, we intend to orient this flight line to be coincident with an ascending TanDEM-X spacecraft ground track, in cooperation with Dr. Son Nghiem's OTASC experiment. As a low priority, this flight (and any other sea ice flight) can be usefully repeated after the passage of an appropriate amount of time.

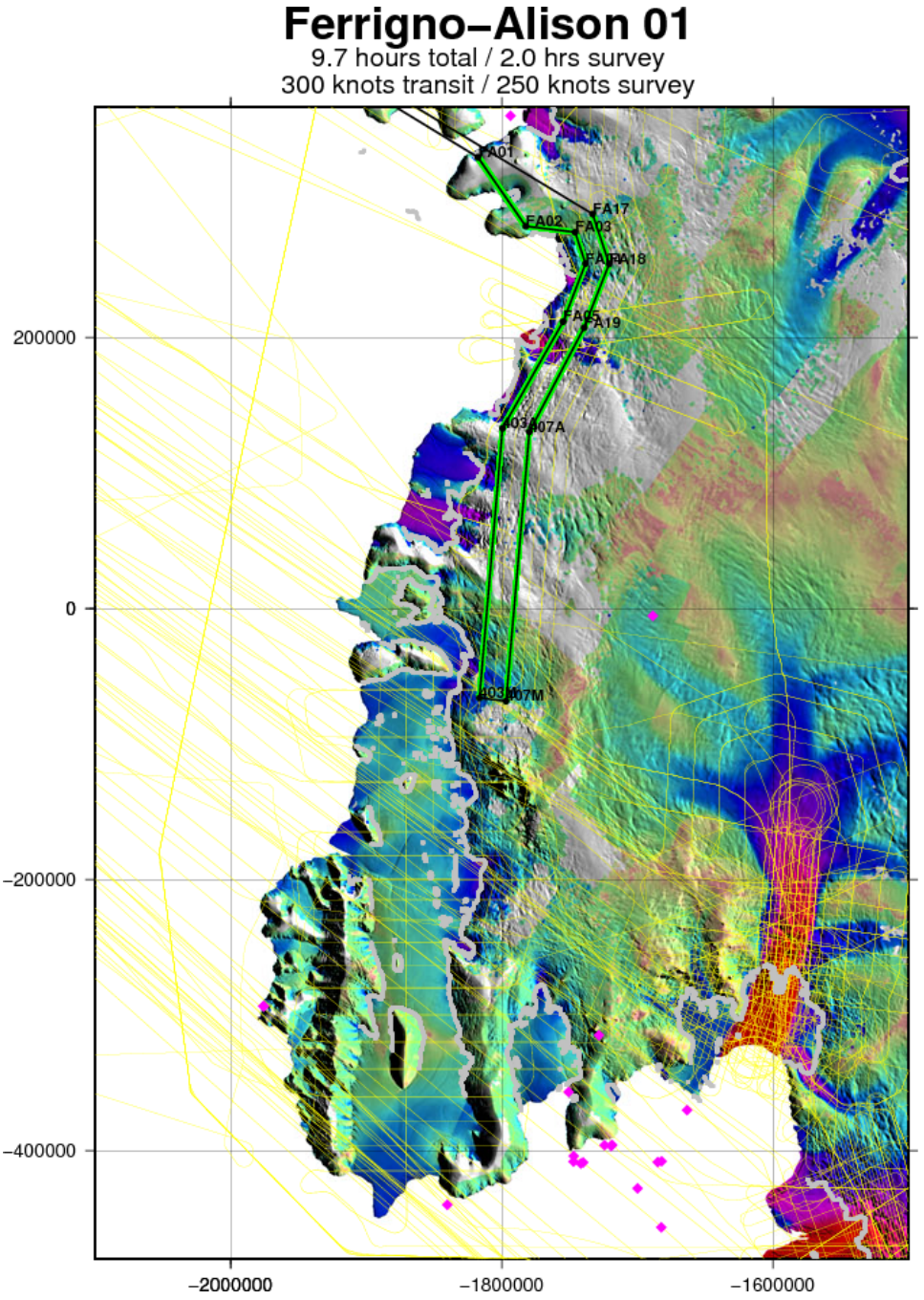
Flight Priority: BASELINE to get either of Seelye Loop legs; high for the other
Spacecraft Tracks: possible TanDEM-X track to be determined
Last Flown: 2016
Remaining Design Issues: create latlon file



Land Ice – Ferrigno-Alison 01

This flight is designed to collect dh/dt measurements on established OIB flight lines along the Eights Coast near the Ferrigno and Alison ice streams.

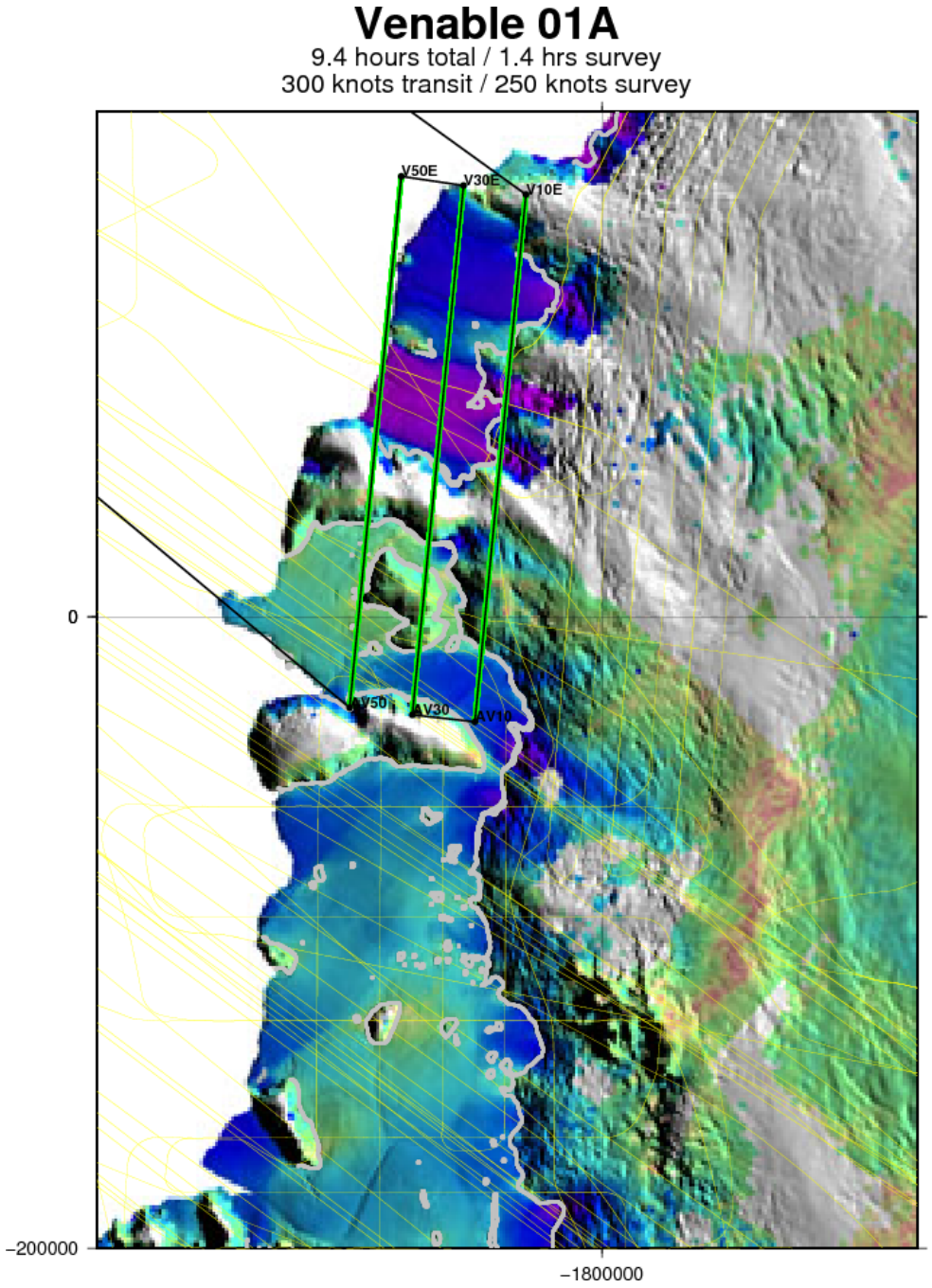
Flight Priority: BASELINE (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2014, easternmost lines 2015 (altimetry only)
Remaining Design Issues: none



Land Ice – Venable 01A

This is a new flight, primarily designed to map the bathymetry beneath the Venable Ice Shelf. This and the Venable 01B flight are companion flights. Each flight by itself establishes a grid spaced at 20 km, and together they establish a 20 km grid.

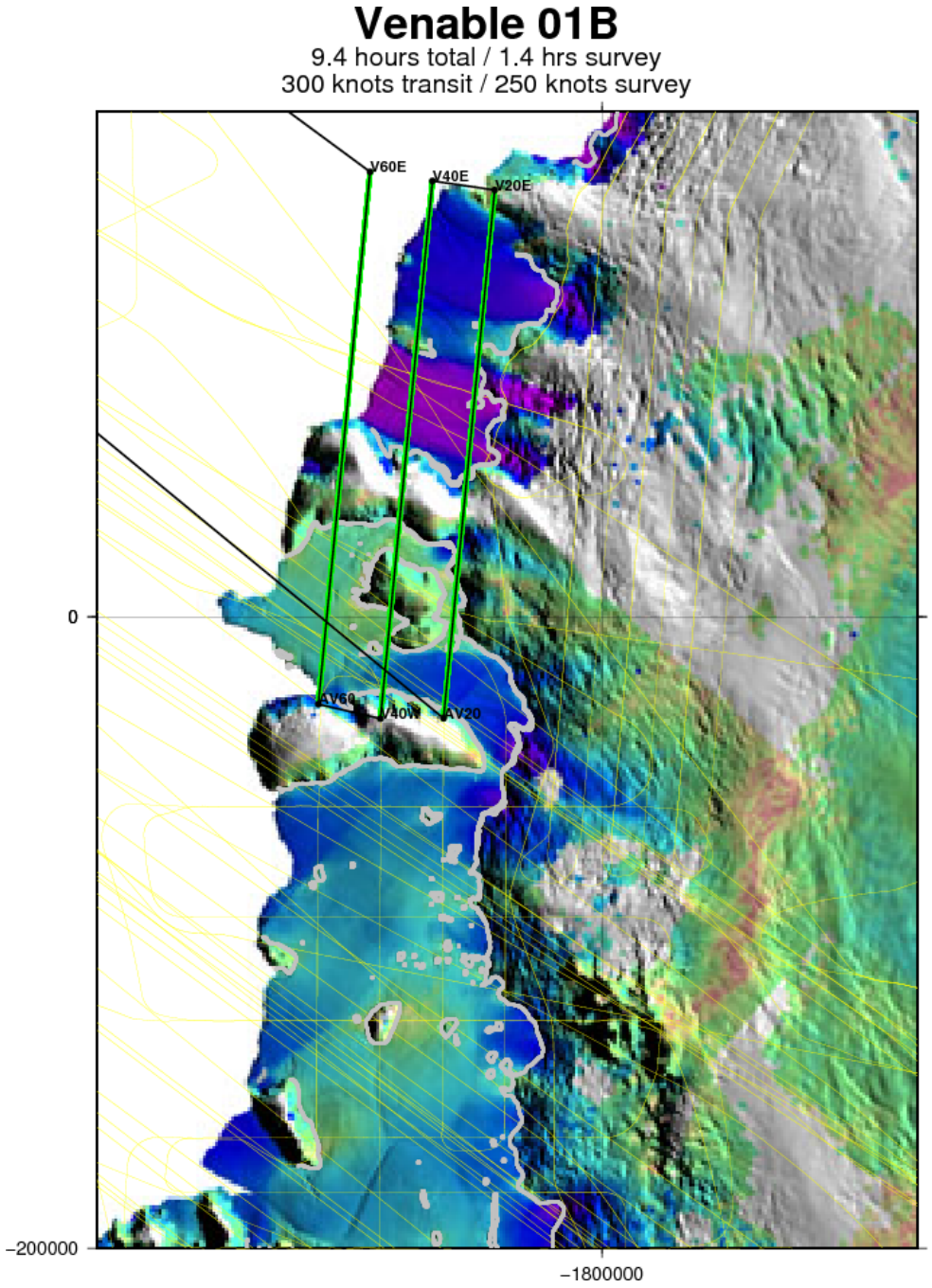
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Venable 01B

This is a new flight, primarily designed to map the bathymetry beneath the Venable Ice Shelf. This and the Venable 01A flight are companion flights. Each flight by itself establishes a grid spaced at 20 km, and together they establish a 20 km grid.

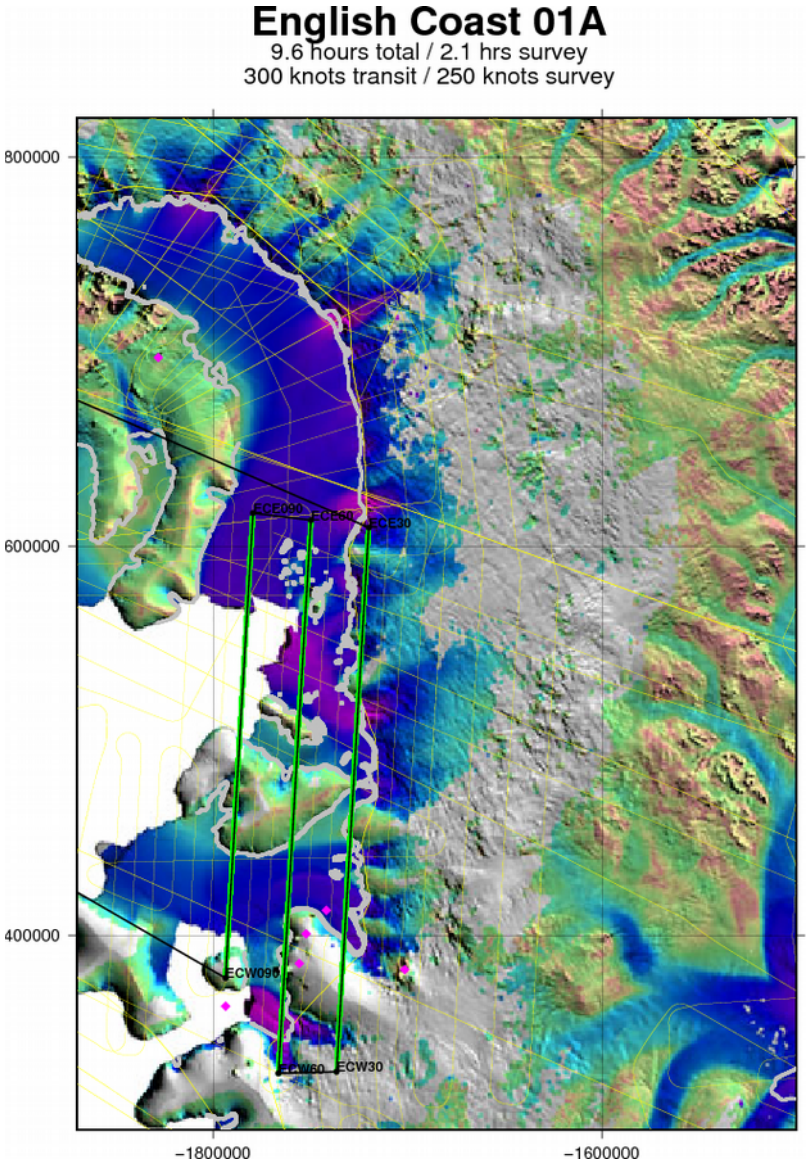
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – English Coast 01A

This flight is designed to map the dh/dt on and bathymetry beneath the Stange Ice Shelf, and the western extremity of the George VI Ice Shelf, along a 20 km coast-parallel grid. This grid connects with the Ferrigno-Alison coast-parallel grid in the west, and overlaps with the George VI grid in the east. It complements the English Coast 01A mission, and the two together create a 10-km grid.

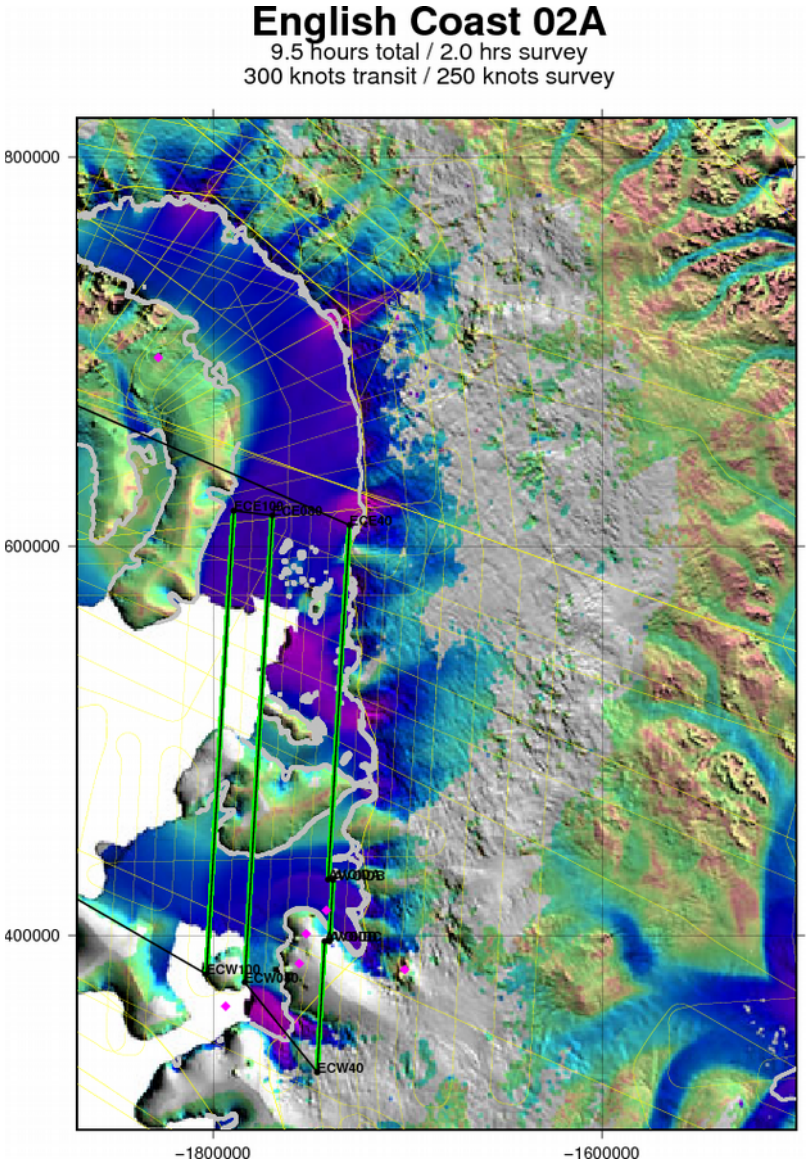
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: none



Land Ice – English Coast 02A

This flight is designed to map the dh/dt on and bathymetry beneath the Stange Ice Shelf, and the western extremity of the George VI Ice Shelf, along a 20 km coast-parallel grid. This grid connects with the Ferrigno-Alison coast-parallel grid in the west, and overlaps with the George VI grid in the east. It complements the English Coast 01A mission, and the two together create a 10-km grid.

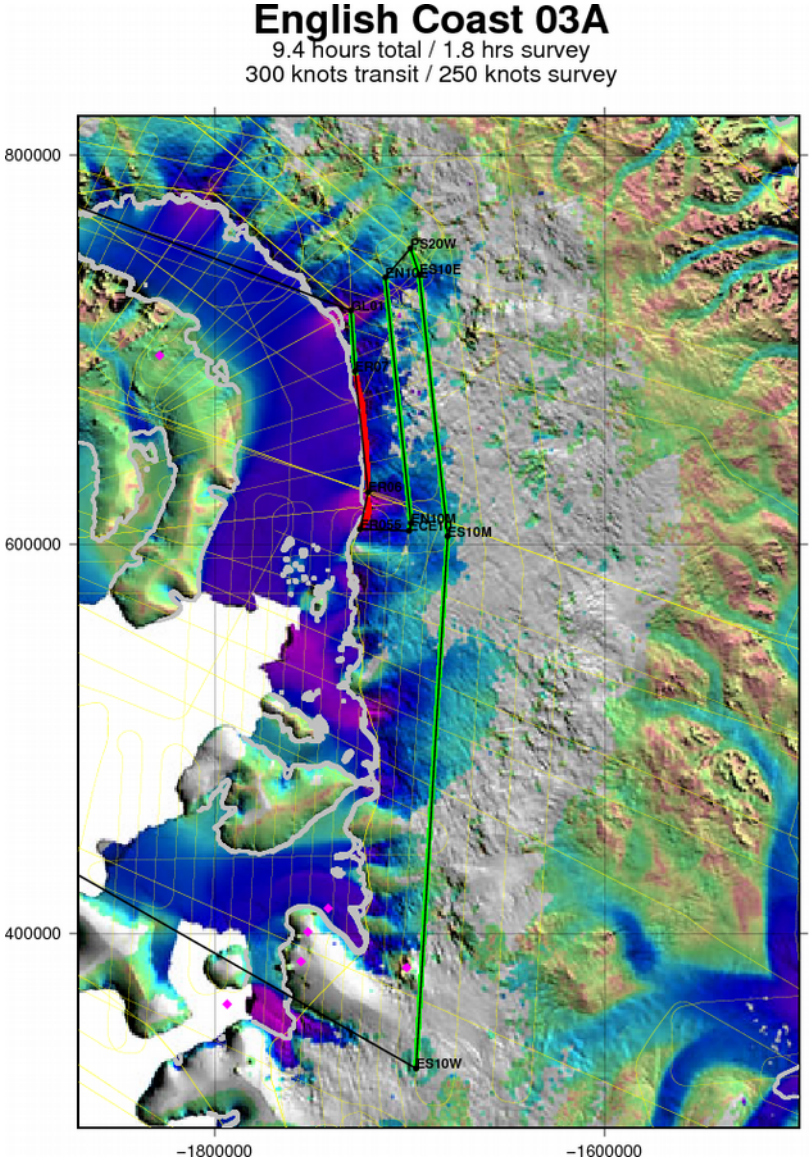
Flight Priority: low
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: none



Land Ice – English Coast 03A

This flight is designed to collect dh/dt measurements in the area inland of the Stange Ice Shelf and western George VI Ice Shelf along a 20 km coast-parallel grid. This grid continues the English Coast 01/02 grid inland, and connects with the South Peninsula grid in the east.

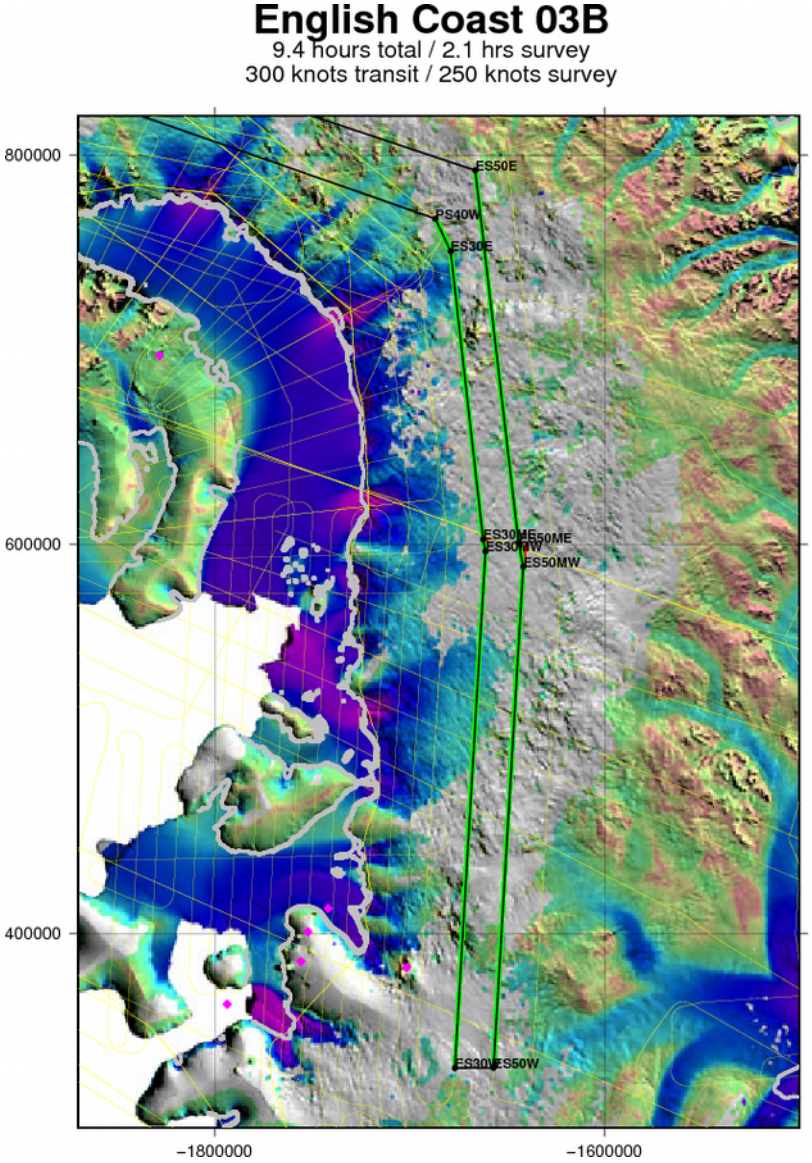
Flight Priority: high (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2014, most in 2015 (altimetry only)
Remaining Design Issues: none



Land Ice – English Coast 03B

This flight is designed to collect dh/dt measurements in the area inland of the Stange Ice Shelf and western George VI Ice Shelf along a 20 km coast-parallel grid. This grid continues the English Coast 01/02 grid inland, and connects with the South Peninsula grid in the east.

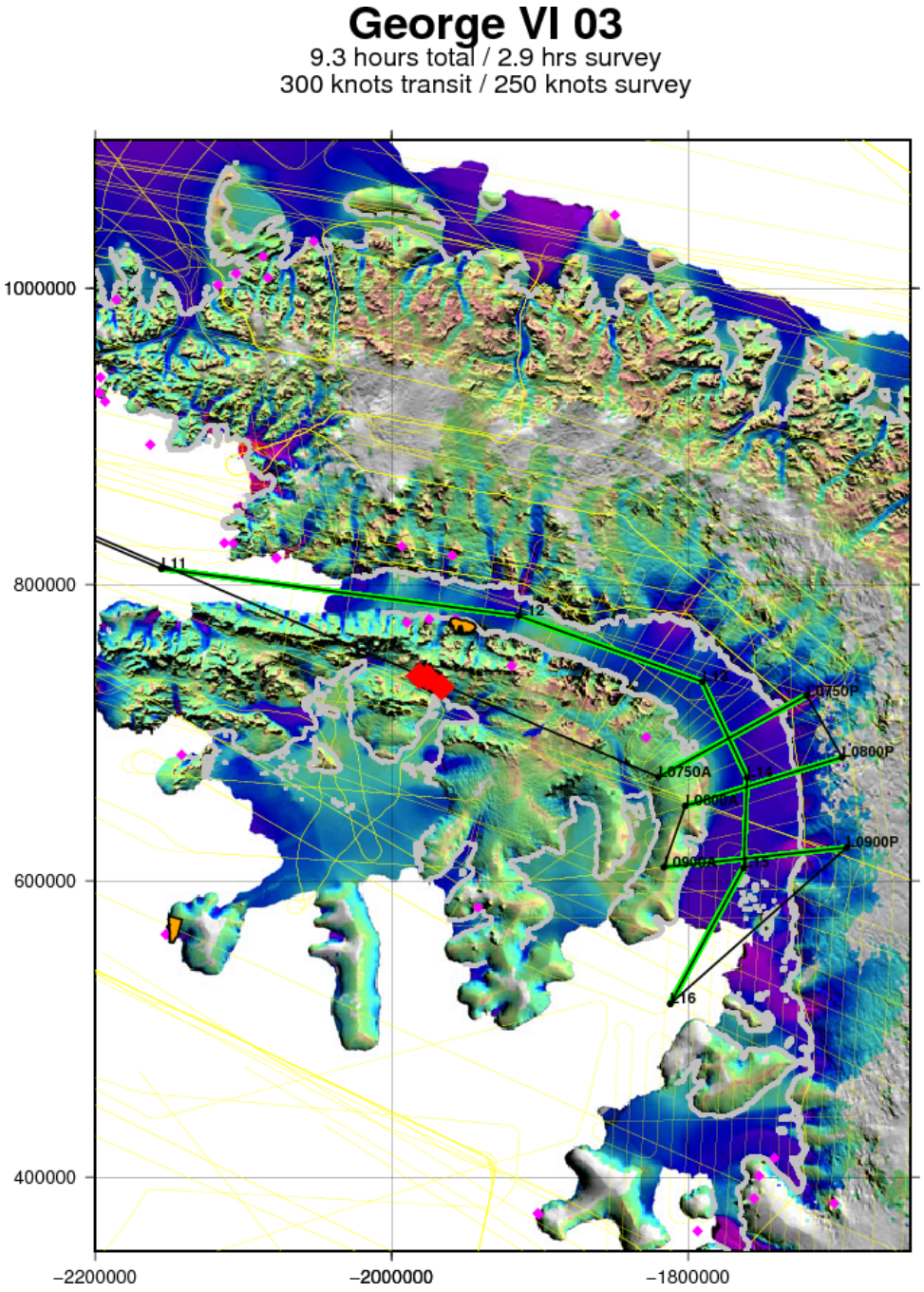
Flight Priority: low (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2014, most in 2015 (altimetry only)
Remaining Design Issues: none



Land Ice – George VI 03

This flight is designed to repeat previous measurements of crossings of the western portion of the George VI ice shelf, and also of the centerline of the ice shelf.

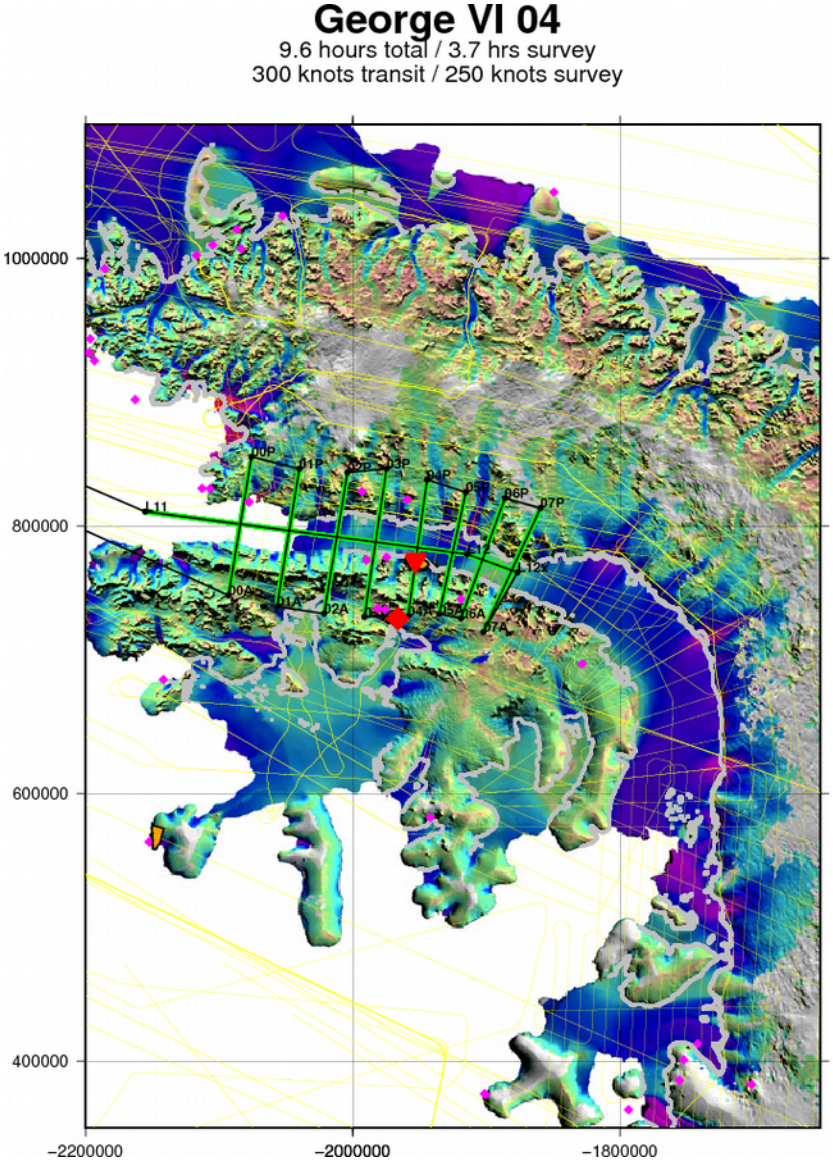
Flight Priority: BASELINE
Spacecraft Tracks: none
Last Flown: crossings in 2016 and 2011, centerline in 2011
Remaining Design Issues: none



Land Ice – George VI 04

This flight is designed to supplement previous George VI gravity surveys with new lines, interspersed between previous gravity-oriented lines. It also reflies a portion of the centerline. This mission concentrates on the northern portion of the ice shelf. This mission directly overflies ASPA 147 (Ablation Valley and Ganymede Heights) between waypoints 04A and 04P. The guidelines for this particular ASPA (http://www.ats.aq/documents/recatt/att523_e.pdf) do not prohibit aircraft overflights at any altitude.

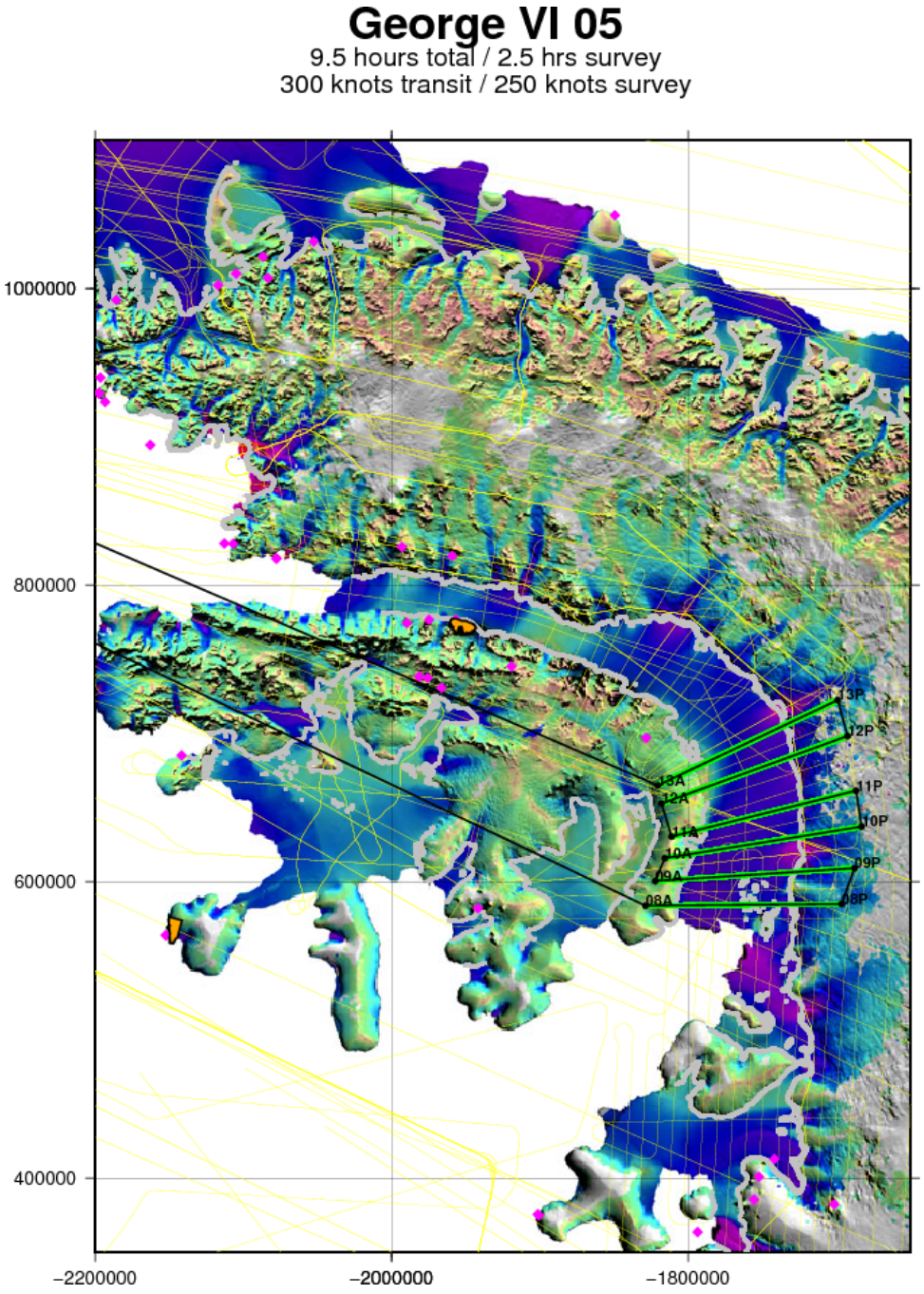
Flight Priority: low
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – George VI 05

This flight is designed to supplement previous George VI gravity surveys with new lines, interspersed between previous gravity-oriented lines. This mission concentrates on the southern portion of the ice shelf.

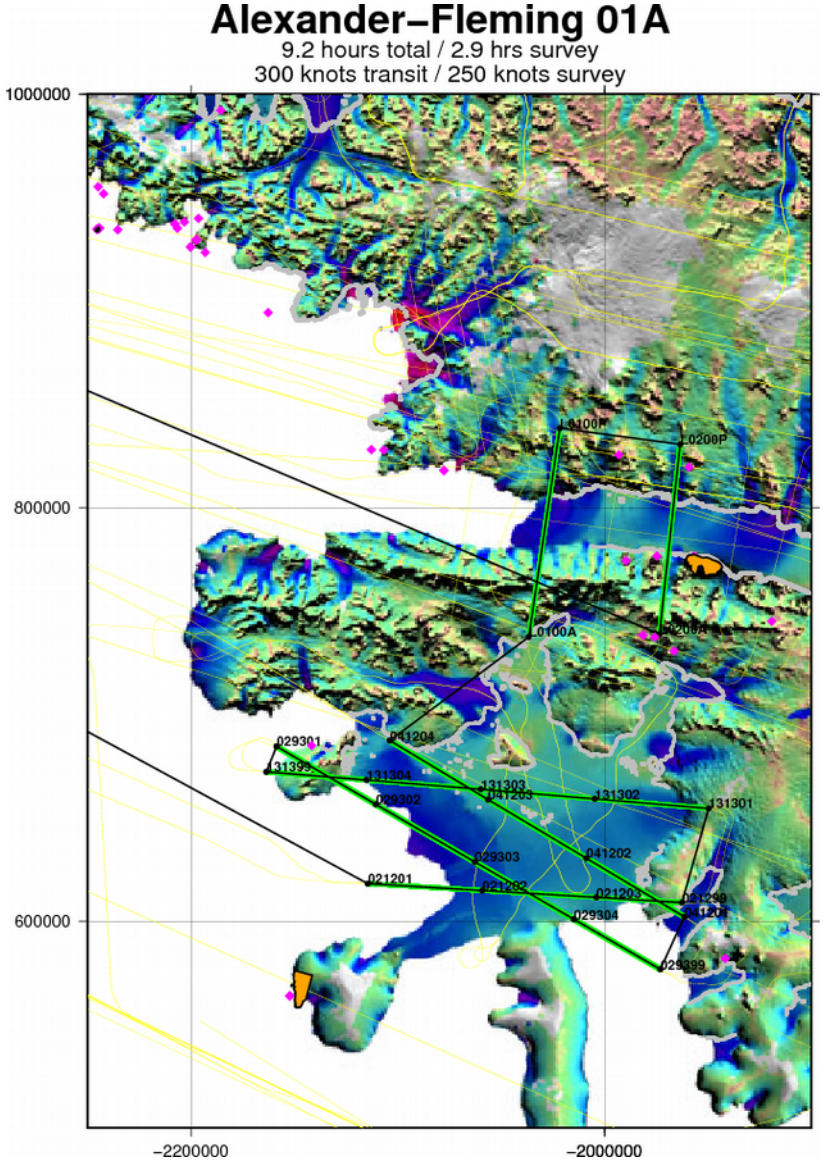
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Alexander-Fleming 01A

This is a repeat flight, designed to measure dh/dt over the Wilkins Ice Shelf and Alexander Island along flight lines first established during the 2008 NASA-Chilean effort, with the IceSat-1 tracks over Wilkins added during a 2011 OIB flight. We also repeat two crossings of the northern George VI ice shelf for dh/dt purposes.

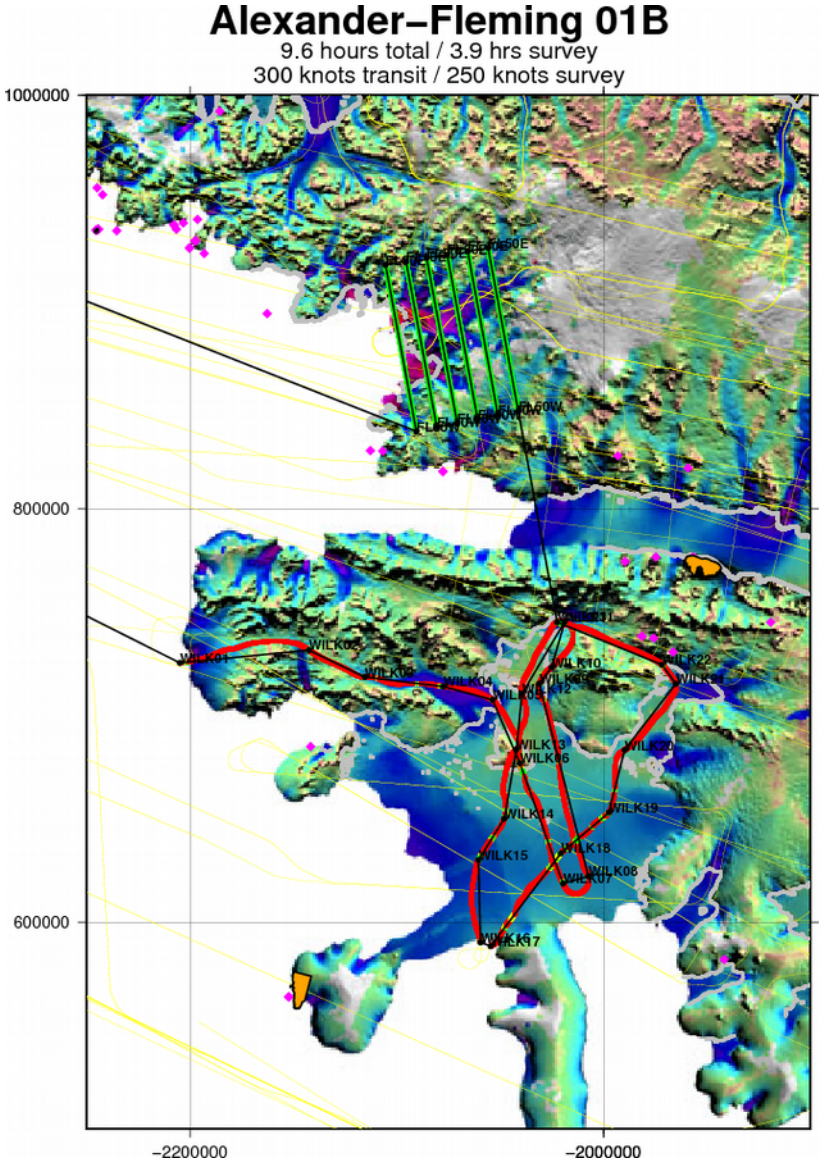
Flight Priority: medium (multi-year repeat flight)
Spacecraft Tracks: 0212,1313,0293,0412 (IceSat-1)
Last Flown: 2014 (Wilkins lines), 2011 (George VI lines)
Remaining Design Issues: none



Land Ice – Alexander-Fleming 01B

This is a repeat flight, designed to measure dh/dt over the Wilkins Ice Shelf and Alexander Island along flight lines first established during the 2008 NASA-Chilean effort. It also repeats a 10-km grid over Fleming Glacier and the remnant Wordie Ice Shelf.

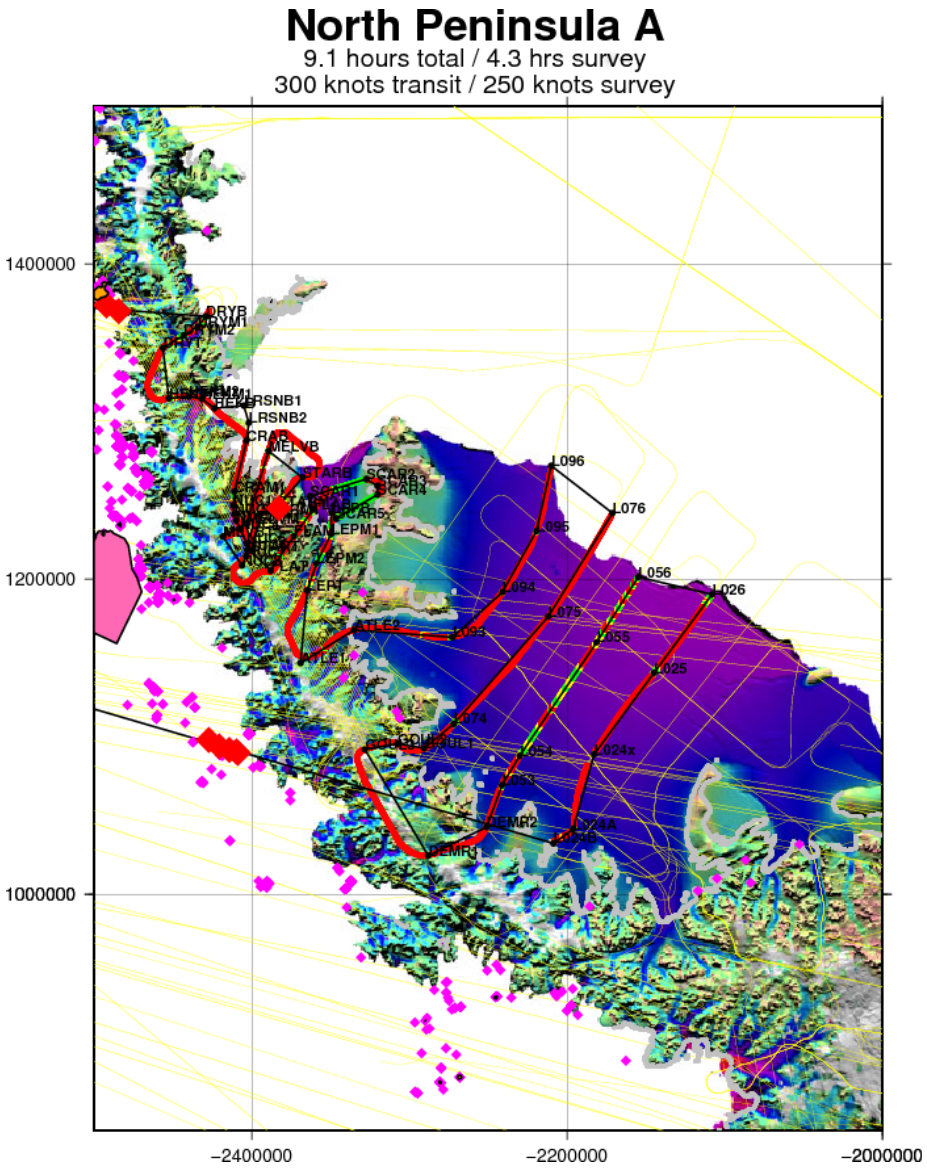
Flight Priority: high (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2014
Remaining Design Issues: none



Land Ice – North Peninsula A

This is a repeat flight, designed to assess dh/dt of several glaciers draining into the Larsen-A, -B, and -C embayments. From north to south, these glaciers are the Drygalski, Hektoria, Crane, Melville, Starbuck, Flask, Leppard, Attlee, Gould, Demorest, and Gibbs. In addition to these glaciers, we repeat two lines over Scar Inlet, and several flowlines on the Larsen-C Ice Shelf. Finally we overfly the Bawden Ice Rise on the eastern edge of the Larsen-C, since it may contribute to the stability of the ice shelf.

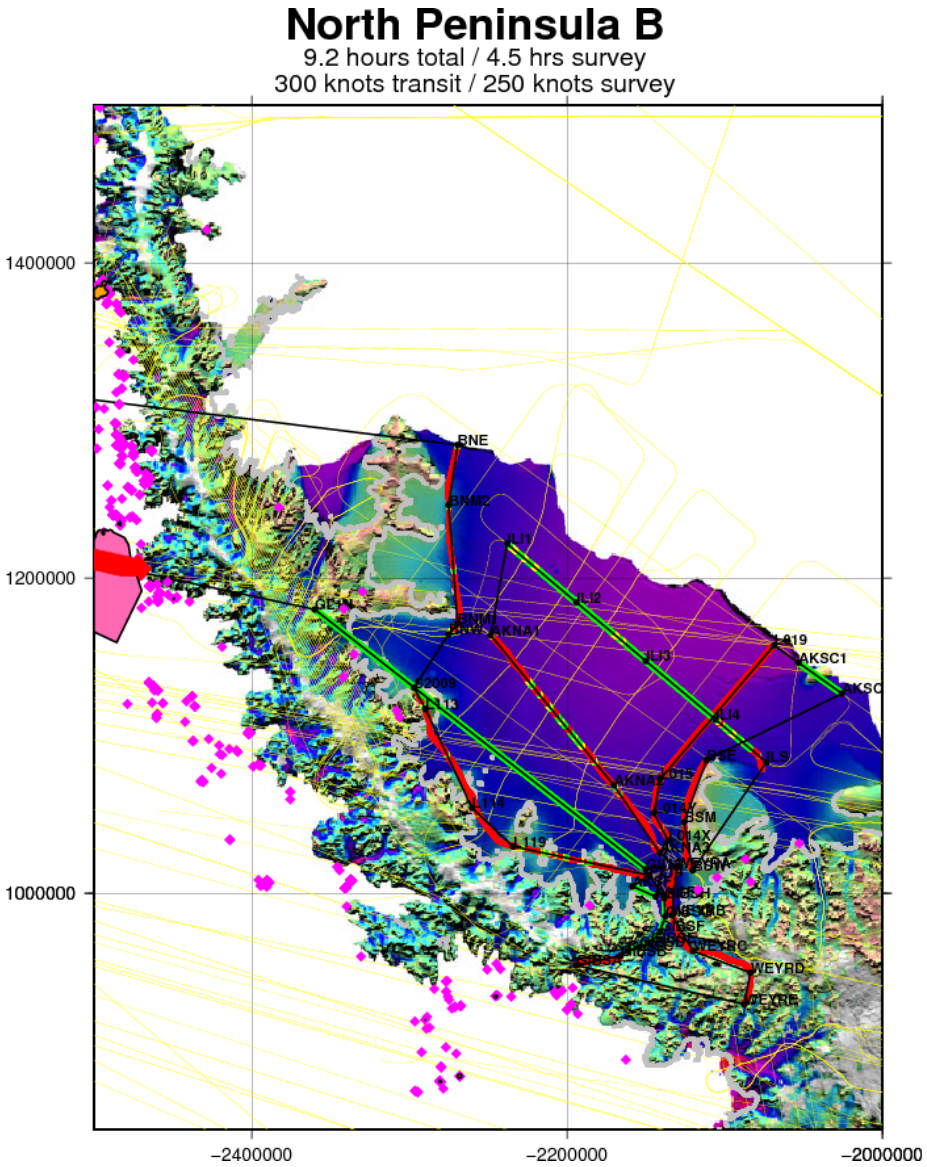
Flight Priority: BASELINE (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: none



Land Ice – North Peninsula B

This is a repeat flight, centered on the Larsen-C ice shelf. We repeat two glacier centerlines on the Gibbs and Weyerhauser Glaciers. In addition to these glaciers, we repeat four north-south tie lines over the Larsen-C, including overflights of three AWS stations and several areas of stagnant ice so that contributions of surface processes to dh/dt can be assessed independently of dynamic processes. Finally we overfly the Gipps Ice Rise on the eastern edge of the Larsen-C, since it may contribute to the stability of the ice shelf. For 2017, we also add a reflight of a 2009 line near the Larsen-C grounding line, plus two new lines intended to establish baseline surface elevations along portions of the shelf which may be impacted by the large July 2017 calving event.

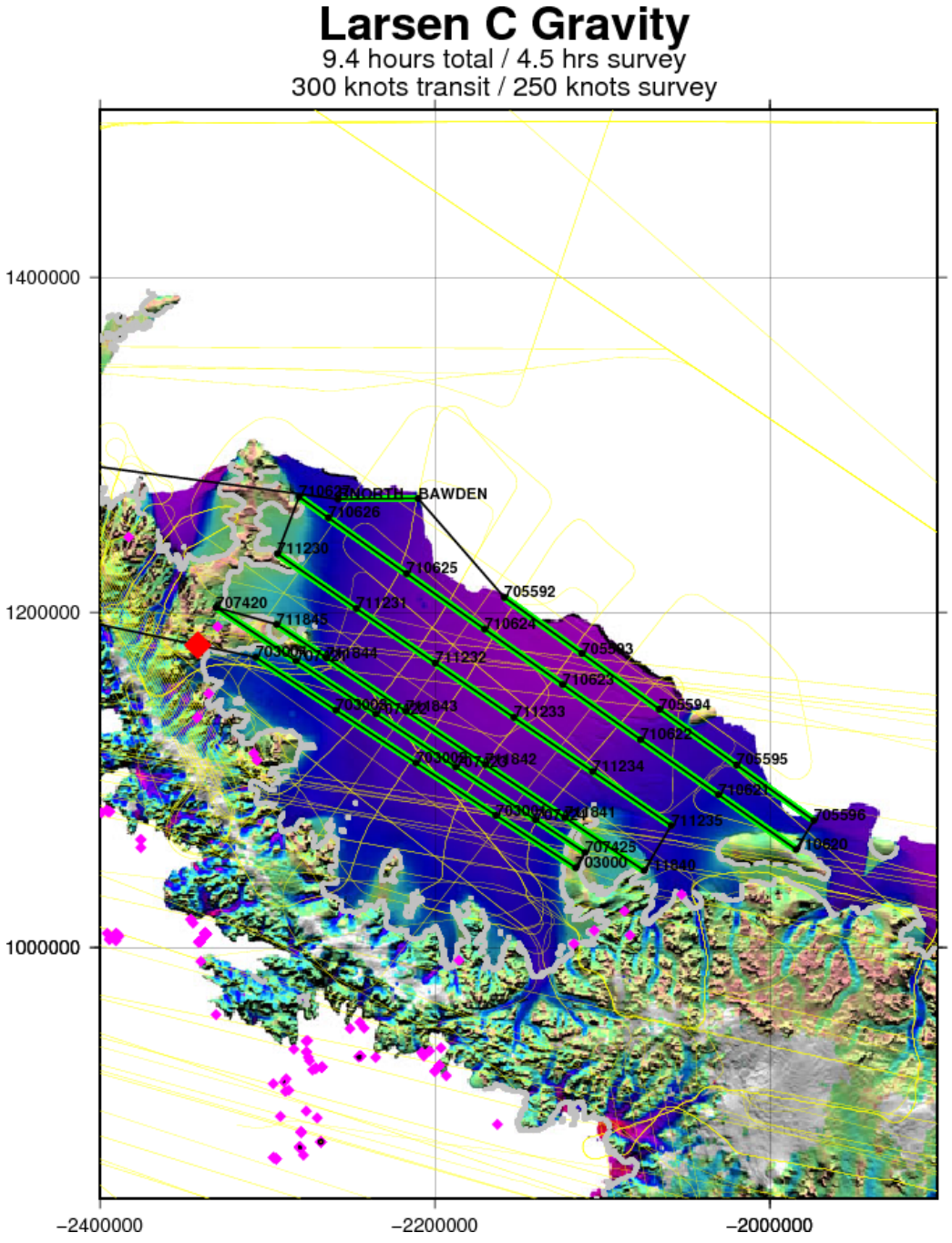
Flight Priority: high (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: none



Land Ice – Larsen-C Gravity

This is a new flight, designed to improve the density of airborne gravity measurements over the Larsen-C ice shelf. Most of the lines are designed along IceSat-2 ground tracks. We also directly overfly the Bawden Ice Rise.

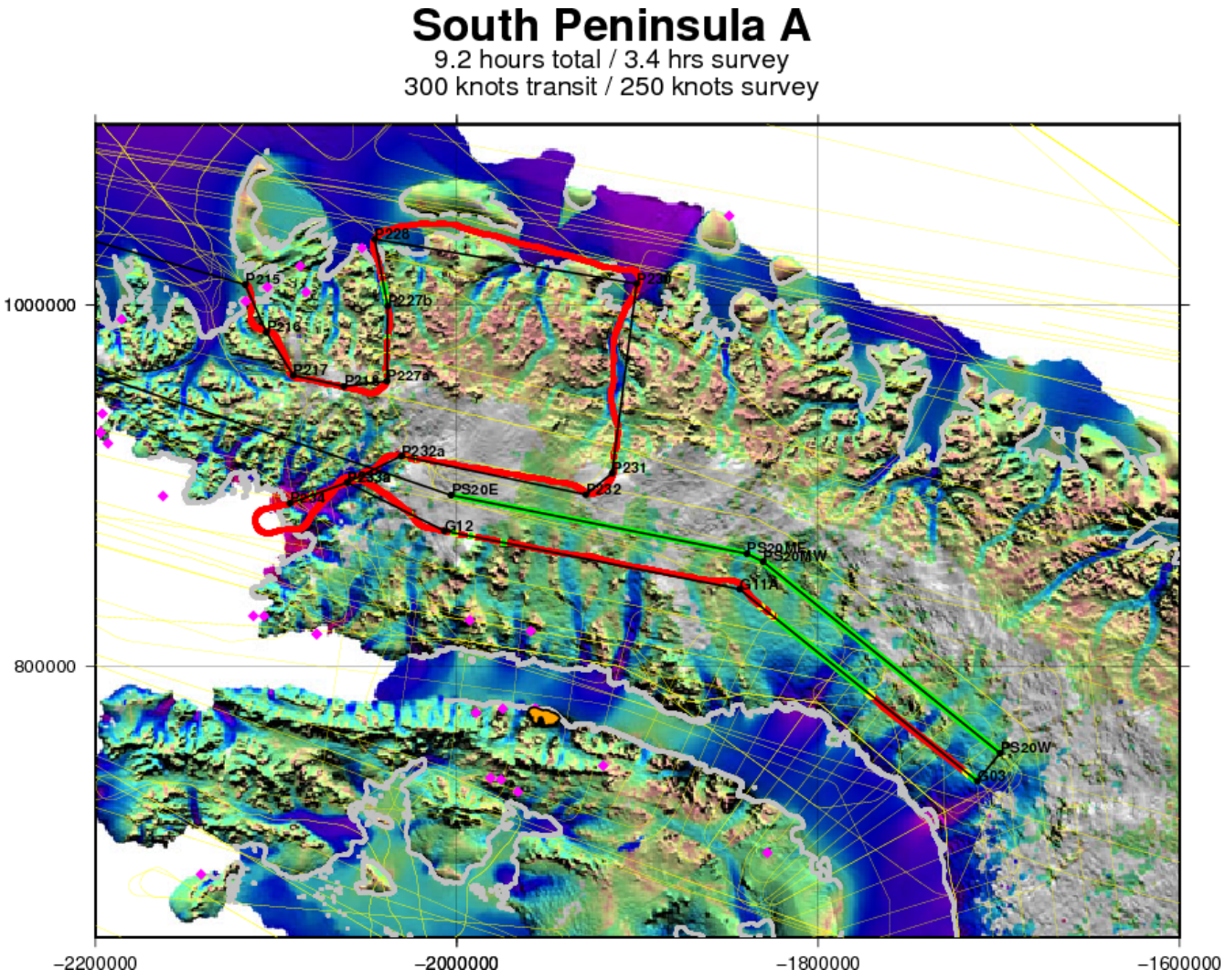
Flight Priority: high
Spacecraft Tracks: 70559,71062,71123,71184,70742,70300 (IceSat-2)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – South Peninsula A

This is primarily a repeat flight, designed to assess dh/dt of four glaciers draining the Dyer Plateau. These are the Fleming, Maitland, Lurabee, and Clifford. We also refly a portion of an established grid uphill from the grounding line on the west side, with grid lines spaced at 20 km. This grid is intended to assess dh/dt in this area, and on its south end it connects with a similarly-designed grid in the English Coast 03 flight. The Fleming Glacier lines in this mission are supplemented by a 10 km grid over Fleming in the Alexander-Fleming 01B flight.

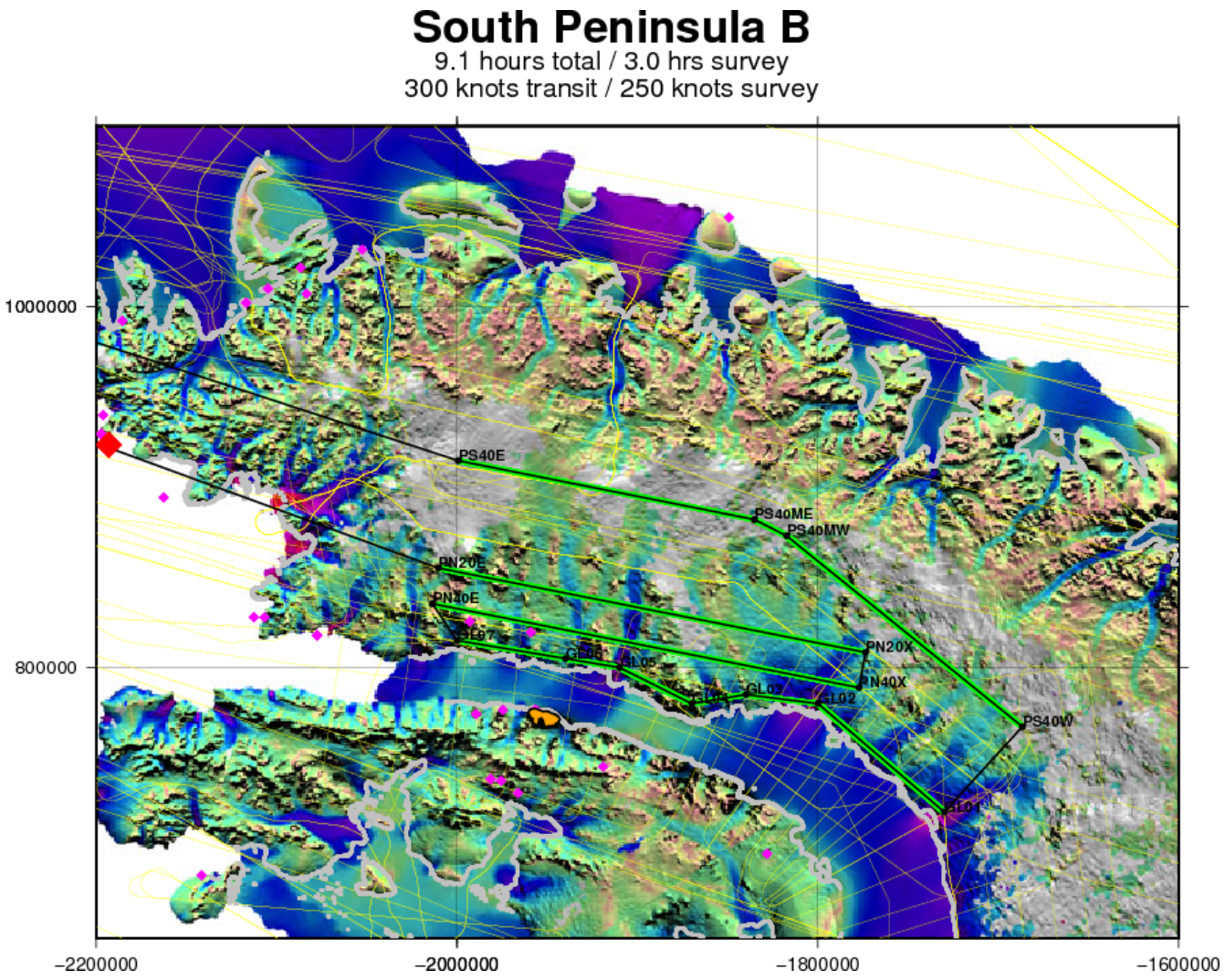
Flight Priority: high (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: none



Land Ice – South Peninsula B

This is primarily a repeat flight, designed to refly a portion of a coast-parallel grid on the west side of Dyer Plateau, with grid lines spaced at 20 km. This grid is intended to assess dh/dt in this area, and on its south end it connects with a similarly-designed grid in the English Coast 03 flight. The remainder of this grid is flown in the companion South Peninsula A flight.

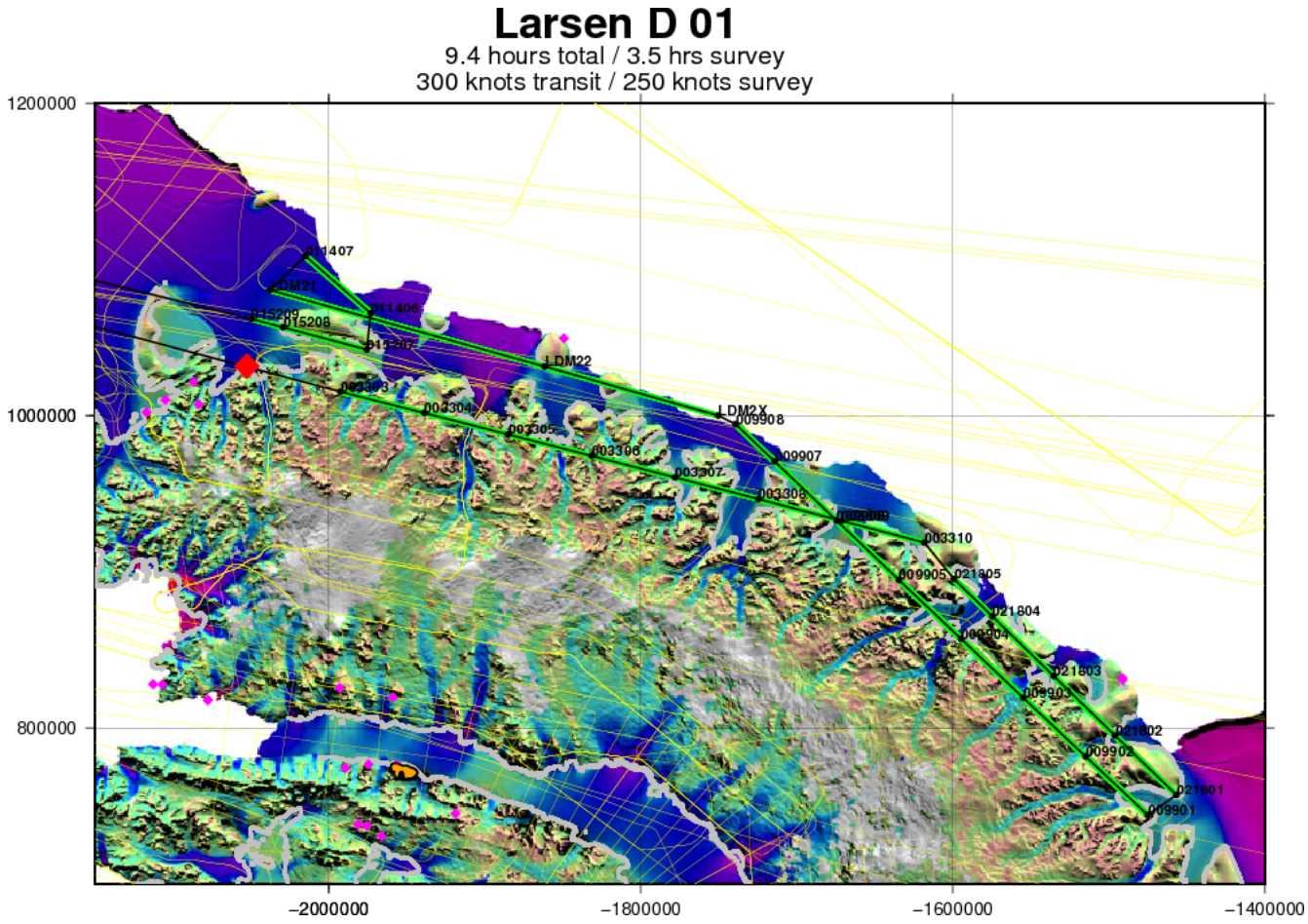
Flight Priority: BASELINE (multi-year repeat flight)
Spacecraft Tracks: none
Last Flown: 2016
Remaining Design Issues: none



Land Ice – Larsen D 01

This flight is designed to map dh/dt in the area of the Larsen-D Ice Shelf, between the southern end of the Larsen-C and the northwestern Ronne ice shelves. It is designed primarily along IceSat-1 tracks. This mission is a condensed version of the 2016 DC-8 version of this flight.

Flight Priority: low (multi-year repeat flight)
Spacecraft Tracks: 0033,0218,0099 (IceSat-1)
Last Flown: 2016
Remaining Design Issues: none



Appendix A: Avoidance of Wildlife and Other Protected Areas

Flight operations over Antarctica are restricted by several factors unique to Antarctica. Some of these factors stem from the fact that the United States is a signatory of the Antarctic Treaty, and certain portions of the Treaty require the signatories to protect wildlife and other designated areas of particular value. In practice, this means that OIB must avoid overflying known wildlife colonies, Antarctic Specially Protected/Managed Areas (ASPAs and ASMAs) , and certain other sites, below specified AGL altitudes. In summer of 2014, the OIB Project Science Office completed a contractual arrangement with UK-based Environmental Research & Assessment (ERA) to obtain their database of Antarctic wildlife colony locations and specially protected areas. We then incorporated an automated analysis which compared planned flights with the colony locations and with the ASPAs/ASMAs into the planning process for each flight. Based on that analysis, we adjusted several flight lines to avoid the indicated areas with explicit maneuvers and waypoints. The waypoints are labeled “AVOIDx” to cue navigators and flight crews to the urgency of avoiding the nearby areas. Even with these adjustments, however, it is impossible to predict the exact flight path of the aircraft in advance, and for this reason we specify a plan here to avoid all known areas with relevant flight restrictions.

The OIB science navigators will display point locations of all known wildlife colonies, and polygons defining the ASPA/ASMA boundaries, on an instance of the Soxmap navigation display and will monitor it carefully, calling out to the flight crew when an undesired upcoming overflight is foreseen. For the wildlife colonies, we use a lateral “stay-out” radius and a minimum overflight altitude somewhat more conservative than the ones used by ERA for their analysis. Thus, each colony location will be at the base of a three-dimensional cylinder which the aircraft will remain well-clear of. For the ASPA polygons, each one has its own overflight restrictions, and a comprehensive database listing these details may not be available in-flight. Thus we plan to steer clear of all ASPAs and ASMAs unless we know the permissible minimum altitude for a particular ASPA.

Our procedures for avoiding wildlife and ASPAs/ASMAs are as follows:

1. No overflights of wildlife colonies below 1000 m AGL within a radius of 2 km
2. No overflights of ASPAs/ASMAs at any altitude unless we know overflight is permitted for that particular area at a particular altitude.