Fall 2014 IceBridge DC-8 Flight Plans
2 September 2014 Draft

compiled by

John Sonntag

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 DC-8 aircraft, beginning in mid-October and ending in late November 2014. 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 via anonymous FTP at the following address: ftp://atm.wff.nasa.gov/outgoing/oibscienceteam/. Note that some users have reported problems connecting to this address with certain browsers. Command-line FTP and software tools such as Filezilla may be of help in such situations.

For each planned mission, we give a map and brief text description for the mission. The missions are planned to be flown from Punta Arenas, Chile. 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. CryoSat underflights are a major exception, since these 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). Sea ice camp/site overflights are also an exception, since these move with the motion of the ice, unless they are situated on shore-fast ice.

Note that this document shows 41 planned land ice and 8 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 49 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 two composite maps 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. This repeat strategy is depicted in the introductory material following this text, 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.

IceBridge Mission Statement

Operation IceBridge will employ aircraft to monitor the most sensitive and critical areas of sea ice, ice sheets and glaciers during the gap in satellite coverage caused by the failure of ICESat-1, in 2009, and the launch of ICESat-2, planned for 2016. Sensitive and critical areas include coastal Greenland and especially its outlet glaciers, costal Antarctica including the Antarctic Peninsula and ice shelves, the sea ice of the Arctic and Antarctic and the southeast Alaskan glaciers. Data collected by IceBridge will improve our knowledge of the contribution of the Greenland and Antarctic ice sheets to sea level rise and will make fundamental contributions to the understanding of changes occurring in the extent and thickness of the polar sea ice cover. Given the societal importance of understanding changes in sea level rise and sea ice extent, IceBridge data will monitor and improve modeling efforts for sea ice, ice sheet and glaciers. IceBridge will also prepare for the future of airborne monitoring efforts of the cryosphere by adapting existing instruments for high altitude unmanned aerial systems such as the NASA Global Hawk.

IceBridge Science Objectives

The following are the major science objectives of Operation IceBridge in priority order and are meet by the following flight plans:

1) Make airborne laser altimetry measurements over the ice sheets and sea ice to fill in the data gap between the failure of ICESat-1 in 2009 and the launch of ICESat-2 planned for 2015.

2) Link measurements made by ICESat, ICESat-2, and CryoSat-2 to allow their comparison and the production of a long-term, ice sheet altimetry record.

3) Use airborne altimetry and radar to monitor key, rapidly changing areas of ice, including sea ice, ice sheets and glaciers, in the Arctic and Antarctic to maintain a long term observation record, improve understanding of glacial dynamics, and augment predictive models of sea level rise and sea ice cover.

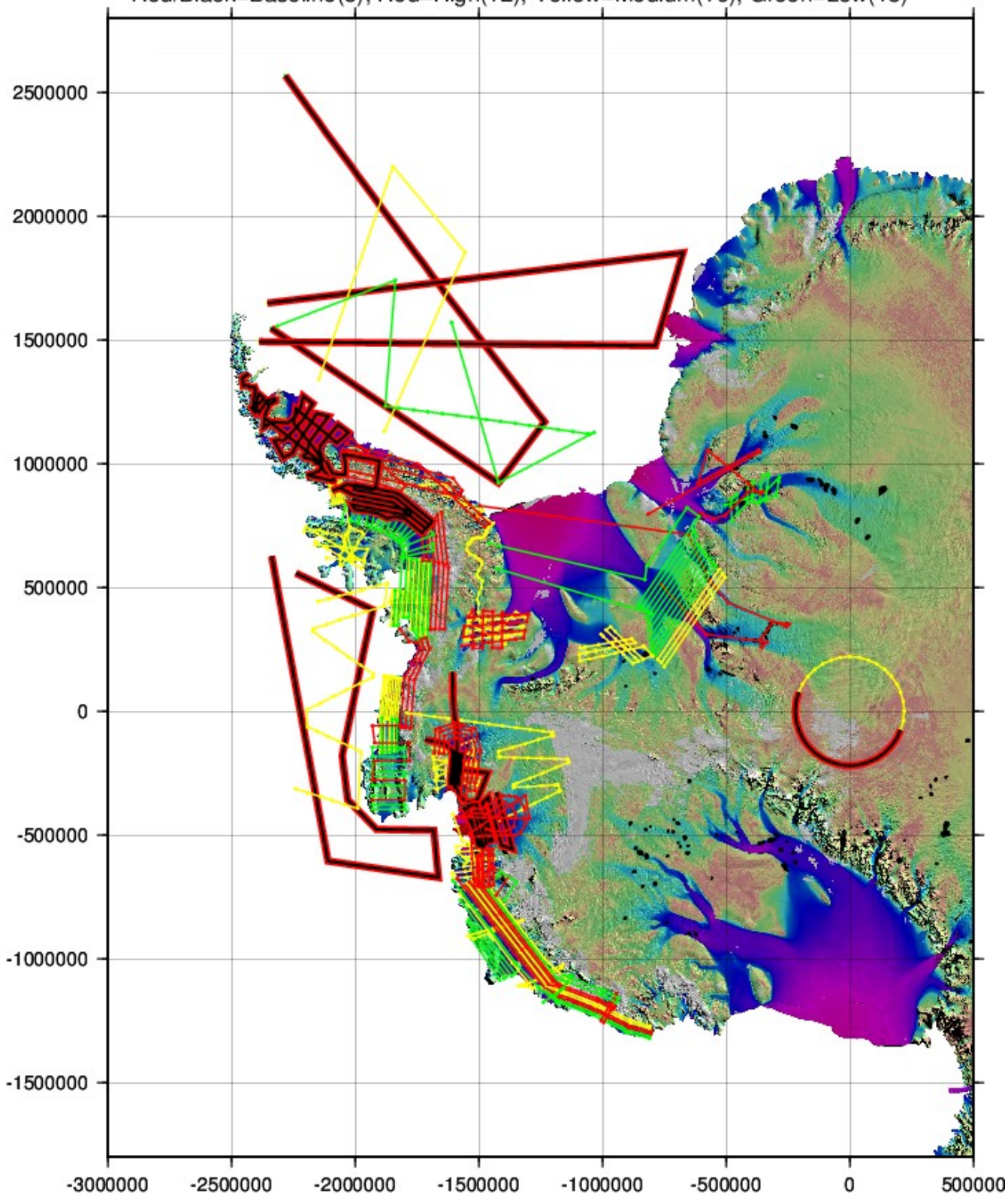
4) In conjunction with altimetry measurements, collect other remotely sensed data to improve predictive models of sea level rise and sea ice cover, especially the following:

- Ice sheet and sea ice thickness, structure and extent;
- Bed topography underlying land-based ice;
- Bathymetry beneath floating ice shelves;
- Snow accumulation and firn structure; and
- Other geophysical constraints that will improve estimates of the geothermal and oceanic heat flux

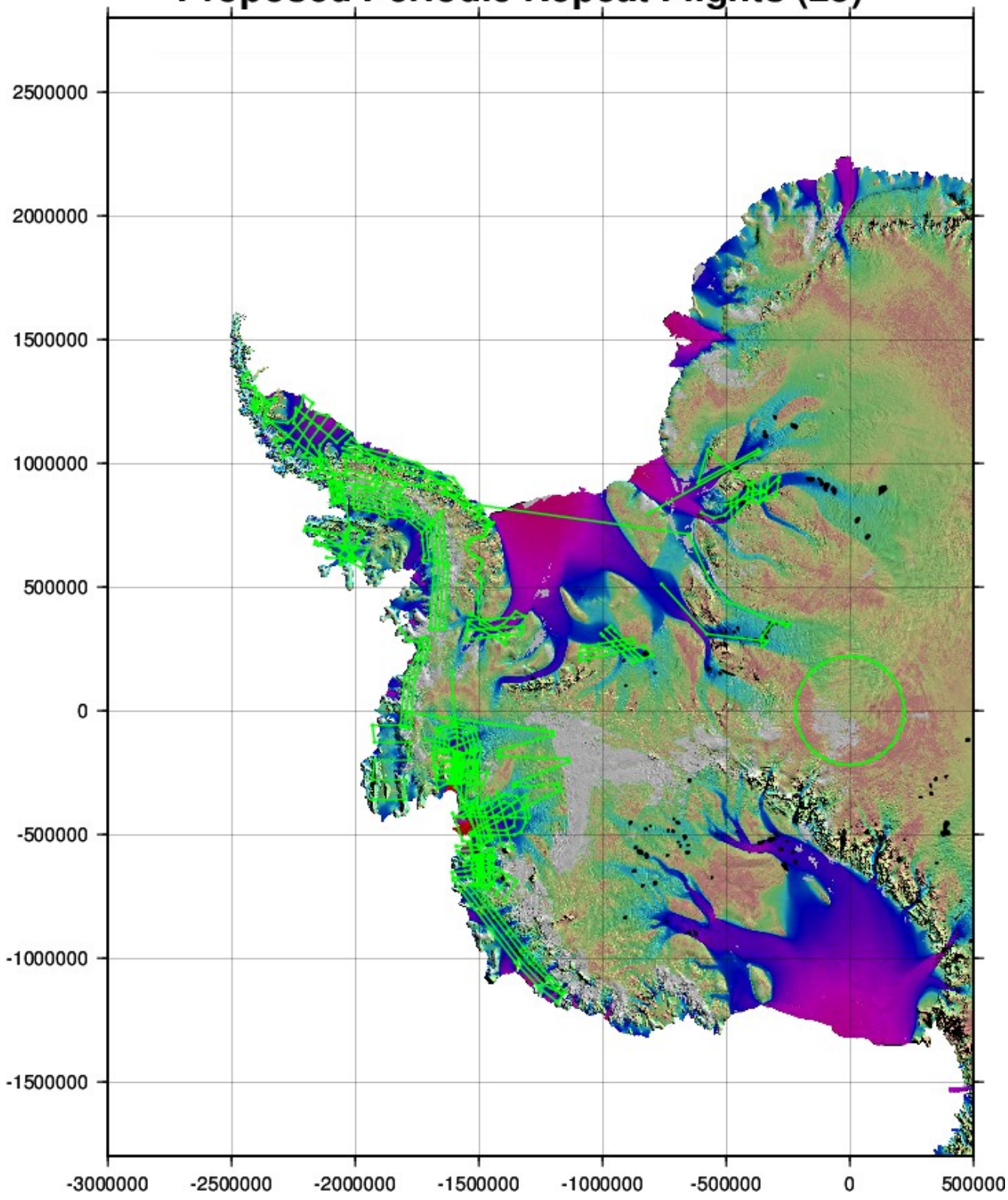
5) Adapt existing instruments for airborne remote sensing of ice by high altitude unmanned aerial systems such as the NASA Global Hawk.

Prioritized 2014 OIB DC-8 Antarctic Flights

Red/Black=Baseline(8); Red=High(12); Yellow=Medium(16); Green=Low(13)



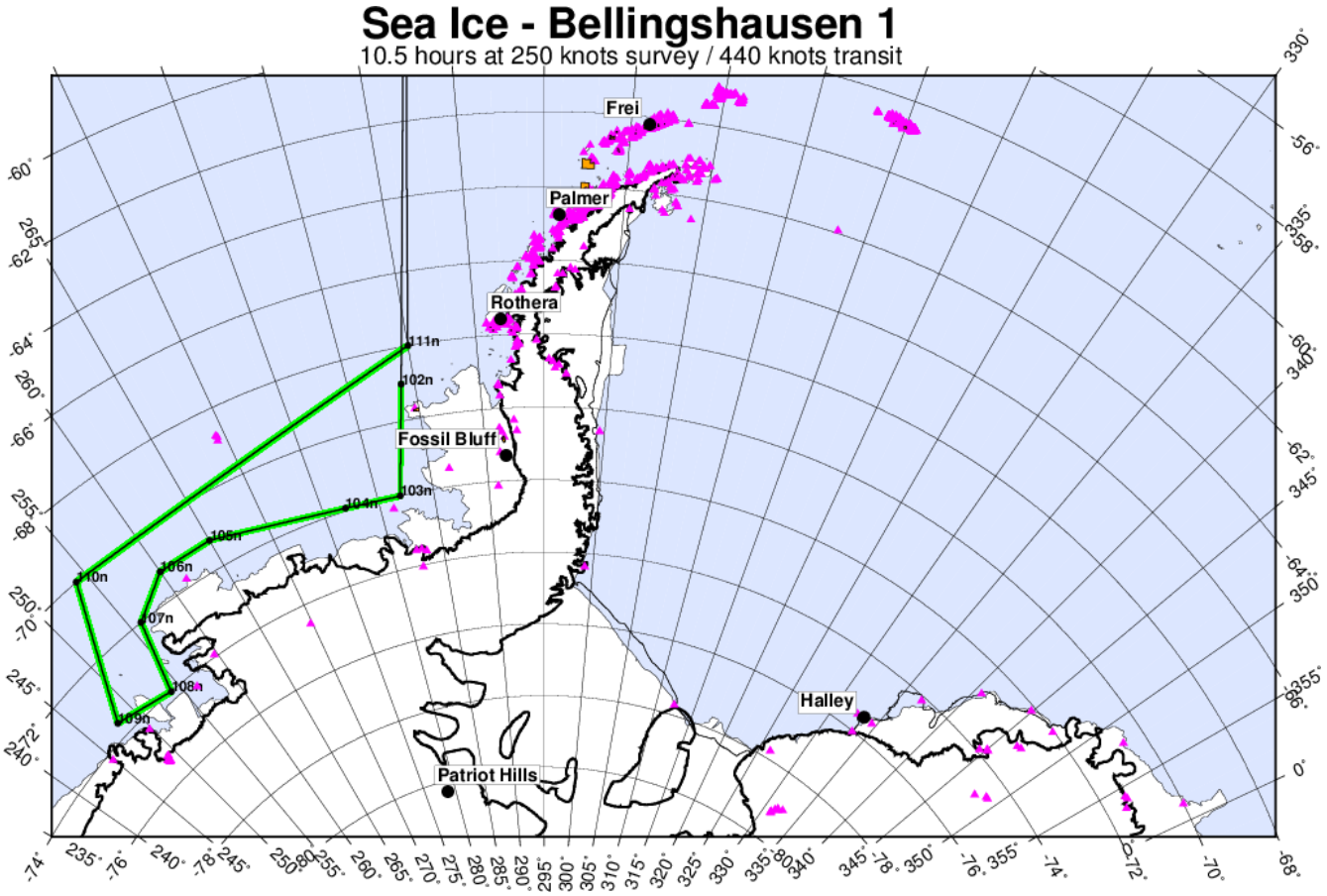
Proposed Periodic Repeat Flights (23)



Sea Ice – Bellingshausen 1

This mission represents a continuation of the IceBridge time series, repeating much of the 21 October 2009 and 30 October 2010 Sea Ice 01 flights and the 23 October 2011 and 13 October 2012 Bellingshausen 1 flights. The northern portion of this flight (i.e. between WP110n and 111n) may be adjusted according to sea ice coverage reports obtained just prior to (or during) the deployment, specifically the location of the ice edge. Also note that that segment of the flight may have to be flown at high altitude, depending on fuel constraints. This mission should be flown as early as possible, preferably before mid-Oct, because of the relatively early onset of melt of in this region.

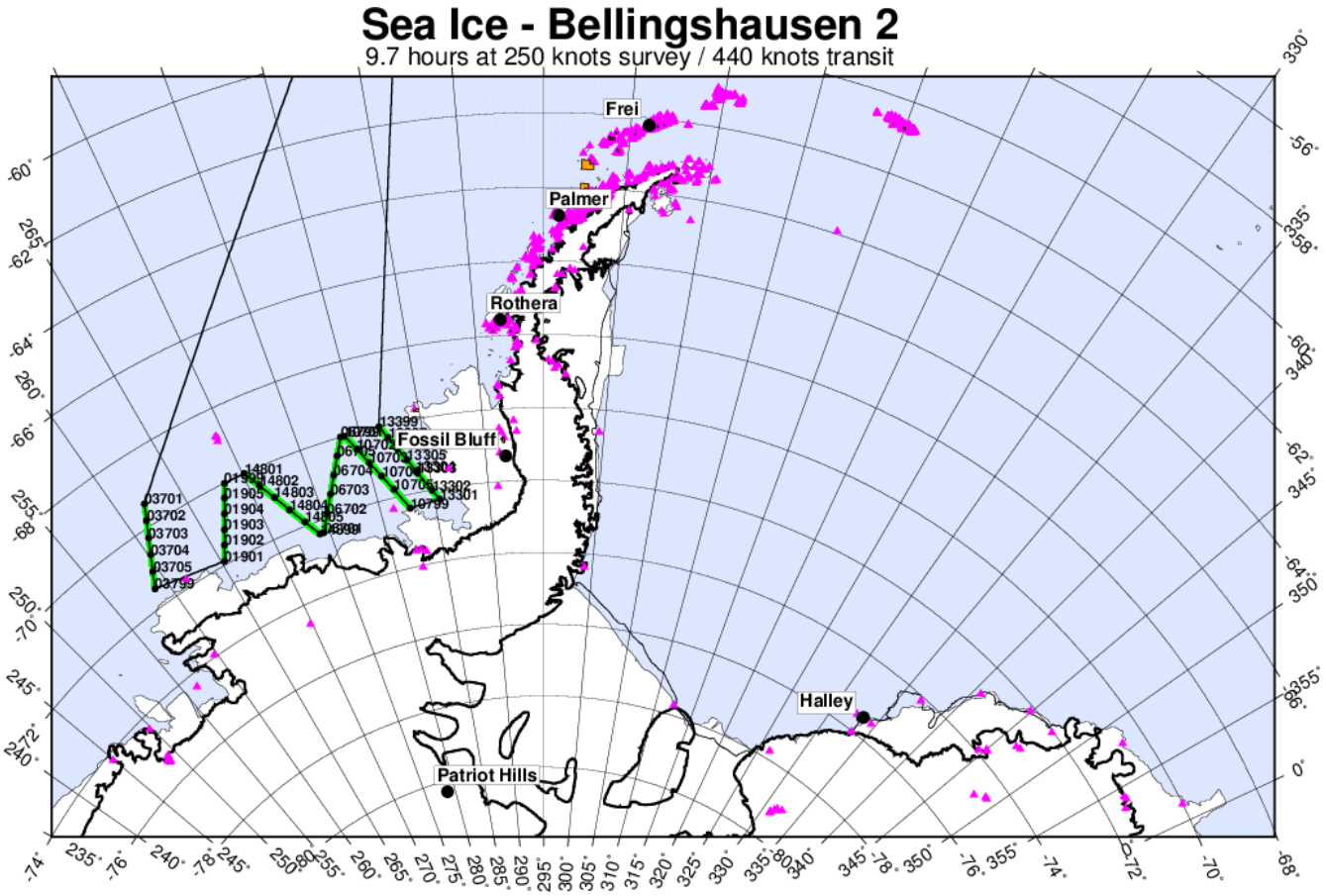
Flight Priority: BASELINE
Science Requirements Addressed: SI1,SI2,SI3c,SI6
Spacecraft Tracks: none
Last Flown: 2012
Remaining Design Issues: none



Sea Ice – Bellingshausen 2

This mission represents a modification of Bellingshausen 1, to be flown in its place in the event that the ice edge in this region has retreated far southward. Adapting to "moderate ice" sea ice condition, the flight pattern is modified to (a) provide denser coverage (i.e. multiple north-south legs) over the smaller expanse of sea ice and (b) the opportunity to make multiple passes over the ice edge. The waypoints are derived from Envisat ground tracks. The specific location of the waypoints should be reviewed before the flight and adjusted based on the sea ice coverage reports obtained just prior to (or during) the deployment, specifically the location of the ice edge. 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.

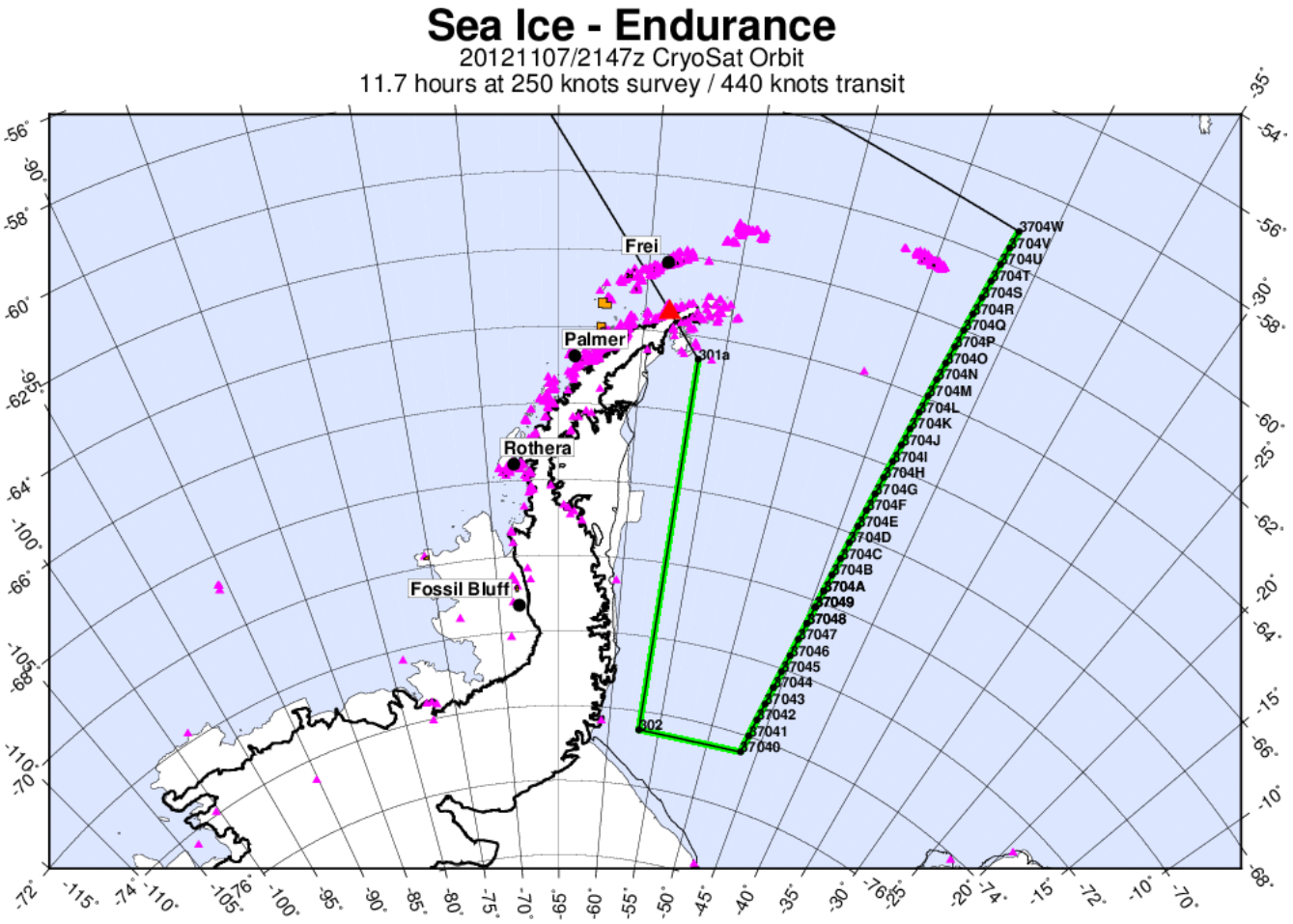
Flight Priority: medium
Science Requirements Addressed: SI1,SI2,SI3c,SI4,SI6
Spacecraft Tracks: CryoSat-2 track TBD
Last Flown: 2012
Remaining Design Issues: none



Sea Ice – Endurance

This mission represents a continuation of the IceBridge time series, repeating the "along shore" flight line (i.e. WP301a to WP302) flown in 2009 and 2010 and the Endurance flight line from 13 October 2011 and 7 November 2012. It typically crosses rough sea ice. The western flight line (i.e. 301a to 302) is a repeat of a segment flown on 28 October 2010. The eastern flight line (37040-3704W) will be adjusted to occupy a contemporaneous CryoSat-2 orbit. The CryoSat-2 orbit should be as close in time to the DC-8 underflight as possible, and the recommended maximum time offset is ~2 hours. The eastern flight line will also be adjusted to allow a 30 minute backtrack loop along the line, repeating a portion of the track to aid in the determination of sea ice drift rate. Finally we will continue the CryoSat track north past the ice edge, if time permits, for 25-50 km over the open ocean. This will permit intercomparison of OIB and CryoSat data over the transition region from the ice edge to open ocean.

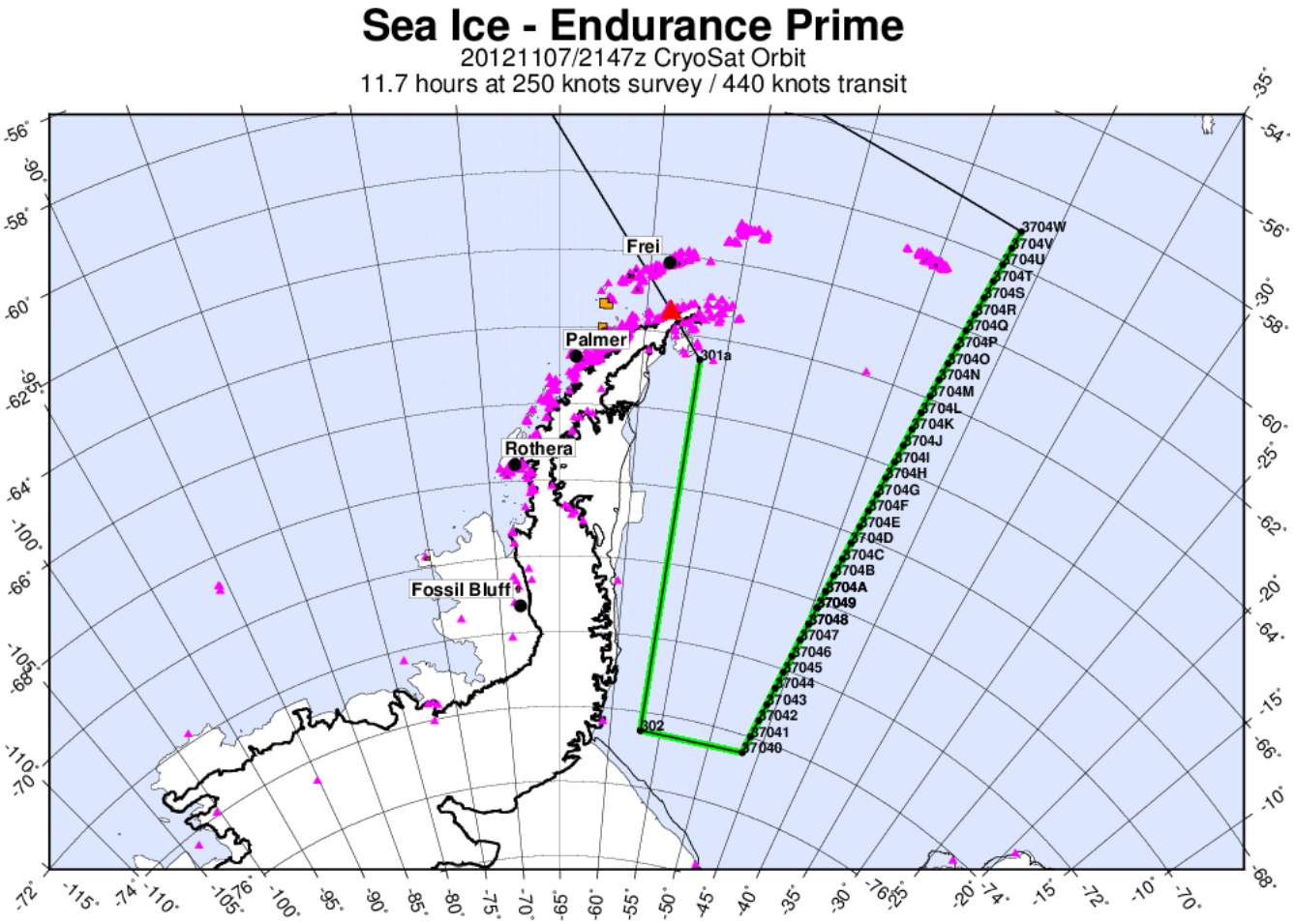
Flight Priority: BASELINE
Science Requirements Addressed: SI1,SI2,SI3b,SI4,SI6
Spacecraft Tracks: CryoSat-2 track TBD
Last Flown: 2012
Remaining Design Issues: eastern line should be a near (within ~2 hours) contemporaneous CryoSat-2 ground track



Sea Ice – Endurance Prime

This mission is a near-repeat of the "Sea Ice Endurance" flight, with the exception of the eastern (CryoSat) leg. The purpose is to repeat the track of the Endurance flight after approximately 2 weeks have elapsed, to enable detection of change in the sea ice conditions over that time. The CryoSat leg, however, would be selected to be contemporaneous with the spacecraft on the day this mission is flown.

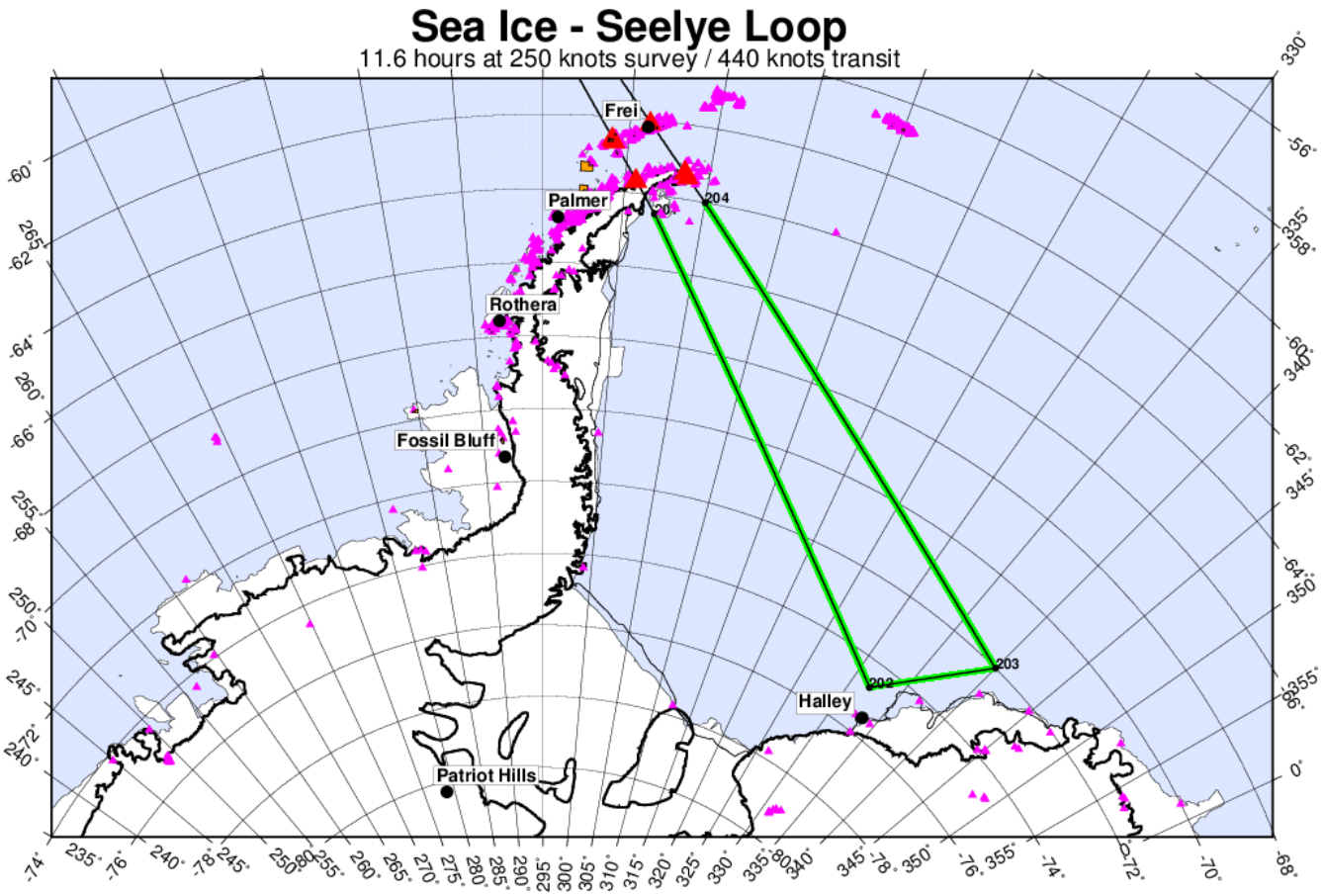
Flight Priority: low
Science Requirements Addressed: SI1,SI2,SI3b,SI4,SI6
Spacecraft Tracks: CryoSat-2 track TBD
Last Flown: new flight
Remaining Design Issues: eastern line should be a near (within ~2 hours) contemporaneous CryoSat-2 ground track



Sea Ice – Seelye Loop

This mission represents a continuation of the IceBridge time series, repeating the 24 October 2009, 101026, 12 October 2011 and 25 October 2011 missions. 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. This mission may have to be shortened if dictated by fuel constraints.

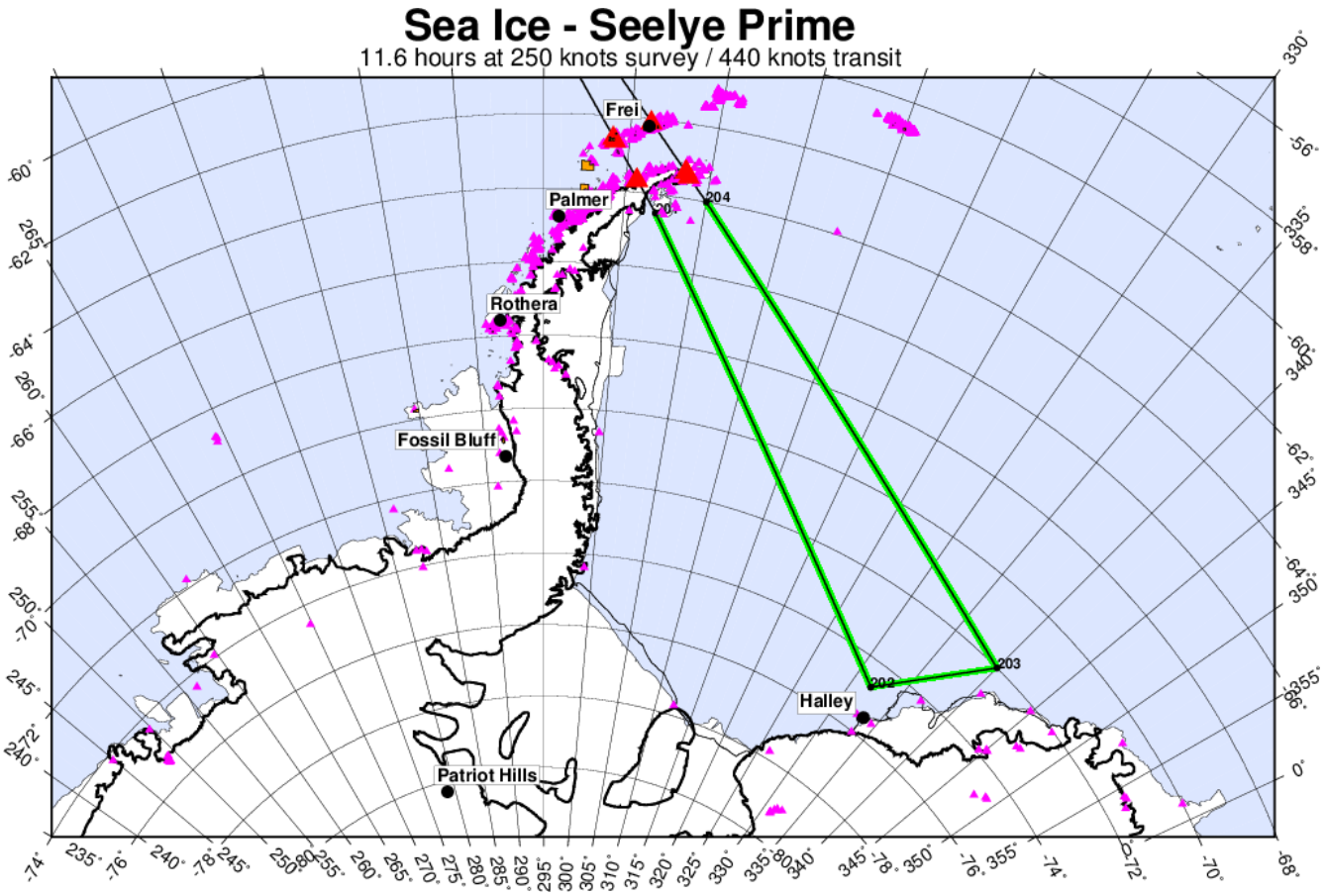
Flight Priority: BASELINE
Science Requirements Addressed: SI1,SI2,SI3a,SI6,SI9
Spacecraft Tracks: none
Last Flown: 2012
Remaining Design Issues: none



Sea Ice – Seelye Prime

This mission would repeat the Seelye Loop above, but following at least two weeks after the first flight. This time period (in the Antarctic Spring) would allow a significant amount of snowmelt to occur and permit validation of the snow radar results. As is the case with the Seelye Loop mision, this mission may have to be shortened if dictated by fuel constraints.

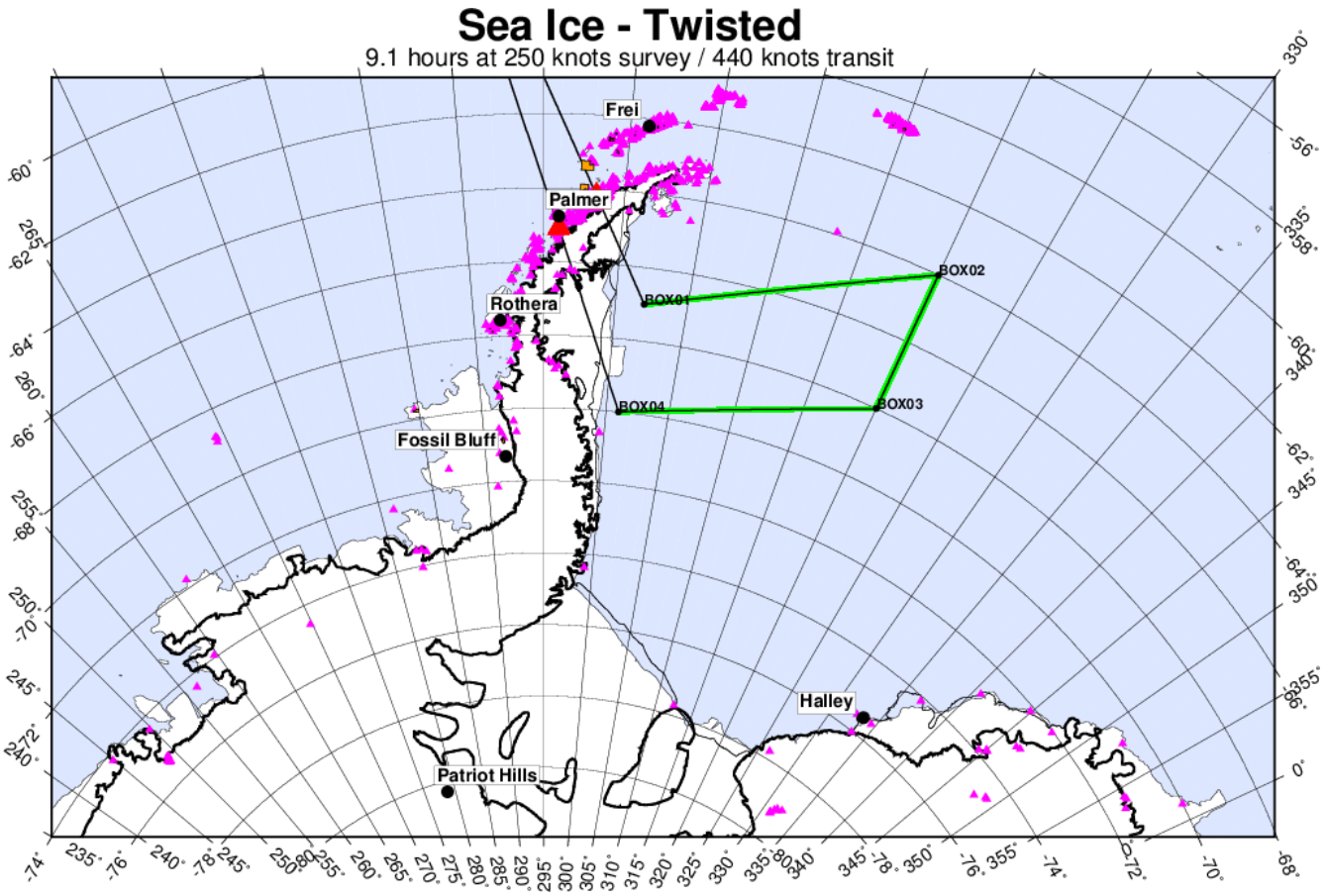
Flight Priority: medium
Science Requirements Addressed: SI1,SI2,SI3a,SI6
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Sea Ice – Twisted

This mission represents an alternative pattern over the Weddell, generally rotating, or twisting, the Seelye Loop pattern northward, closer to ice edge. This is a repeat of the 18 October 2011 OIB flight. This is a medium priority mission to be considered in the event of poor weather at other sea ice mission sites.

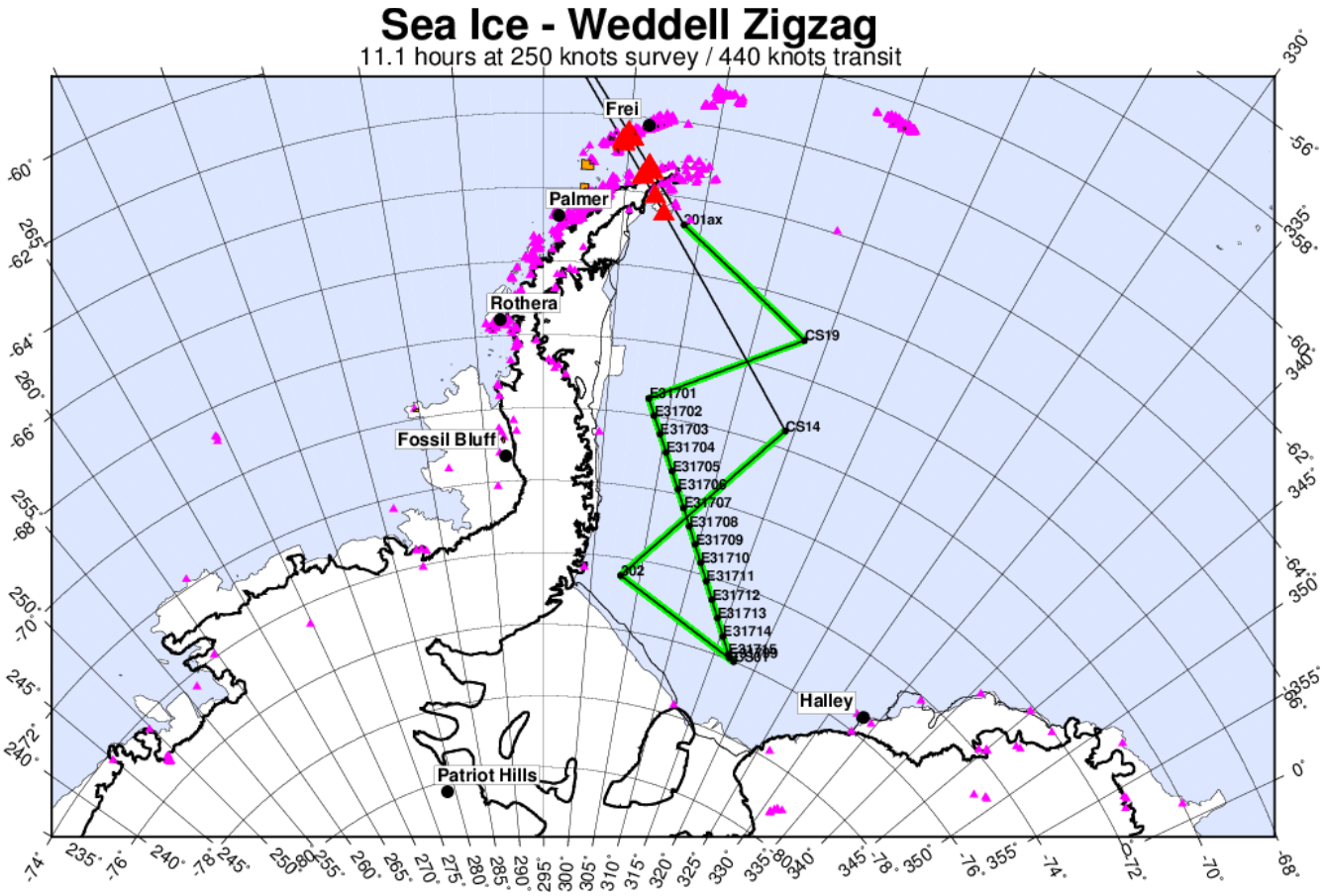
Flight Priority: medium
Science Requirements Addressed: SI1,SI2,SI3b,SI6
Spacecraft Tracks: none
Last Flown: 2011
Remaining Design Issues: none



Sea Ice – Weddell Zigzag

This is a new mission, designed with the aim of providing more detailed coverage over a region in the Weddell Sea characterized by a significant thickness gradient (the ice gets older and thicker closer to the Antarctic Peninsula). The zig-zag pattern crosses the space between the Endurance flight lines. The southernmost line is a repeat of the Endurance line, which is desired for comparisons between the two missions. The segment from E31701 to E31799 follows an Envisat ground track. This is a low-priority mission to be considered in the event of poor weather at other sea ice mission sites.

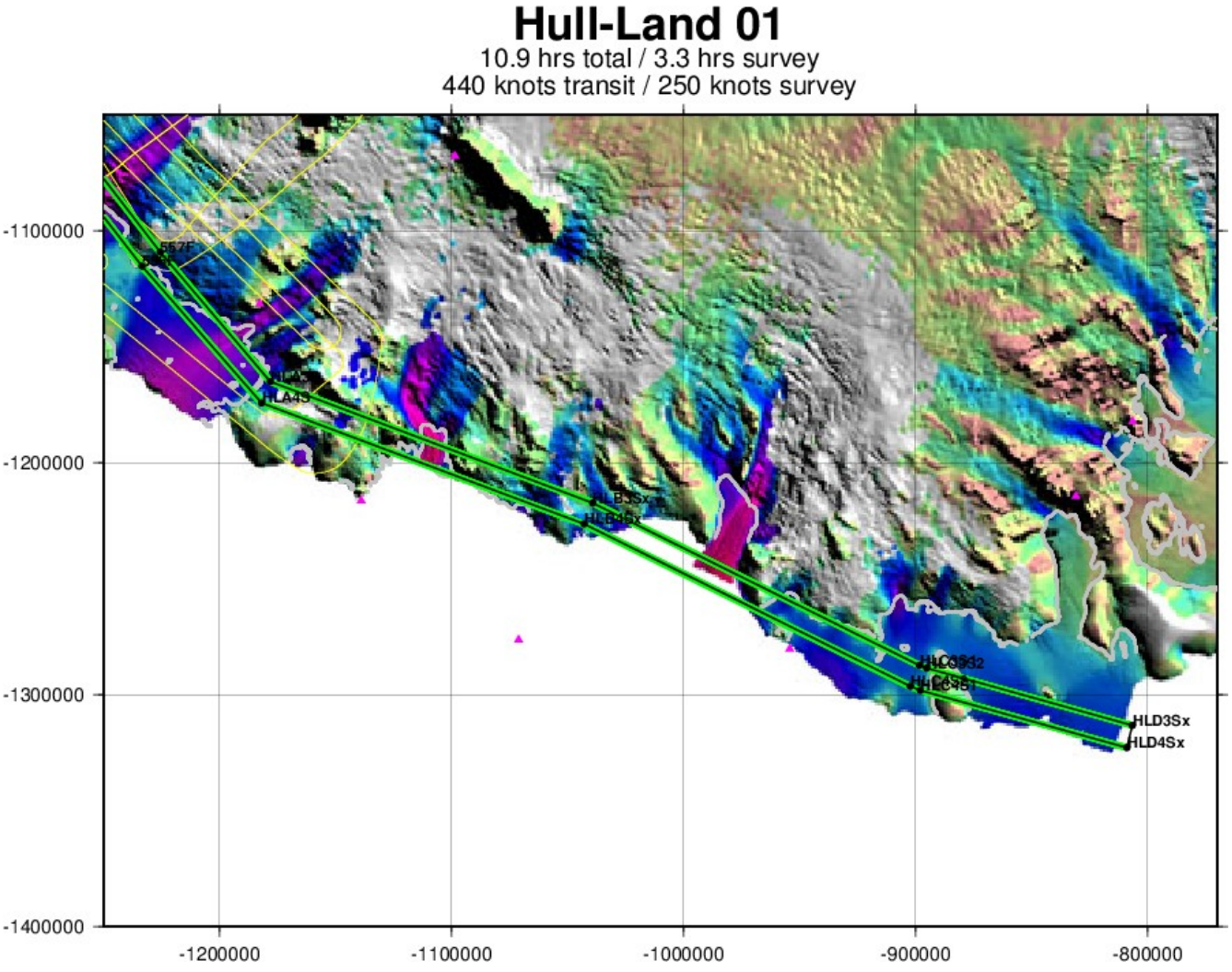
Flight Priority: low
Science Requirements Addressed: SI1,SI2,SI3b,SI6
Spacecraft Tracks: single Envisat track
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Hull-Land 01

This is a new mission, one of a suite of five missions designed to map the coastal region encompassing the Hull and Land glaciers and surrounding areas to the west of the Getz Ice Shelf. The twofold purpose is to map the bathymetry and basal topography using the gravimeter and MCoRDS radar, and at the same time to establish surface topography measurements for dh/dt. This particular flight is the outboard-most of the five planned flights. We also overfly LVIS grid lines in the Getz area during transits at high altitude, to obtain high-altitude data on an opportunistic basis.

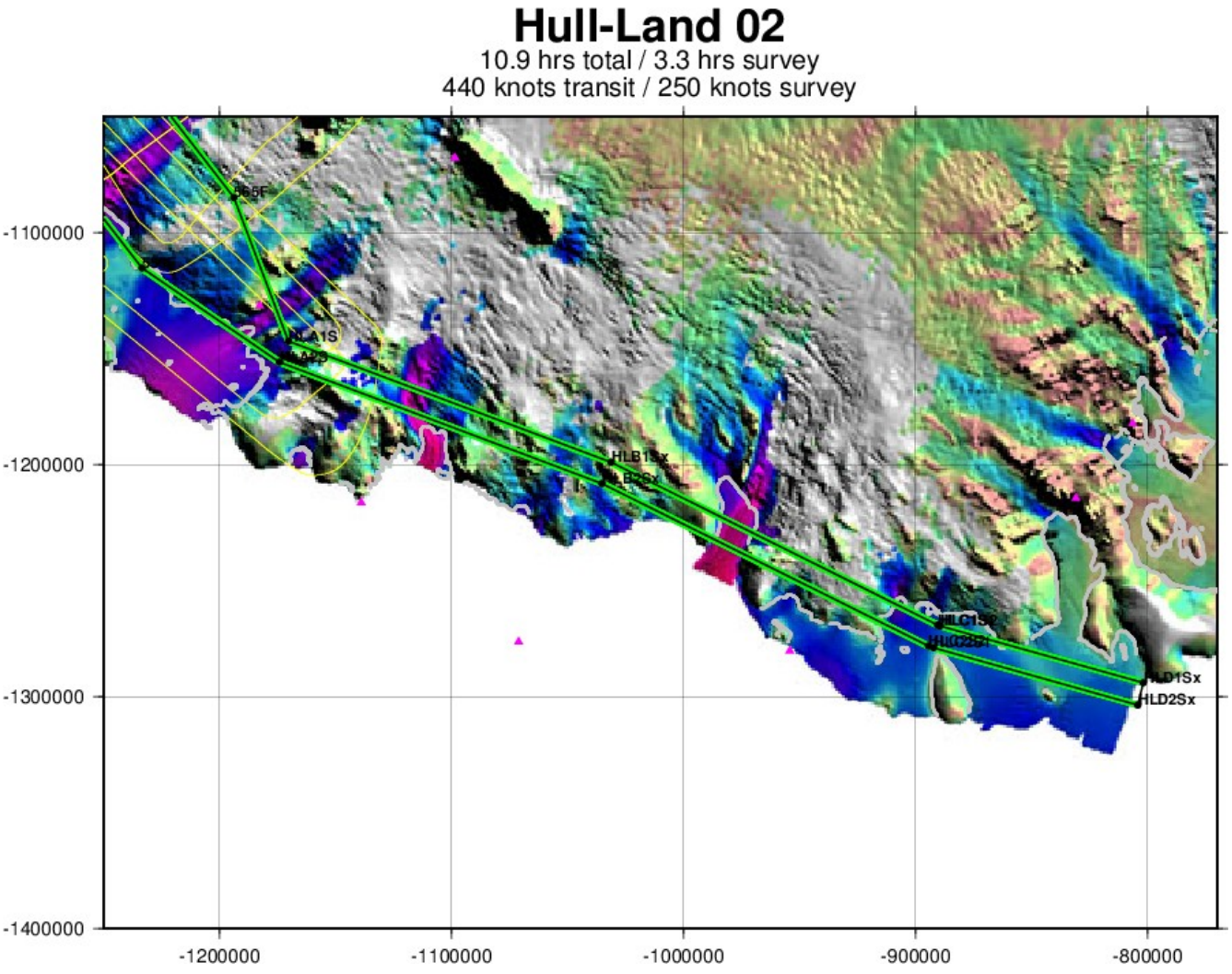
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Hull-Land 02

This is a new mission, one of a suite of five missions designed to map the coastal region encompassing the Hull and Land glaciers and surrounding areas to the west of the Getz Ice Shelf. The twofold purpose is to map the bathymetry and basal topography using the gravimeter and MCoRDS radar, and at the same time to establish surface topography measurements for dh/dt. This particular flight is the second most outboard of the five planned flights. We also overfly LVIS grid lines in the Getz area during transits at high altitude, to obtain high-altitude data on an opportunistic basis.

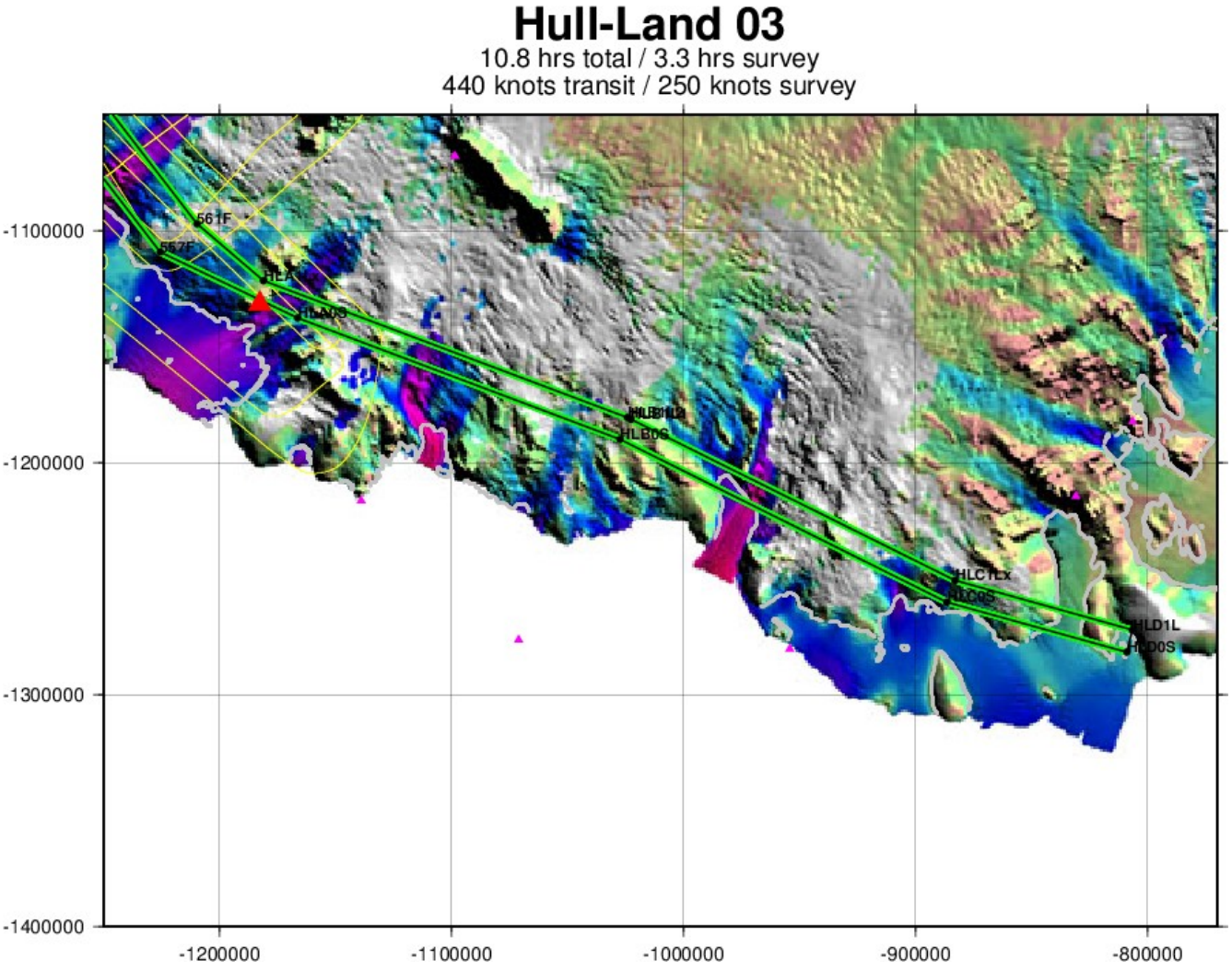
Flight Priority: high
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Hull-Land 03

This is a new mission, one of a suite of five missions designed to map the coastal region encompassing the Hull and Land glaciers and surrounding areas to the west of the Getz Ice Shelf. The twofold purpose is to map the bathymetry and basal topography using the gravimeter and MCoRDS radar, and at the same time to establish surface topography measurements for dh/dt. This particular flight occupies the center of the area of study of the five planned flights. We also overfly LVIS grid lines in the Getz area during transits at high altitude, to obtain high-altitude data on an opportunistic basis.

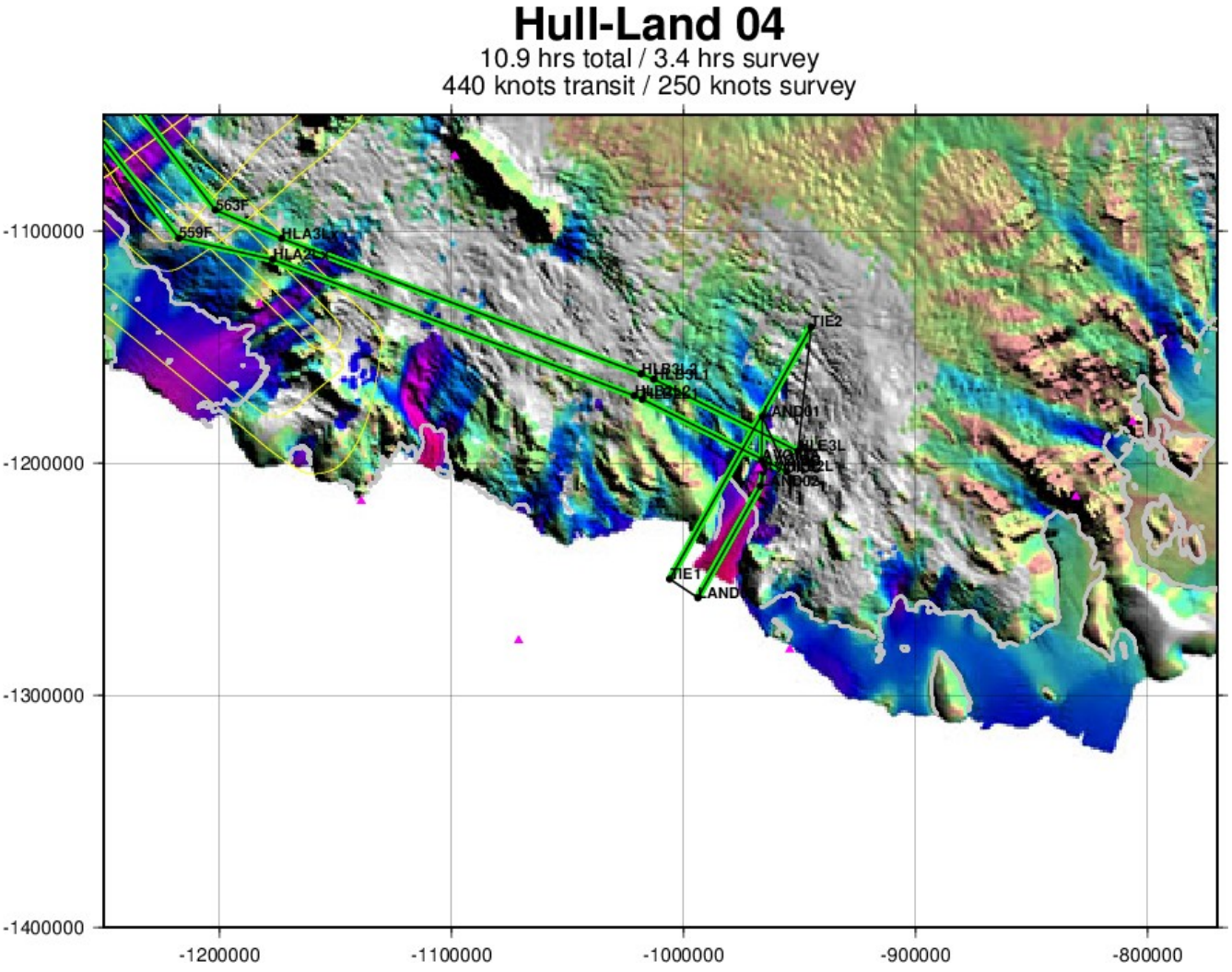
Flight Priority: medium
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Hull-Land 04

This is a new mission, one of a suite of five missions designed to map the coastal region encompassing the Hull and Land glaciers and surrounding areas to the west of the Getz Ice Shelf. The twofold purpose is to map the bathymetry and basal topography using the gravimeter and MCoRDS radar, and at the same time to establish surface topography measurements for dh/dt. This particular flight is the second most inboard of the five planned flights, and it includes a centerline run of the Land Glacier and a nearby tie line. Finally we overfly LVIS grid lines in the Getz area during transits at high altitude, to obtain high-altitude data on an opportunistic basis.

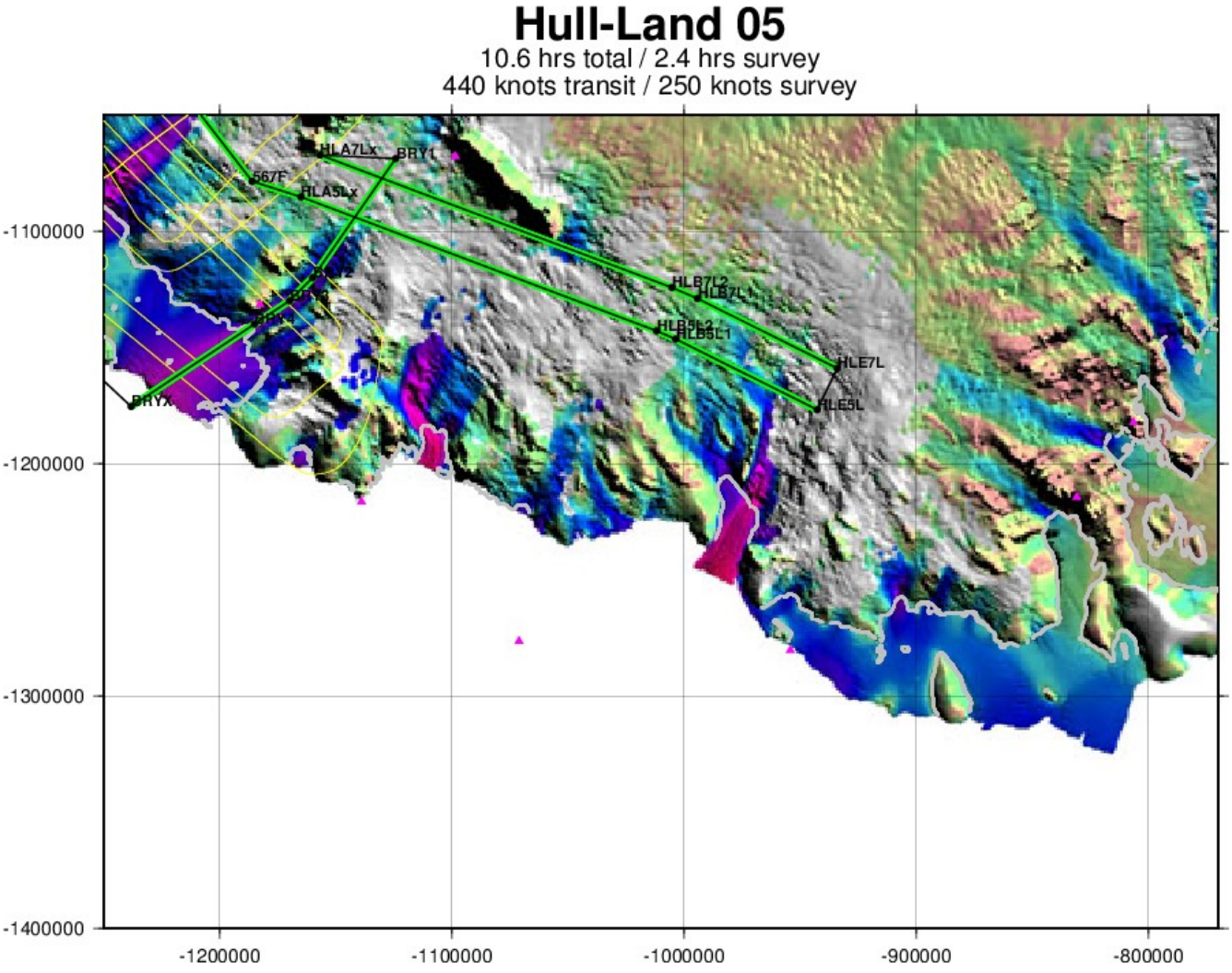
Flight Priority: high
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Hull-Land 05

This is a new mission, one of a suite of five missions designed to map the coastal region encompassing the Hull and Land glaciers and surrounding areas to the west of the Getz Ice Shelf. The twofold purpose is to map the bathymetry and basal topography using the gravimeter and MCoRDS radar, and at the same time to establish surface topography measurements for dh/dt. This particular flight is the most inboard of the five planned flights, and it increases the spacing of the lines from 10 km to 20 km, mainly for the purpose of extending the surveys to the base of the Flood Range. It also includes a centerline survey of the Berry Glacier, and the curvature of this line may be small enough to enable the line to be suitable as a gravity tie line as well. Finally we overfly an LVIS grid line in the Getz area during the inbound transit at high altitude, to obtain high-altitude data on an opportunistic basis.

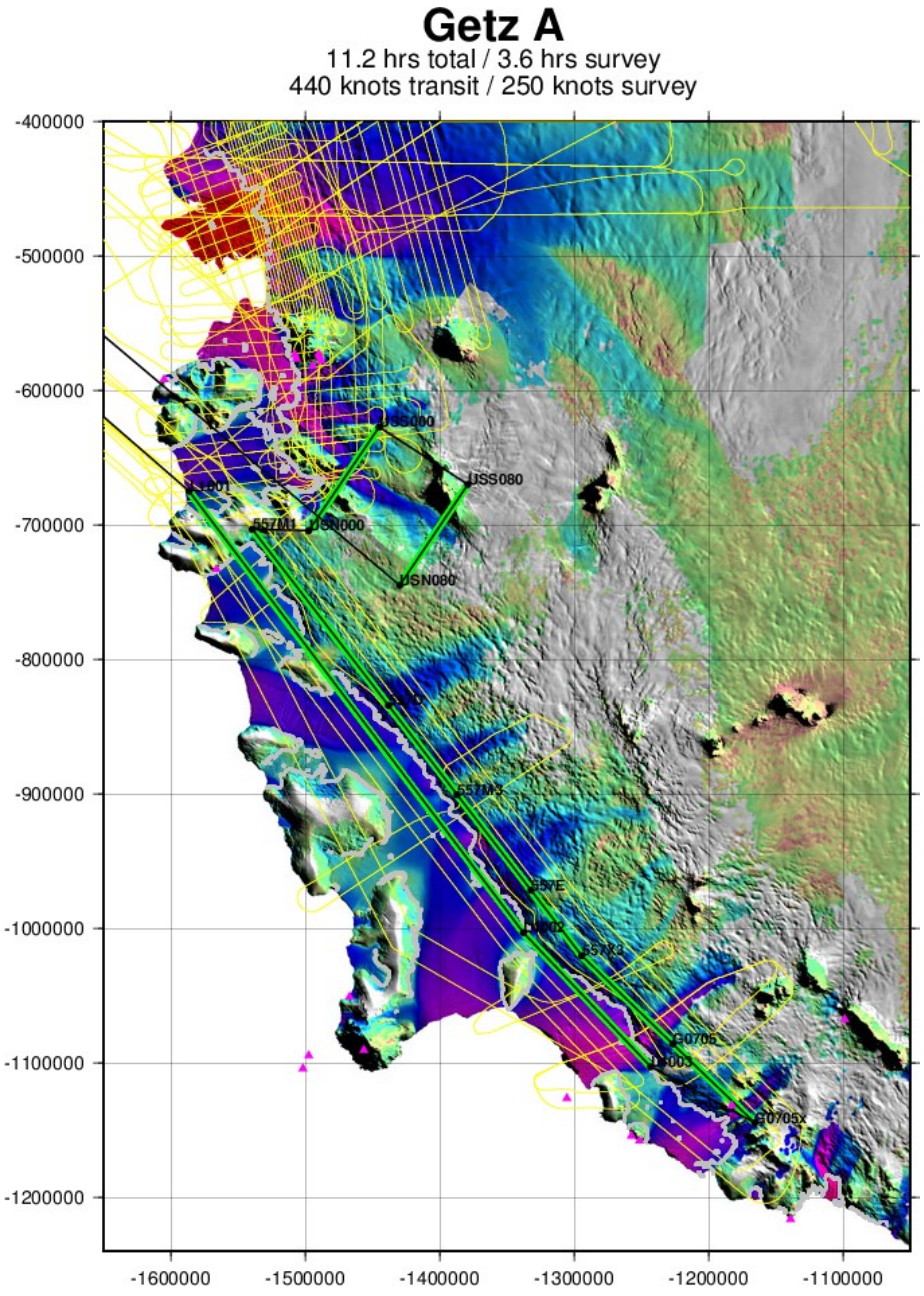
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Getz A

This is a new mission, designed in parallel with the Getz B mission to collect dh/dt measurements over the Getz Ice Shelf and grounded ice just inland. This flight overflies OIB lines flown in 2010 (the outboard line) and 2012 (the inland line). In addition, this mission captures two new lines over the upper catchment of Smith and Kohler Glaciers, spaced at 80 km apart. This spacing drops to 40 km if both Getz A and Getz B are flown.

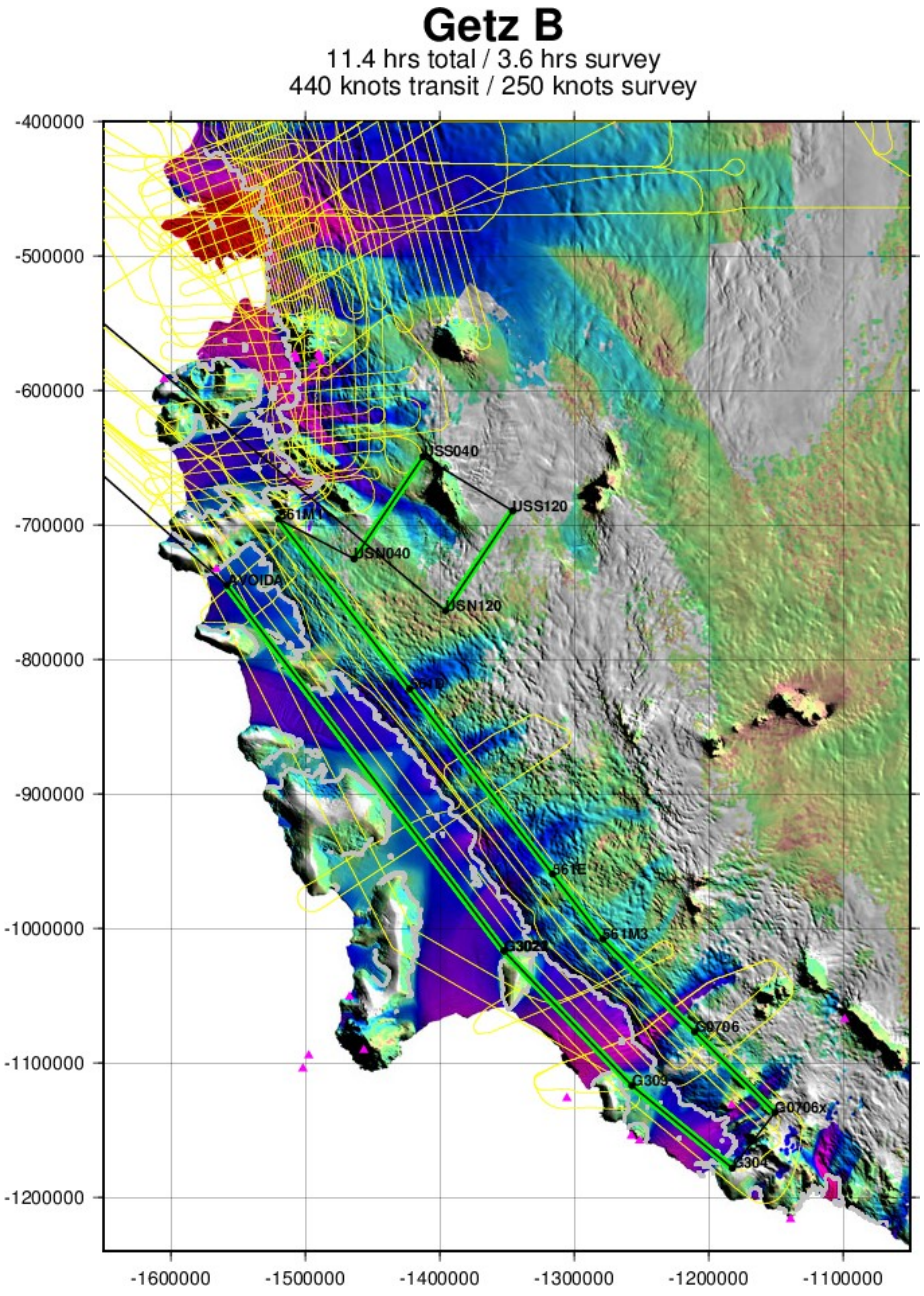
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: portions in 2010 and 2012
Remaining Design Issues: none



Land Ice – Getz B

This is a new mission, designed in parallel with the Getz A mission to collect dh/dt measurements over the Getz Ice Shelf and grounded ice just inland. This flight overflies OIB lines flown in 2011 (the outboard line) and 2012 (the inland line). In addition, this mission captures two new lines over the upper catchment of Smith and Kohler Glaciers, spaced at 80 km apart. This spacing drops to 40 km if both Getz A and Getz B are flown.

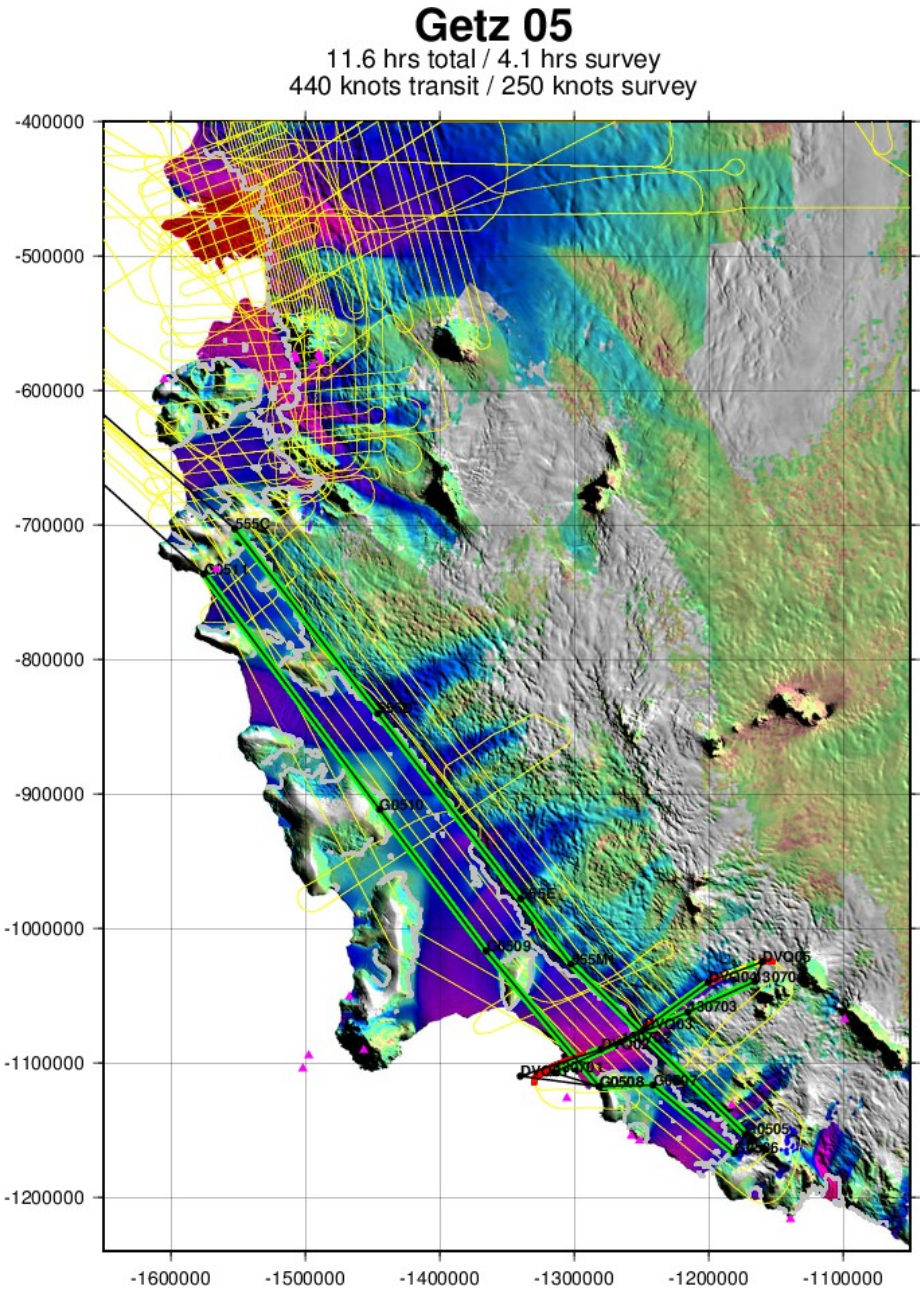
Flight Priority: low (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: portions in 2011 and 2012
Remaining Design Issues: none



Land Ice – Getz 05

This is a new mission, one of a suite of four designed to supplement the 2009-2012 Getz Ice Shelf flights. The twofold purpose is to continue mapping the sub ice-shelf bathymetry using the gravimeter, and to continue mapping the ice surface and bedrock upstream of the grounding line. This particular flight includes a repeat centerline run of the Devicq Glacier and nearby ICESat track which should also serve as a tie line. The along-shore line near the grounding line is coincident with an LVIS track.

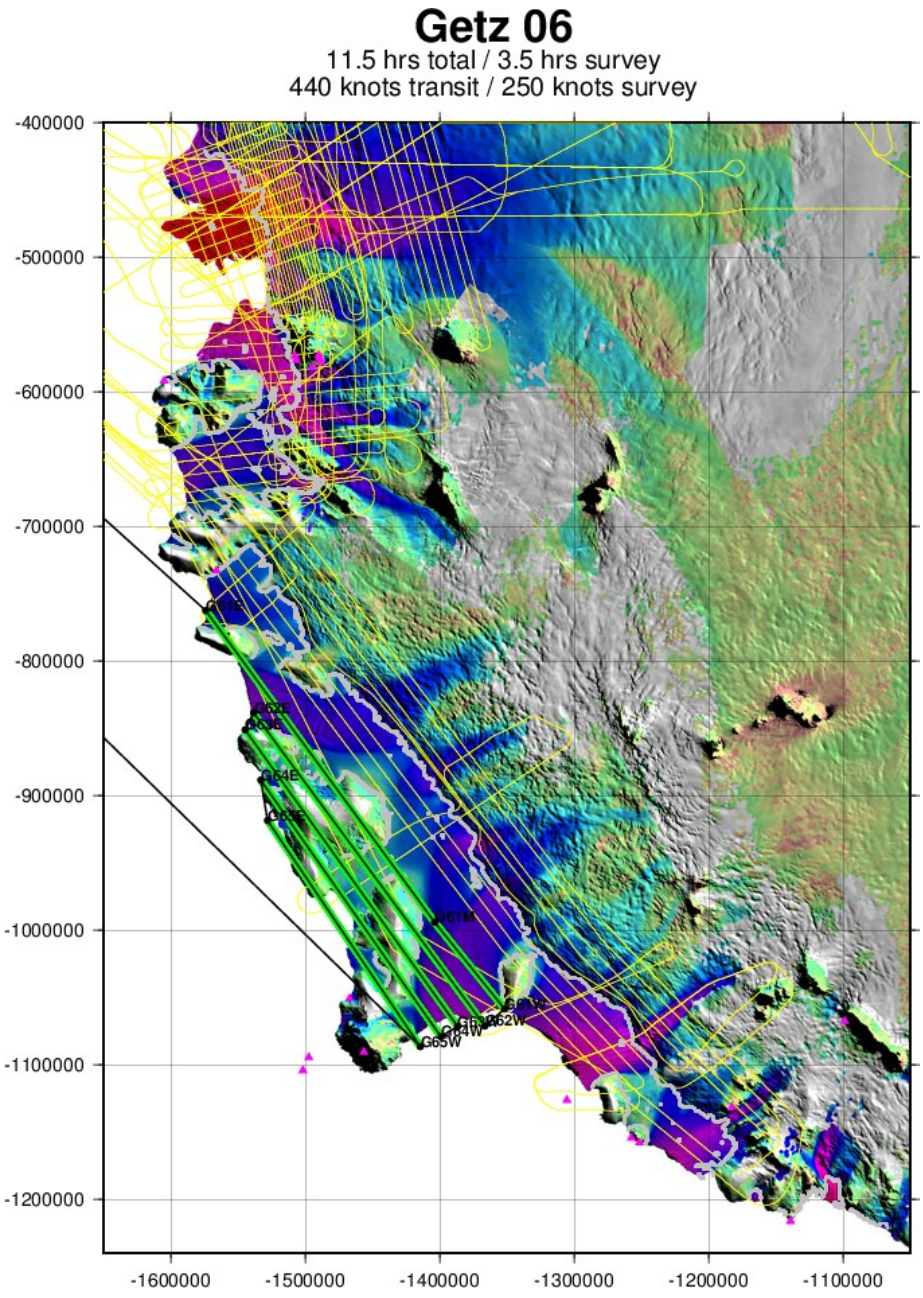
Flight Priority: medium
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 1307 (IceSat-1)
Last Flown: DeVicq Glacier in 2010
Remaining Design Issues: none



Land Ice – Getz 06

This is a new mission, one of a suite of four designed to supplement the 2009-2012 Getz Ice Shelf flights. The twofold purpose is to continue mapping the sub ice-shelf bathymetry using the gravimeter, and to continue mapping the ice surface and bedrock upstream of the grounding line. This particular flight focuses on the outboard-most portion of the ice shelf.

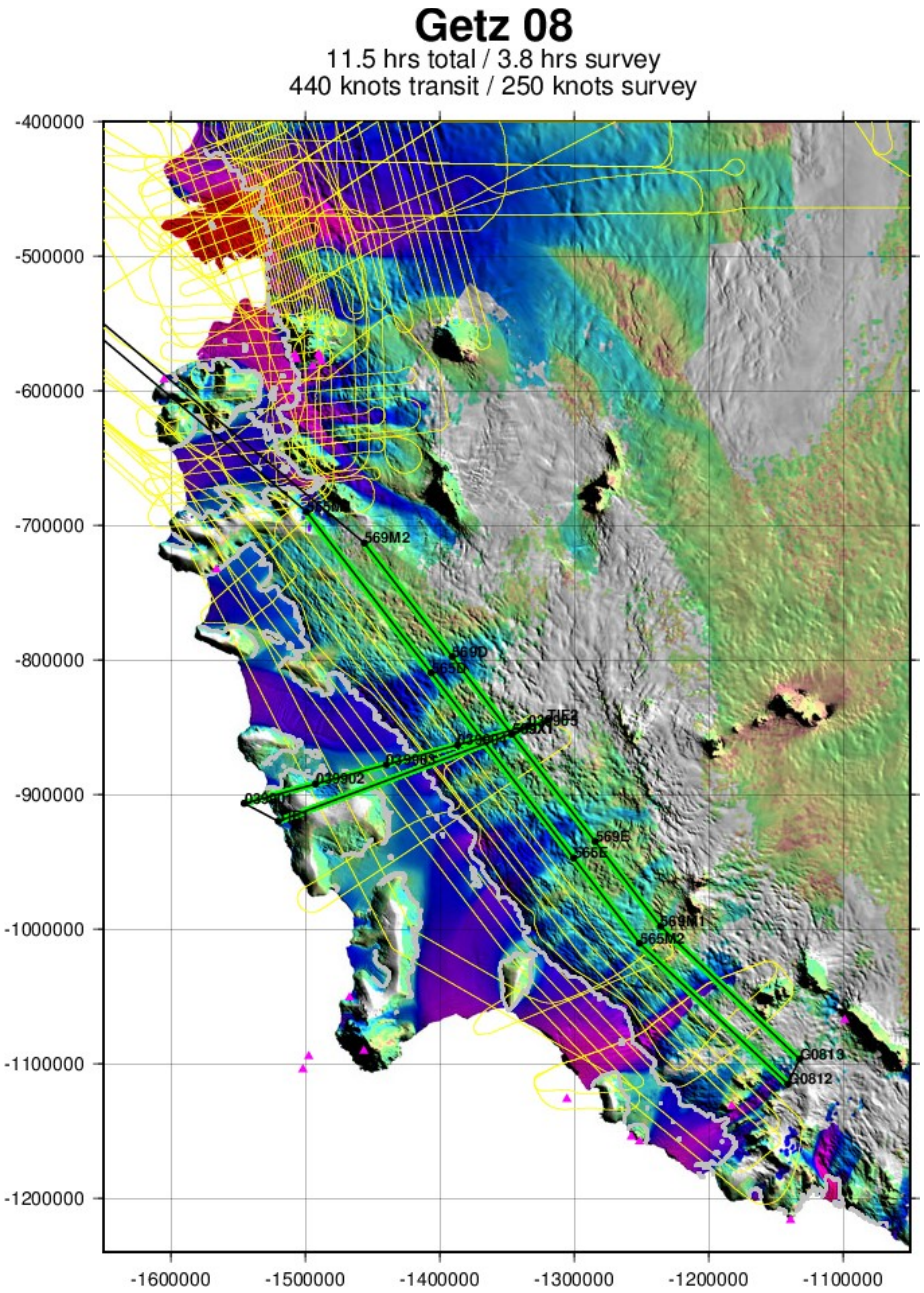
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Getz 08

This is a new mission, one of a suite of four designed to supplement the 2009-2011 Getz Ice Shelf flights. The twofold purpose is to continue mapping the sub ice-shelf bathymetry using the gravimeter, and to continue mapping the ice surface and bedrock upstream of the grounding line. This particular flight focuses on the upper-most portion of the region, and it includes a pair of tie lines, one of which follows an ICESat track and the other of which is centered on a nearby ice stream. The main along-shore lines are coincident with LVIS lines.

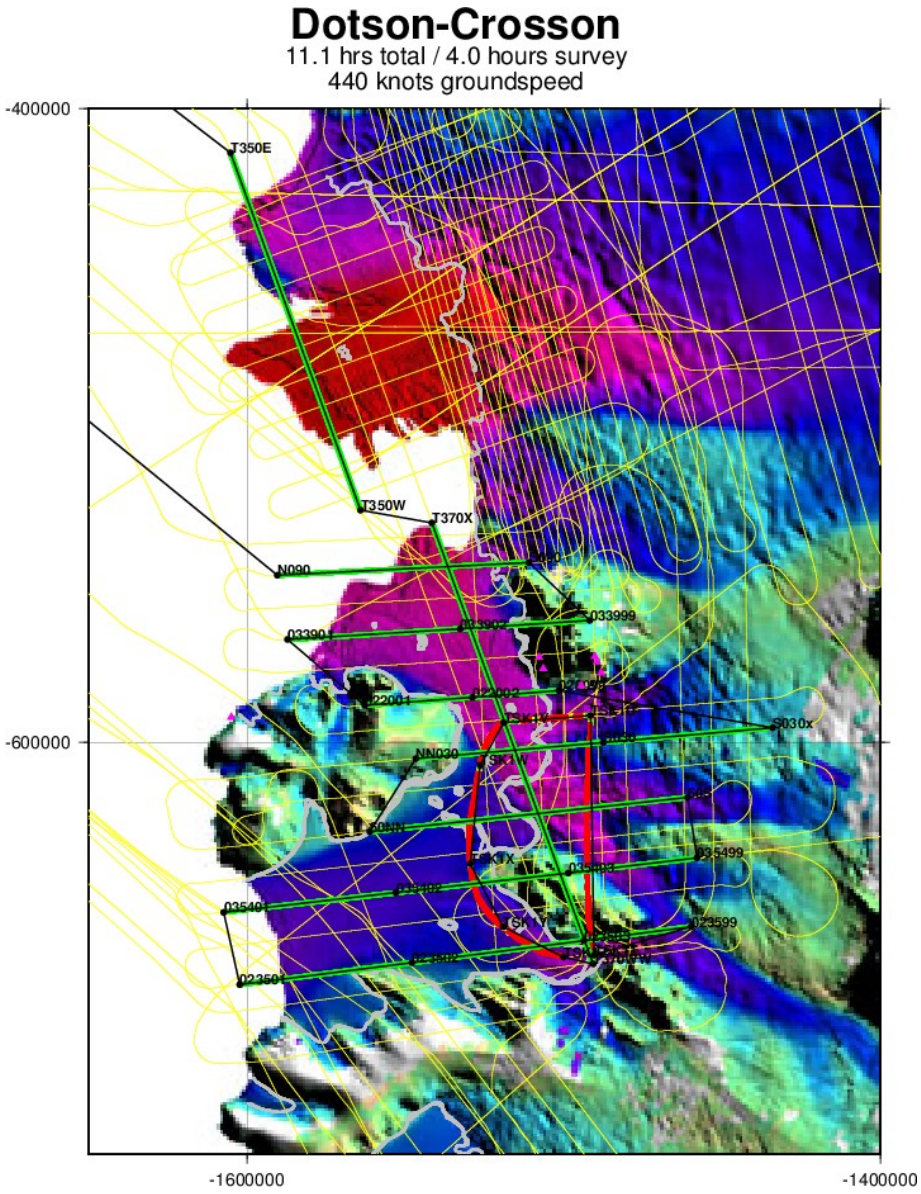
Flight Priority: medium
Science Requirements Addressed: IS1,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0399 (IceSat-1)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Dotson-Crosson

This is a new mission, designed to collect surface dh/dt measurements over the Dotson and Crosson Ice Shelves and over the lower Smith, Kohler and Pope Glaciers. All lines were previously flown by OIB, and the two primarily cross-flow lines in the western part of the survey were first flown by ATM and CreSIS during the NASA-Chilean 2002 project. The easternmost line over the Thwaites Glacier tongue is selected to overfly a small ice rise on the eastern portion of the tongue.

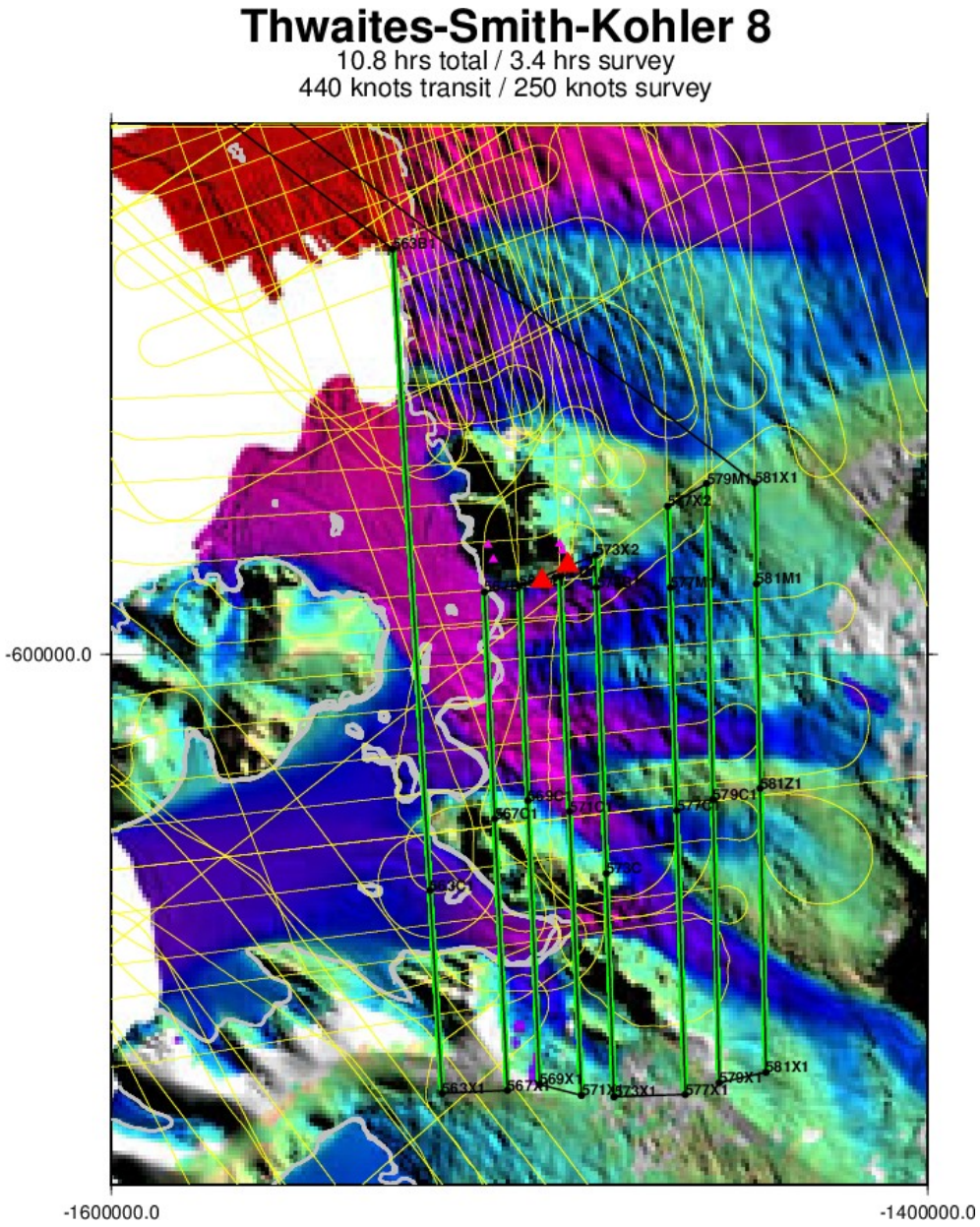
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0235,0354,0220,0339 (IceSat-1)
Last Flown: portions in 2009, 2010 and 2011
Remaining Design Issues: none



Land Ice – Thwaites-Smith-Kohler 8

This is a new mission, based on the western portion of the 2012 PTSK High-Altitude mission. It is designed to collect dh/dt measurements over the Smith, Kohler and Pope Glacier catchments. The 2012 lines were truncated in the east (mostly the portions over Mount Murphy) and extended to the west to capture the entire Kohler trunk.

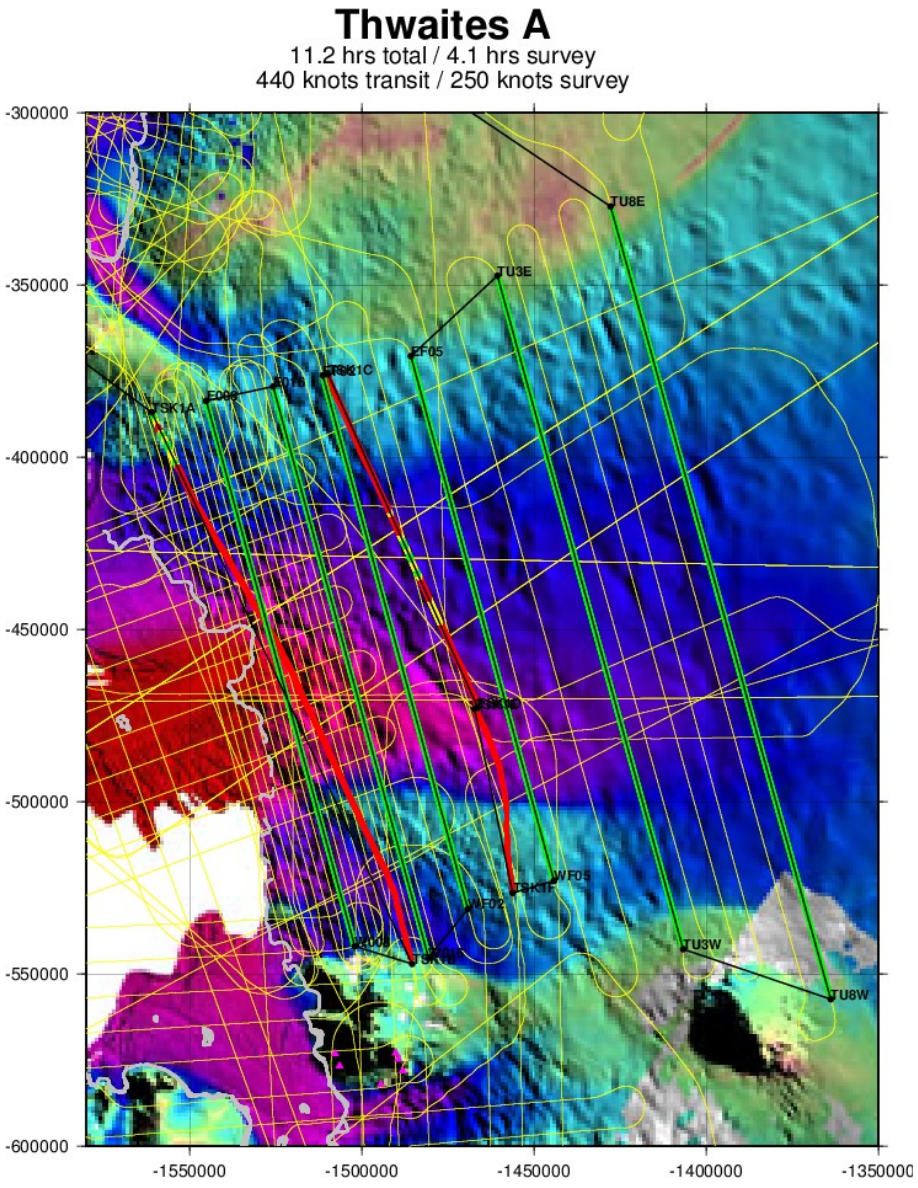
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: portions in 2012
Remaining Design Issues: none



Land Ice – Thwaites A

This is a new mission, designed to collect dh/dt measurements over lower Thwaites Glacier. It re-occupies six flight lines first flown in 2011 and 2012 as part of an extensive grid, as well as two crossing lines last flown in 2009, and first flown in 2002 by ATM and CreSIS as part of the NASA-Chilean project.

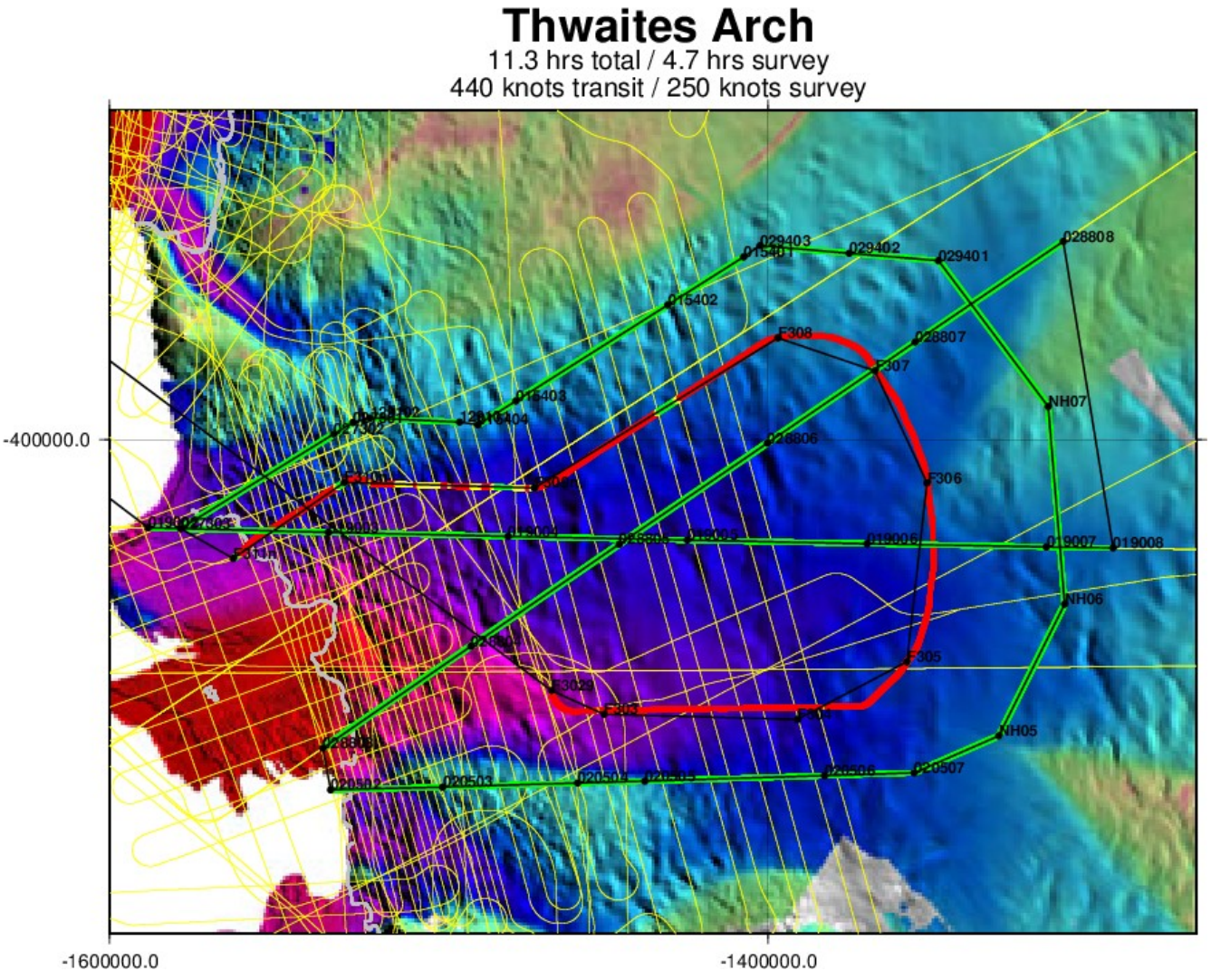
Flight Priority: BASELINE (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: portions in 2009, 2011 and 2012
Remaining Design Issues: none



Land Ice – Thwaites Arch

This is a new mission, designed to collect dh/dt measurements over Thwaites Glacier and its lower tributary channels. It re-occupies two IceSat-1 lines last flown in 2011, the inner "arch" last flown in 2009 and first flown in 2002 by the NASA-Chilean joint project, and an outer "arch" planned for 2010 but not yet flown.

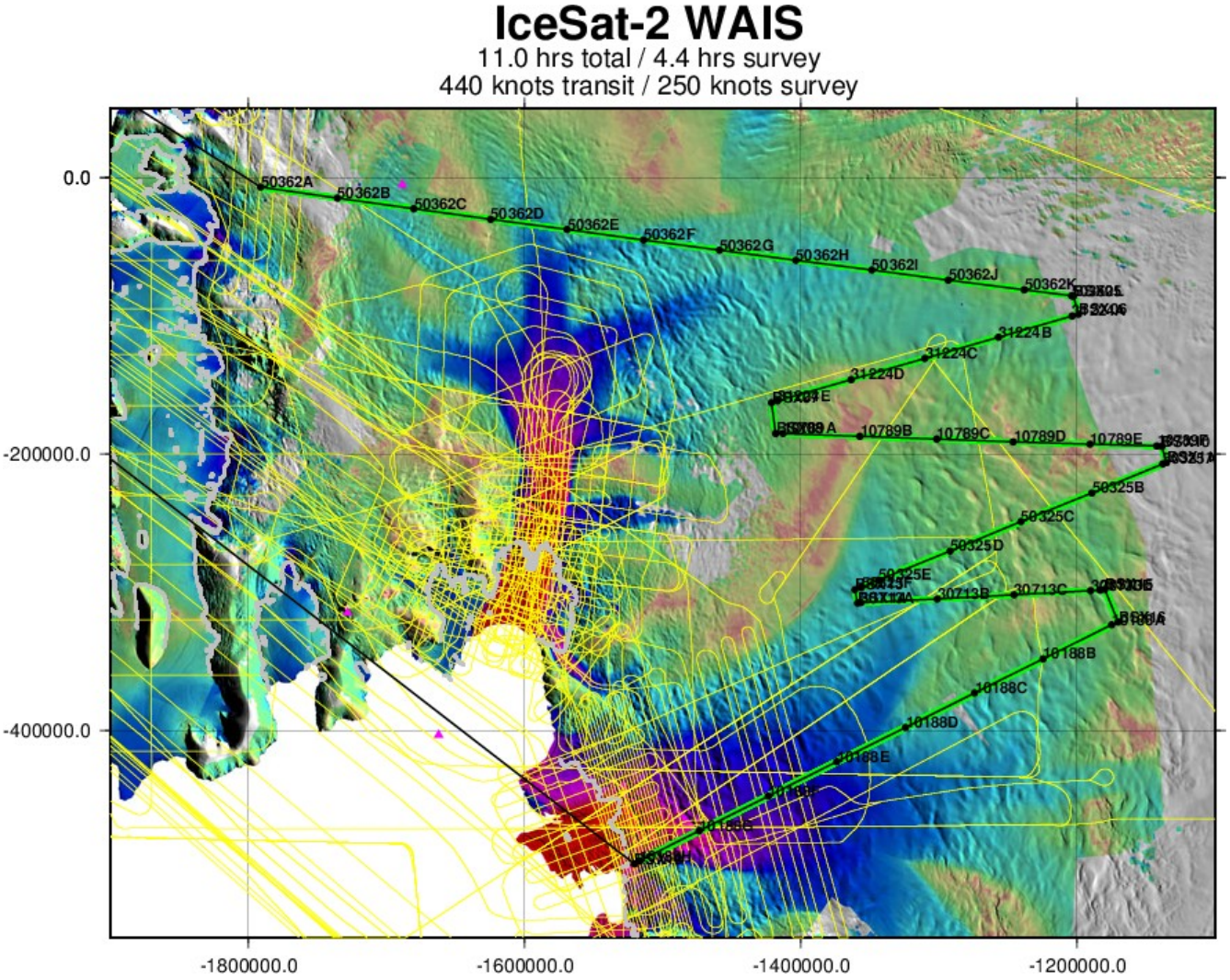
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS15
Spacecraft Tracks: 0190,0288,0205,0294,0154,1291,0273 (IceSat-1)
Last Flown: portions in 2009 and 2011
Remaining Design Issues: none



Land Ice – IceSat-2 WAIS

This is a new mission, designed to collect baseline measurements along planned IceSat-2 ground tracks. Most of the lines are located between the Pine Island and Thwaites channels, where the ice is expected to change relatively slowly, making this a suitable area for comparisons with future IceSat-2 measurements. This is also an area with relatively few dh/dt measurements collected to date, making it desirable to collect measurements of background change rates outside the fast-changing outlets. We also broaden the ice types measured with overflights of IceSat-2 ground tracks over lower Thwaites and upper Pine Island channels. We target left, center and right IS-2 beam pairs each with two ground tracks.

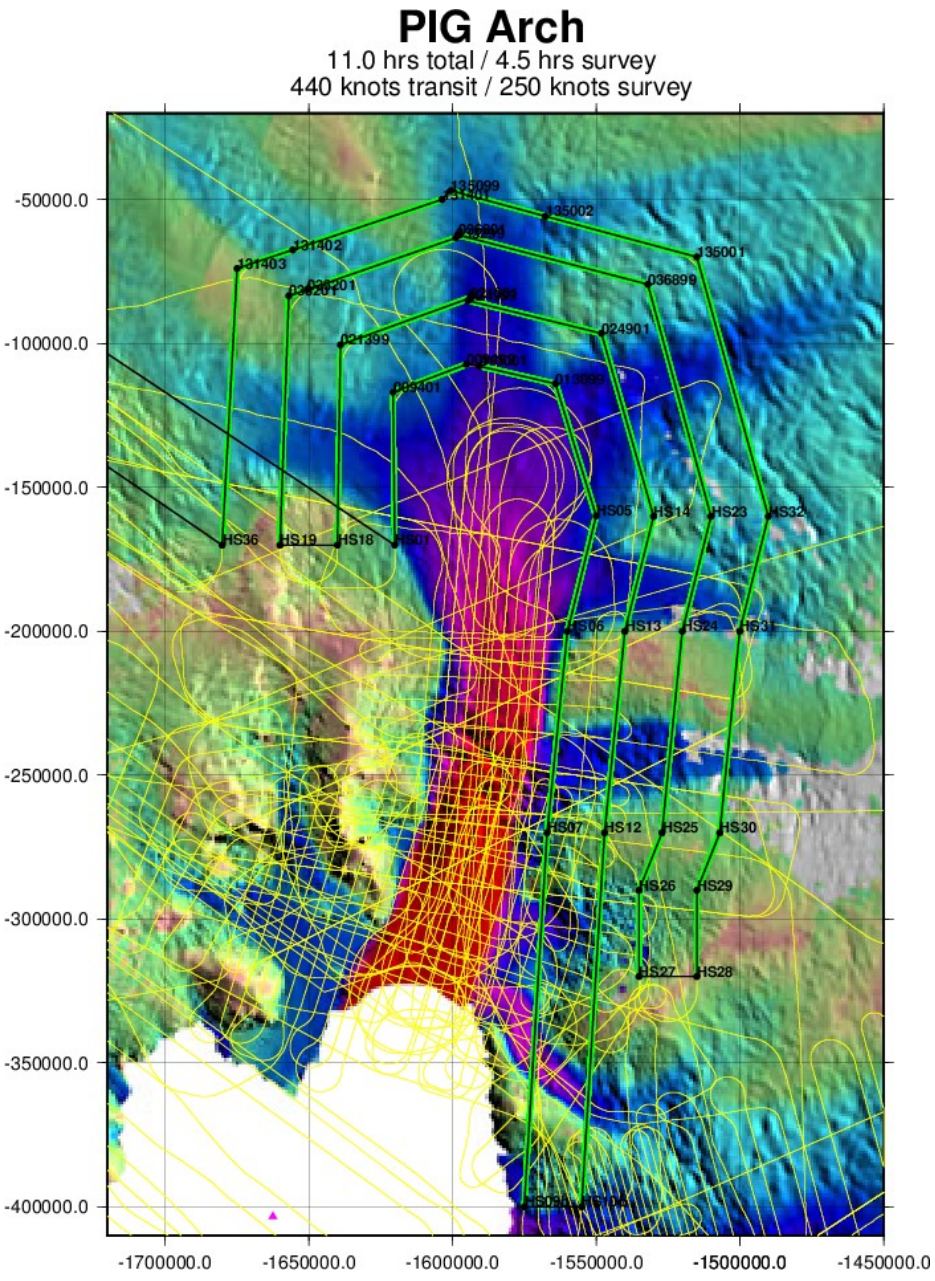
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS3,IS4,IS6,IS15
Spacecraft Tracks: 0362,1224,0789,0325,0713,0188 (IceSat-2)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – PIG Arch

This mission is a repeat of a 2010 flight. It is primarily intended to provide measurements of ice surface elevation change beyond those provided by other Pine Island Glacier IceBridge flights. We accomplish this by sampling the numerous tributaries feeding into the main Pine Island Glacier trunk.

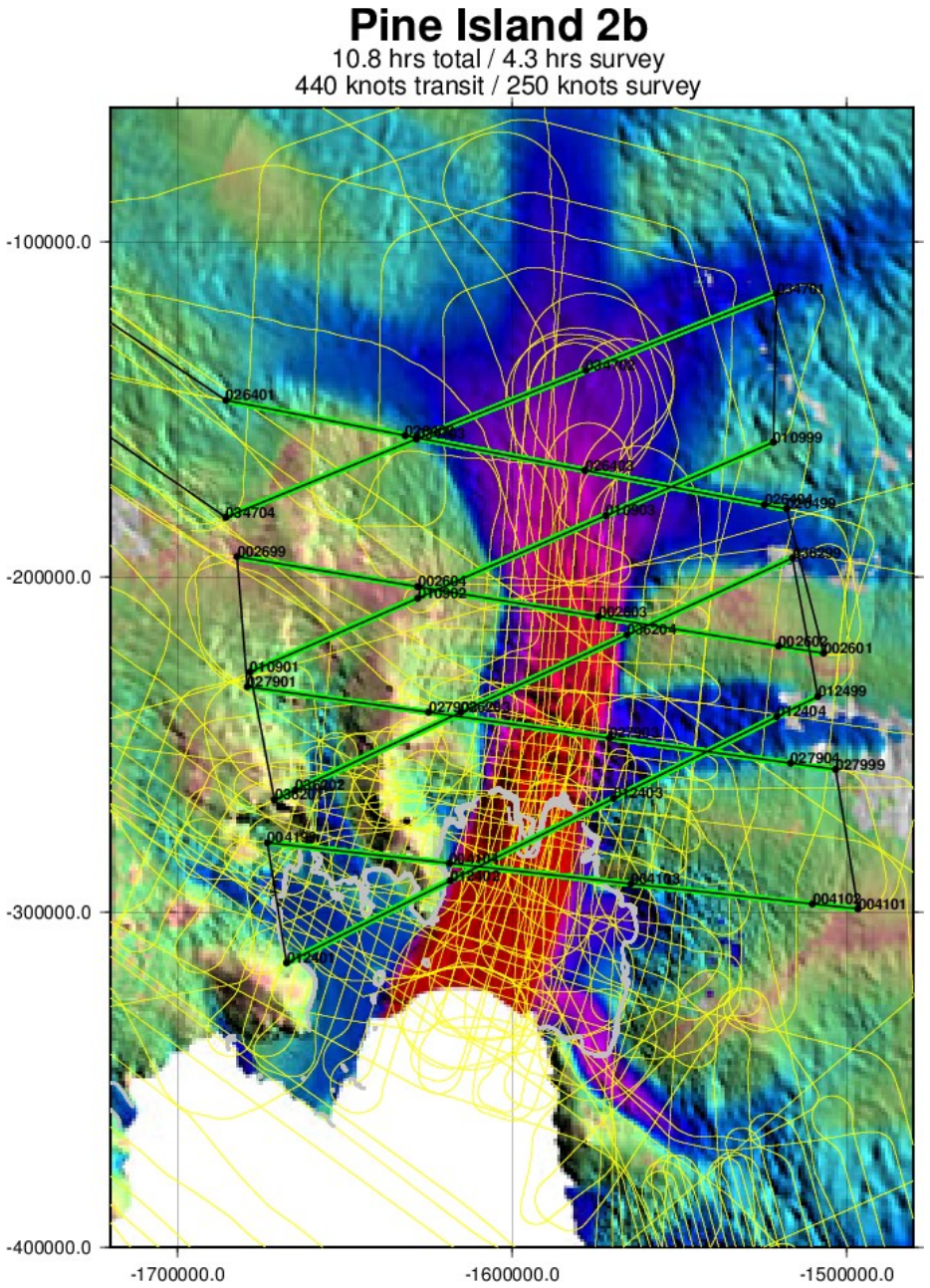
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS15
Spacecraft Tracks: 0094,0130,0249,0213,0332,0368,1350,1314 (IceSat-1)
Last Flown: 2010
Remaining Design Issues: none



Land Ice – Pine Island 2b

This flight is a near repeat of the 27 October 2009 IceBridge flight. It is intended to track ongoing changes in the Pine Island Glacier trunk, by comparison along ICESat ground tracks. This version differs slightly from the 2009 flight, in that three lines on the floating shelf of the glacier, intended to target the gravimeter to the findings of the BAS auto-sub, have been removed and replaced with two additional ascending ICESat lines on the upper trunk of the glacier. The original purpose of the "autosub" lines was superseded when we flew a 5 km grid over the shelf in 2009.

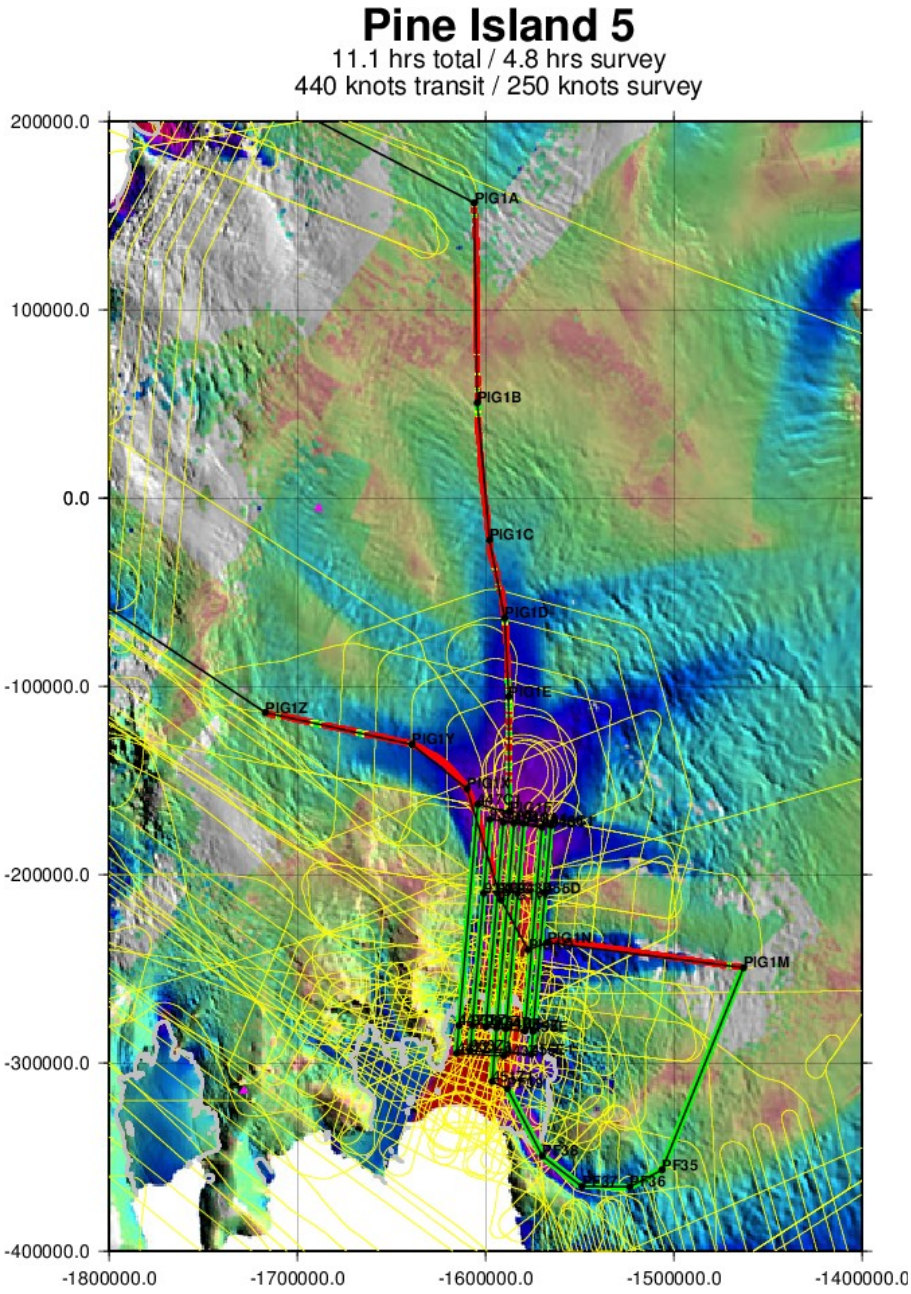
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0264,0026,0279,0041,0124,0362,0109,0347 (IceSat-1)
Last Flown: 2011
Remaining Design Issues: none



Land Ice – Pine Island 5

This flight is primarily derived from the eastern portion of the 2012 PTSK High-Altitude flight, whose lines were themselves derived from 2009 LVIS lines over the main Pine Island Glacier trunk. The mission is designed to collect dh/dt measurements over this area. We supplement these lines with segments from the 2002-2009 NASA-Chilean and OIB lines over several of the tributary channels feeding the main channel.

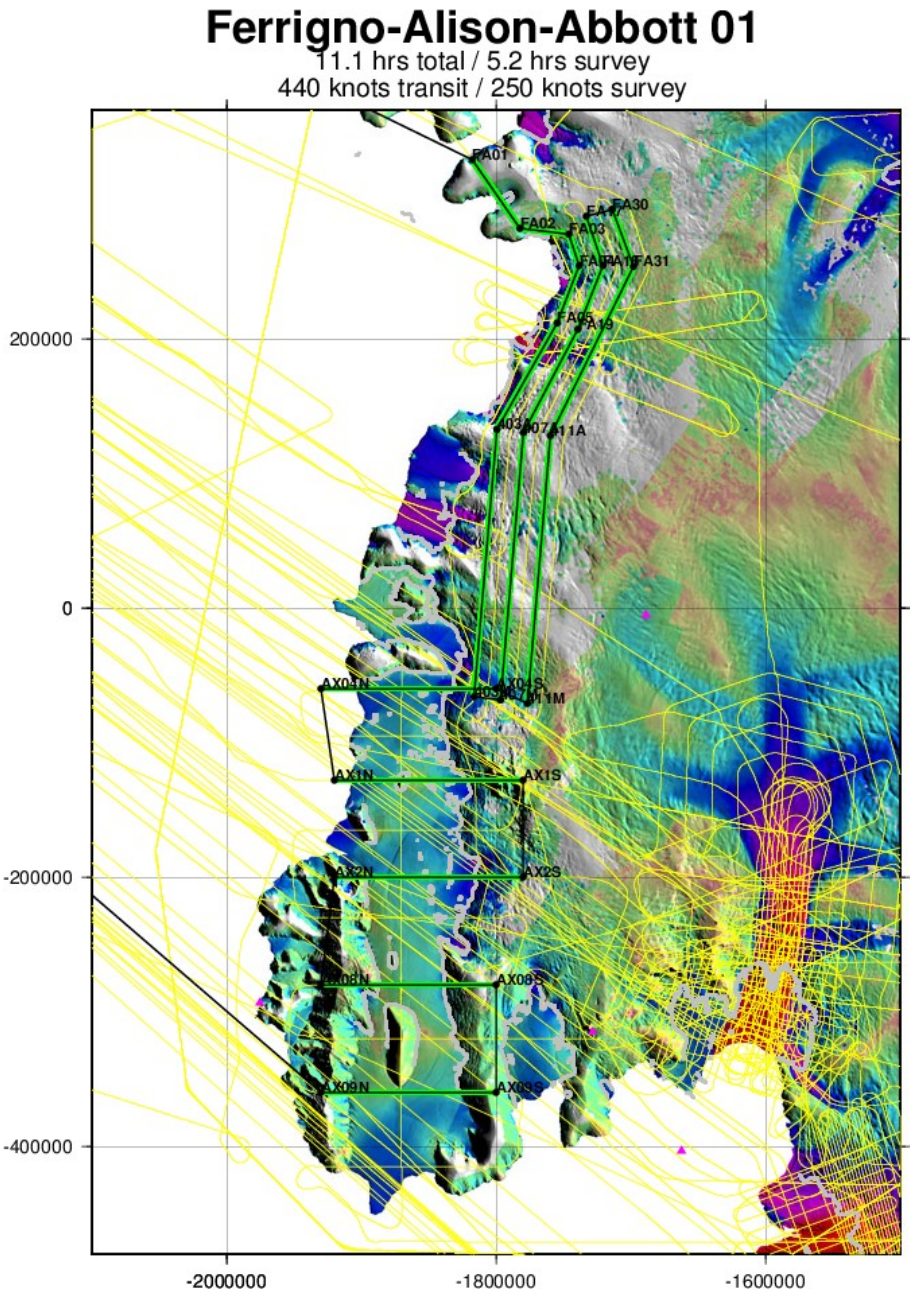
Flight Priority: BASELINE (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: some in 2009, most in 2012
Remaining Design Issues: none



Land Ice – Ferrigno-Alison-Abbott 01

This is a new flight, designed to collect dh/dt measurements on established OIB flight lines along the coast near the Ferrigno and Alison ice streams, and on the Abbott Ice Shelf and adjacent grounded ice along the Eights Coast.

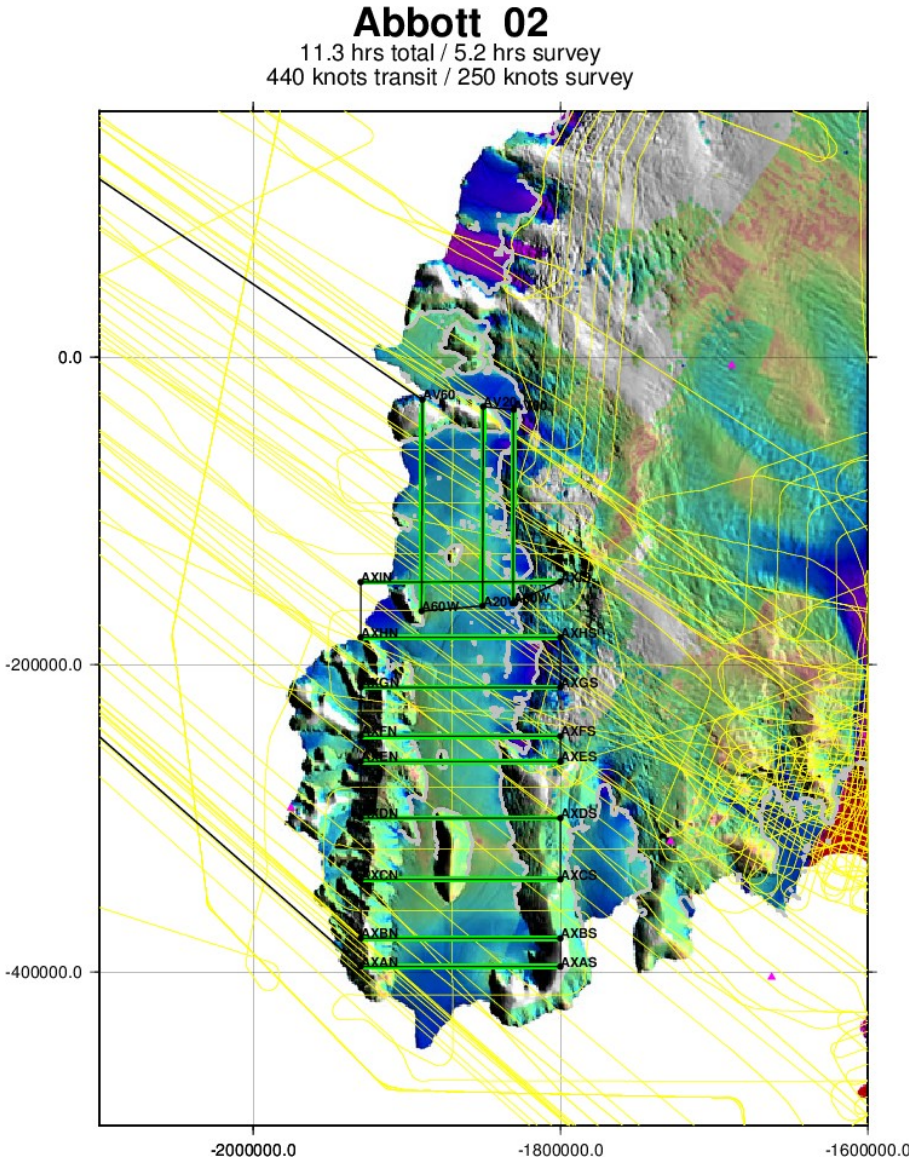
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: Ferrigno-Alison lines in 2012, Abbott lines in 2009
Remaining Design Issues: none



Land Ice – Abbott 02

This is a new flight, designed to improve the density of the 2009 survey lines over the Abbott Ice Shelf. For the western two-thirds of the ice shelf, we interlace the 2009 north-south lines with parallel lines, since the 2009 survey showed that the most significant bathymetric features in this area are oriented in an east-west direction, across the axis of the flight lines. The easternmost third of the ice shelf lies in a different tectonic setting where the most important bathymetric features may be oriented in a north-south direction, so there we orient the flight lines east-west.

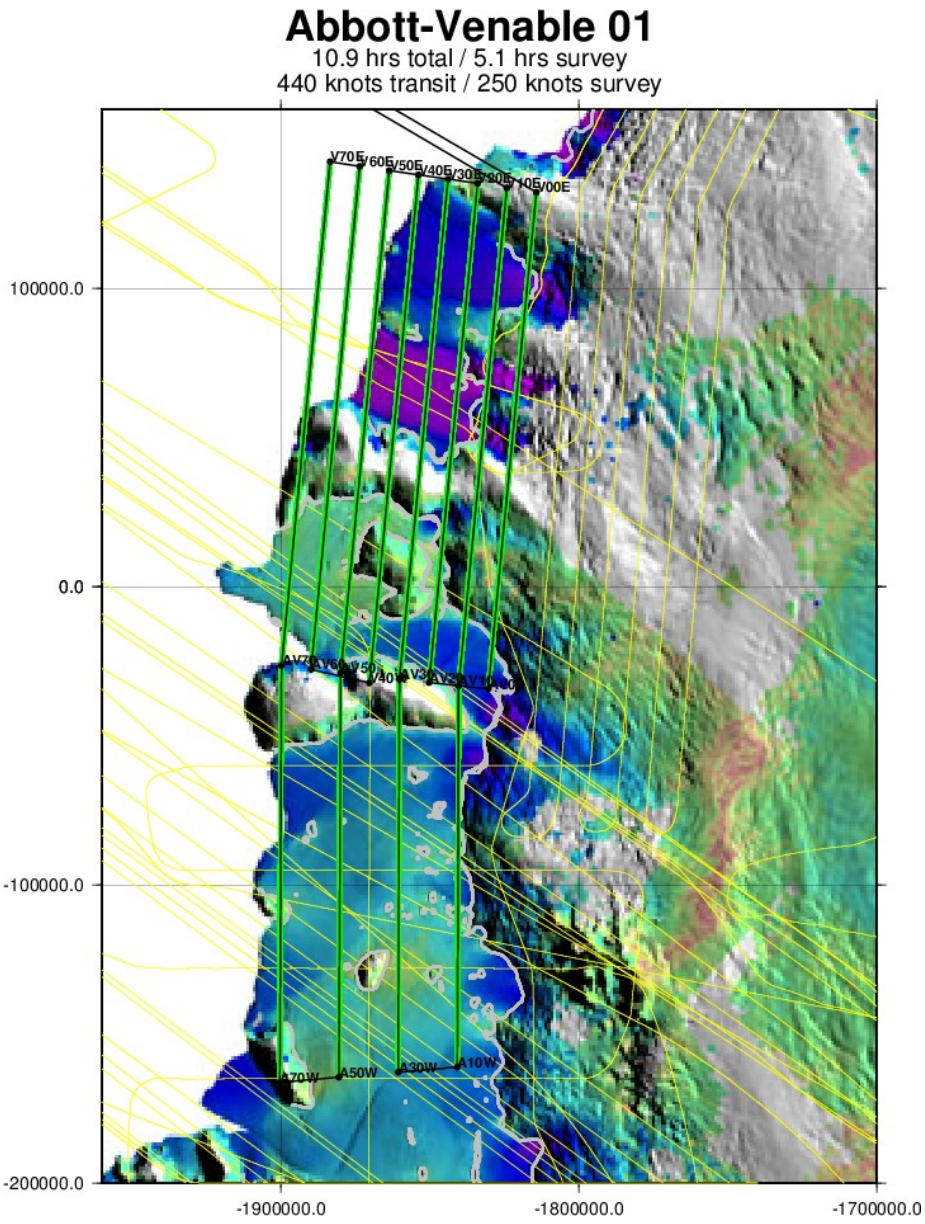
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Abbott-Venable 01

This is a new flight, primarily designed to map the bathymetry beneath the Venable Ice Shelf along a 10 km coast-parallel grid. We also improve the density of the coast-parallel coverage of the eastern portion of the Abbott Ice Shelf, achieved with the Abbott 02 mission, from 20 km to 10 km.

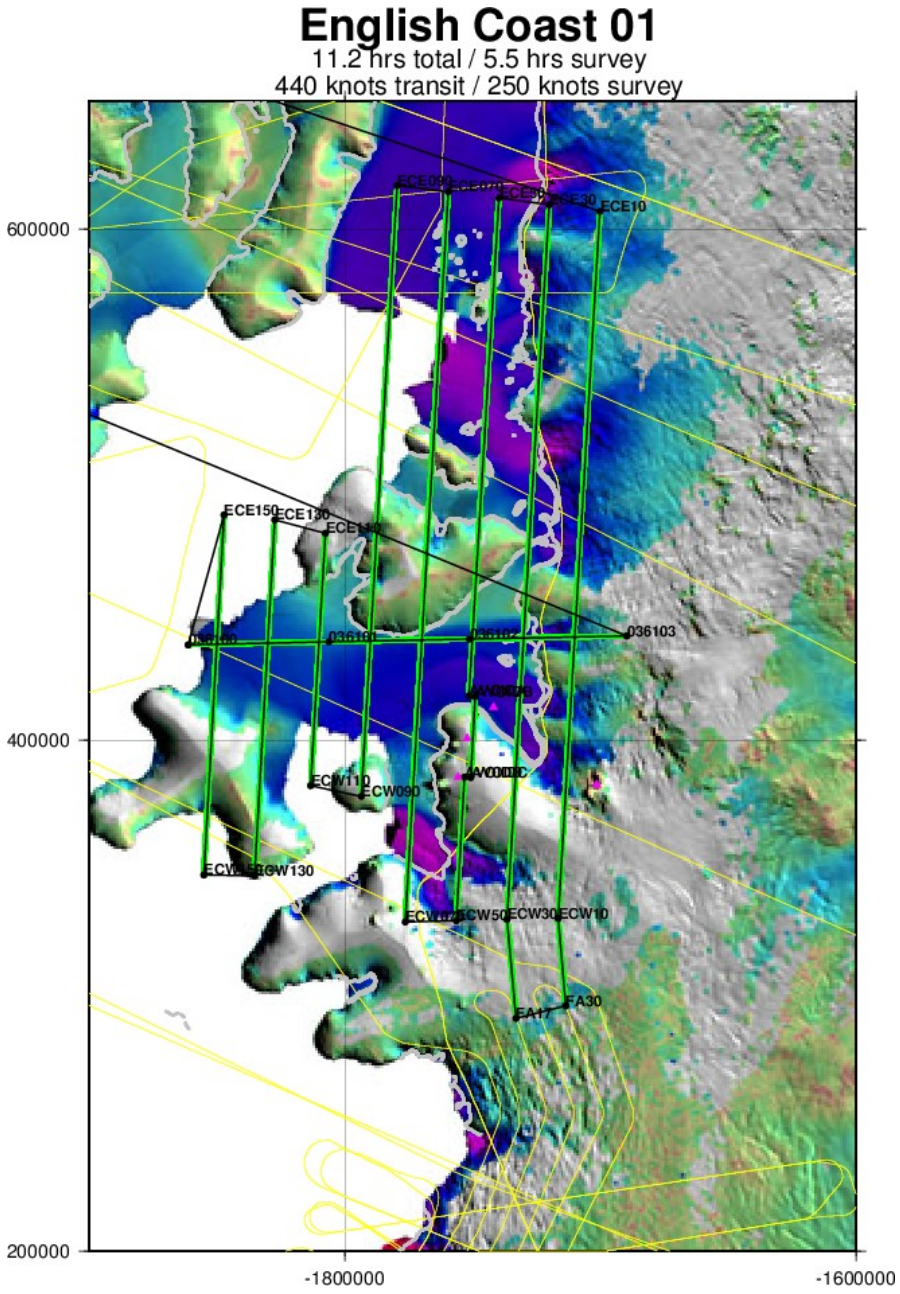
Flight Priority: medium
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – English Coast 01

This is a new flight, primarily designed to map the 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 spacing improves to 10 km with the addition of the companion English Coast 02 mission. This grid connects with the Ferrigno-Alison coast-parallel grid in the west, and overlaps with the George VI grid in the east. We also fly a tie line along IceSat-1 track 0361.

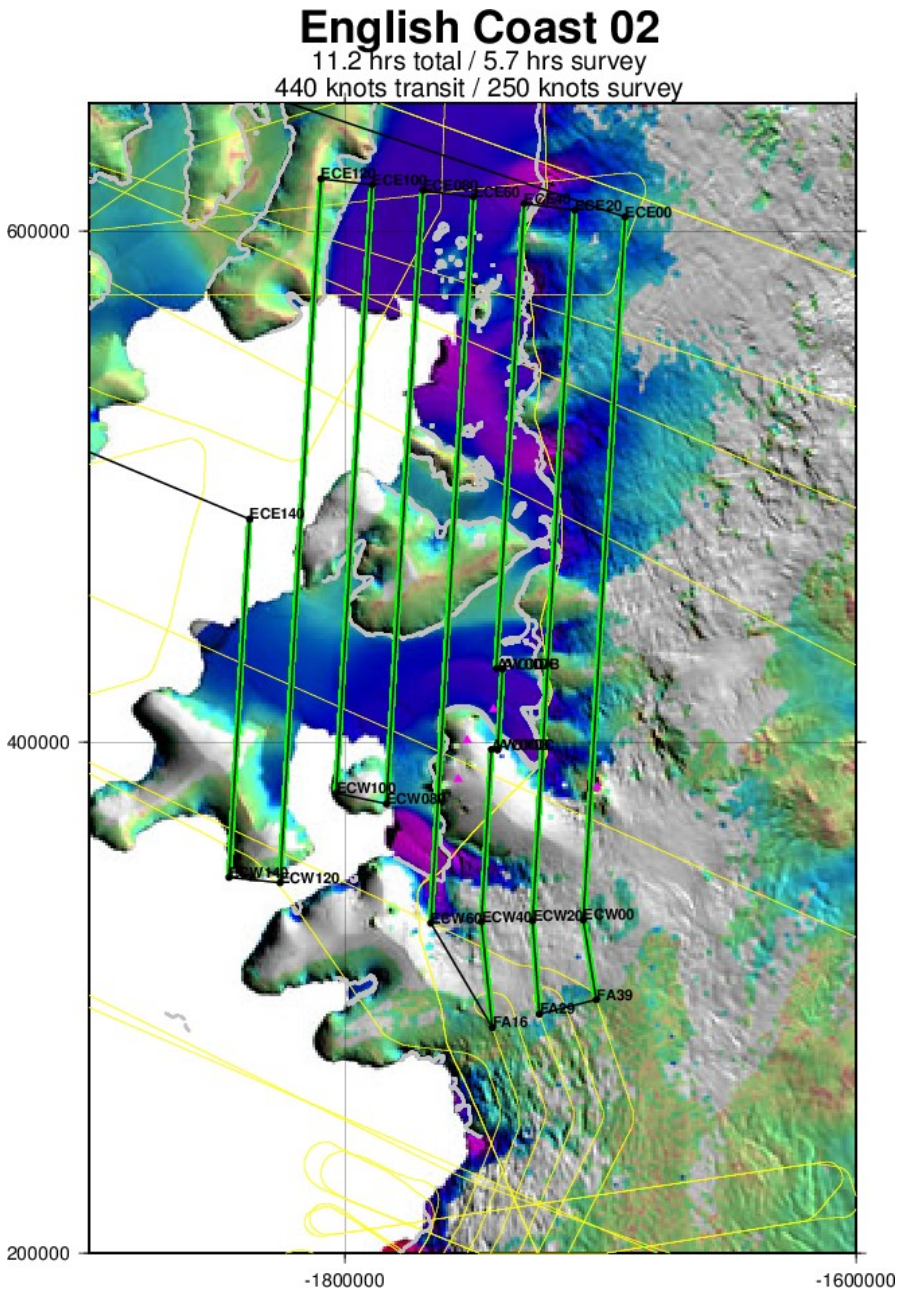
Flight Priority: medium
Science Requirements Addressed: IS1,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0361 (IceSat-1)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – English Coast 02

This is a new flight, primarily designed to map the 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 is designed to improve the 20 km grid spacing achieved with the English Coast 01 flight to a 10-km combined grid. This grid connects with the Ferrigno-Alison grid in the west, and overlaps the George VI grid in the east.

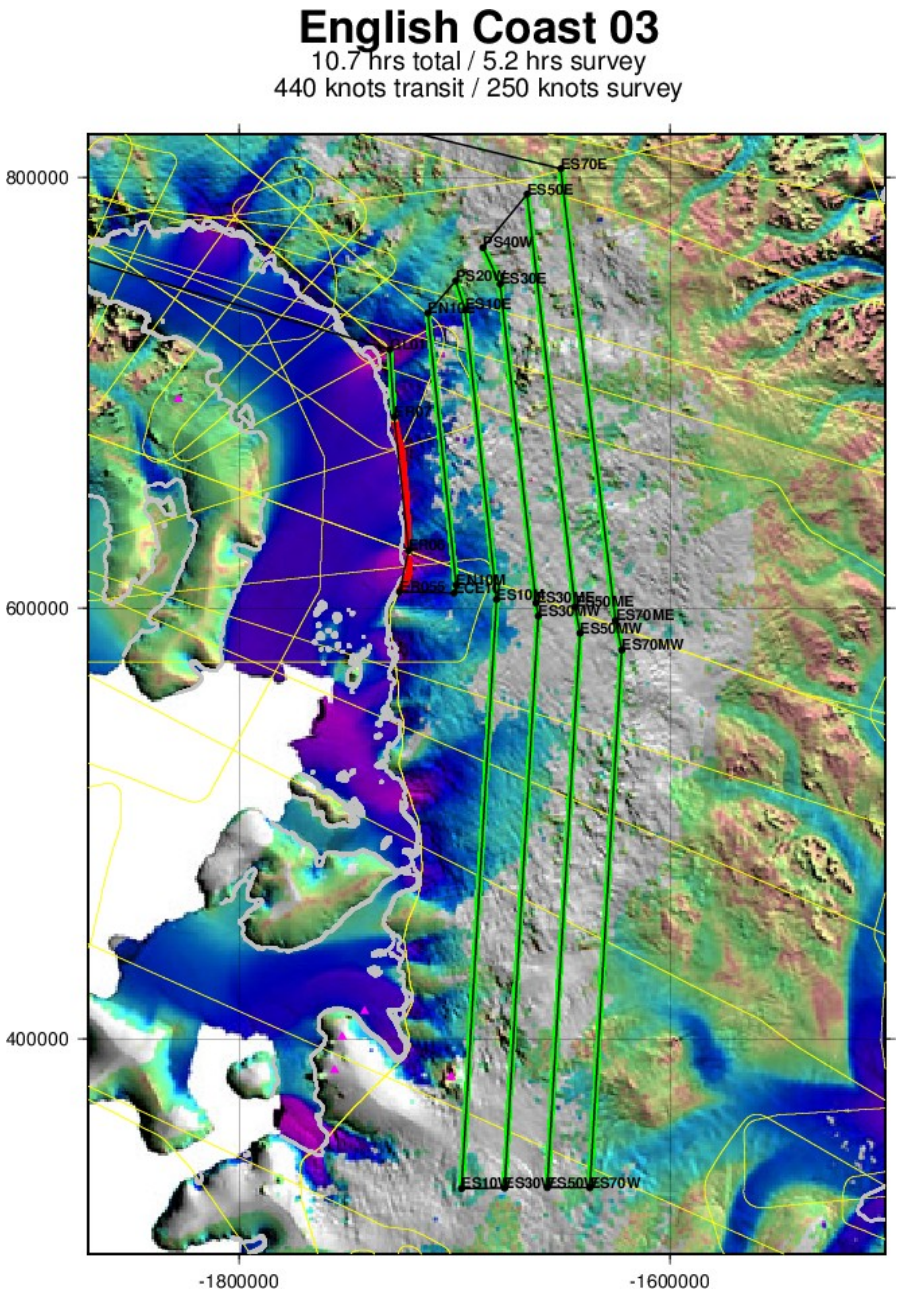
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – English Coast 03

This is a new flight, 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.

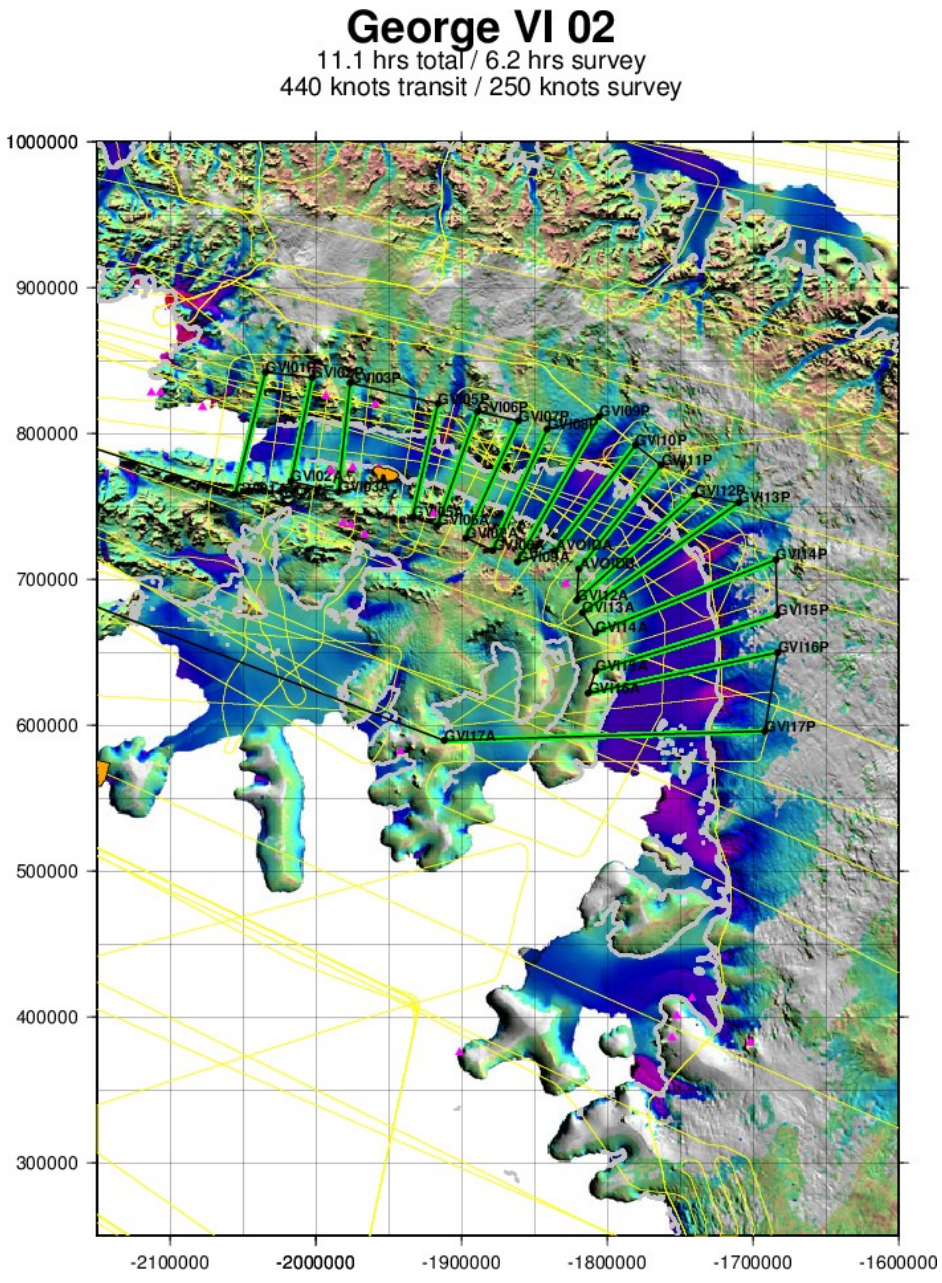
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: grounding line portion in 2011
Remaining Design Issues: none



Land Ice – George VI 02

This is a new flight, designed to improve previous OIB bathymetry measurements (primarily through gravimetry combined with depth-sounding radar) under the George VI ice shelf. It does this by interlacing the 2011 OIB grid over the ice shelf.

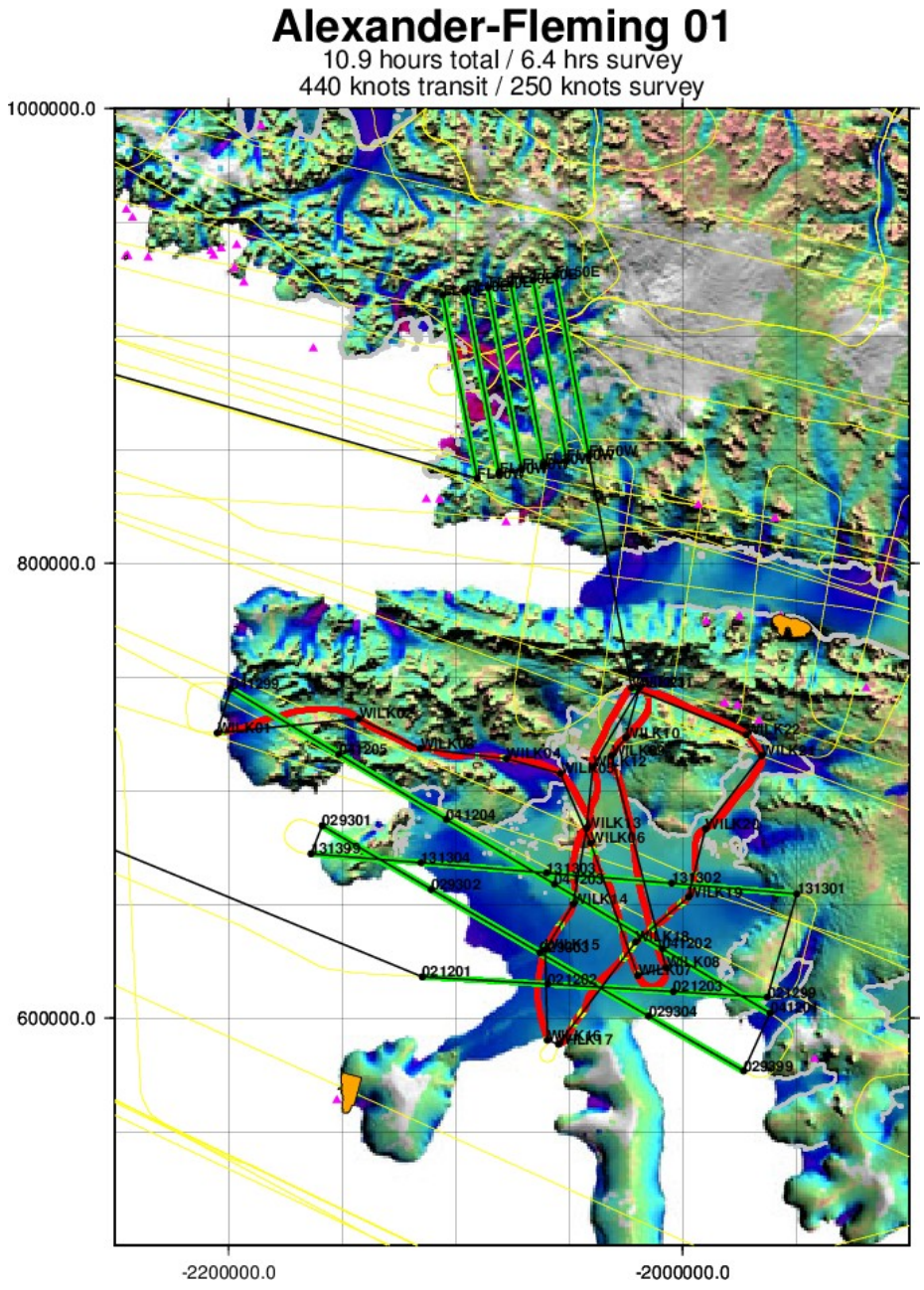
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Alexander-Fleming 01

This is primarily 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 add a six-line, 10 km grid over the Fleming Glacier and remnant Wordie Ice Shelf, also for dh/dt purposes.

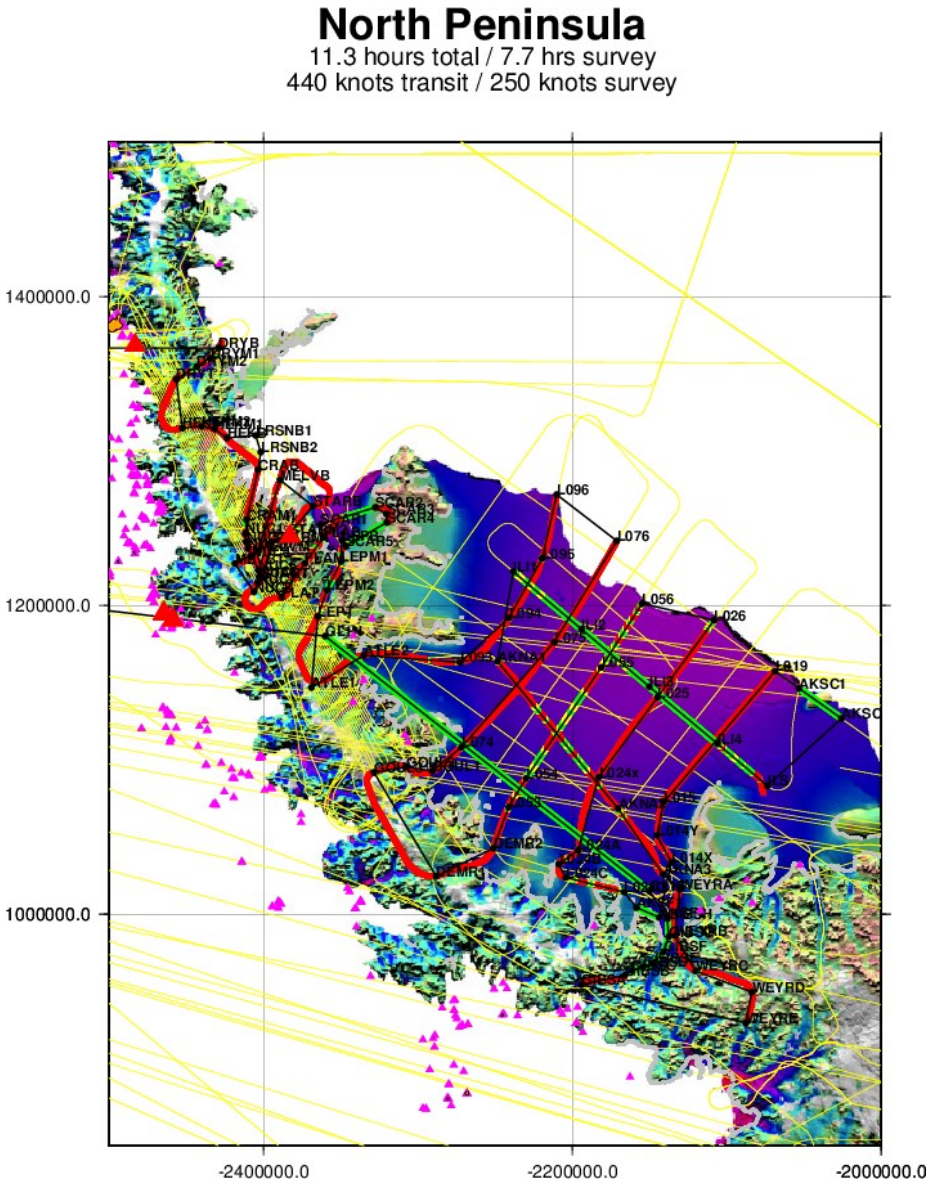
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0212,1313,0293,0412 (IceSat-1)
Last Flown: Alexander and Wilkins portion in 2011
Remaining Design Issues: none



Land Ice – North Peninsula

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, Gibbs, and Weyerhauser. In addition to these glaciers, we repeat two lines over Scar Inlet, several flowlines on the Larsen-C Ice Shelf, and 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 (in the south) and Bawden (north) Ice Rises on the eastern edge of the Larsen-C, since these may contribute to the stability of the ice shelf.

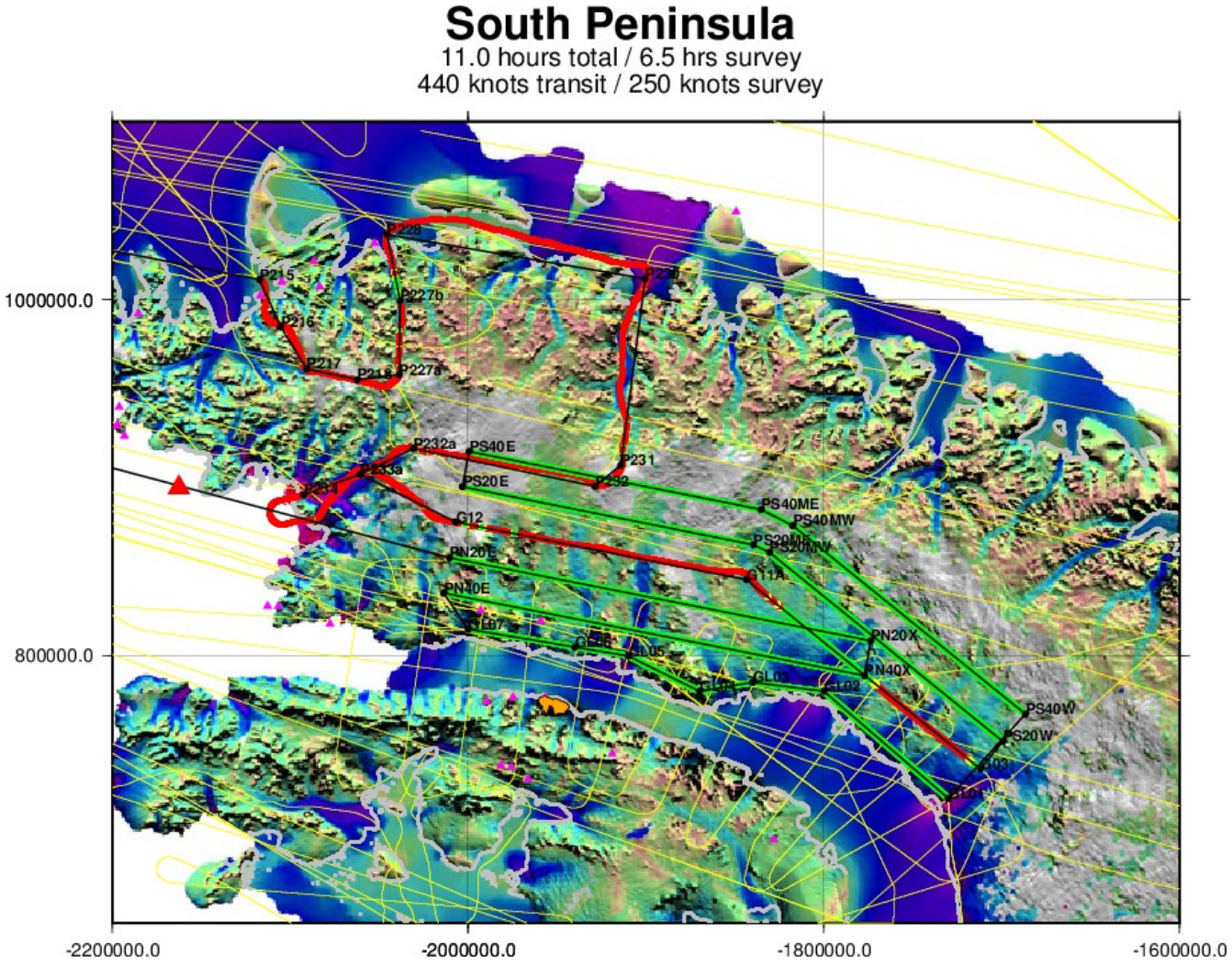
Flight Priority: BASELINE (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: portions in 2009, 2010 and 2011
Remaining Design Issues: none



Land Ice – South Peninsula

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 the grounding line along the George VI Ice Shelf, which was last flown in 2011. Finally we establish a new 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 flight.

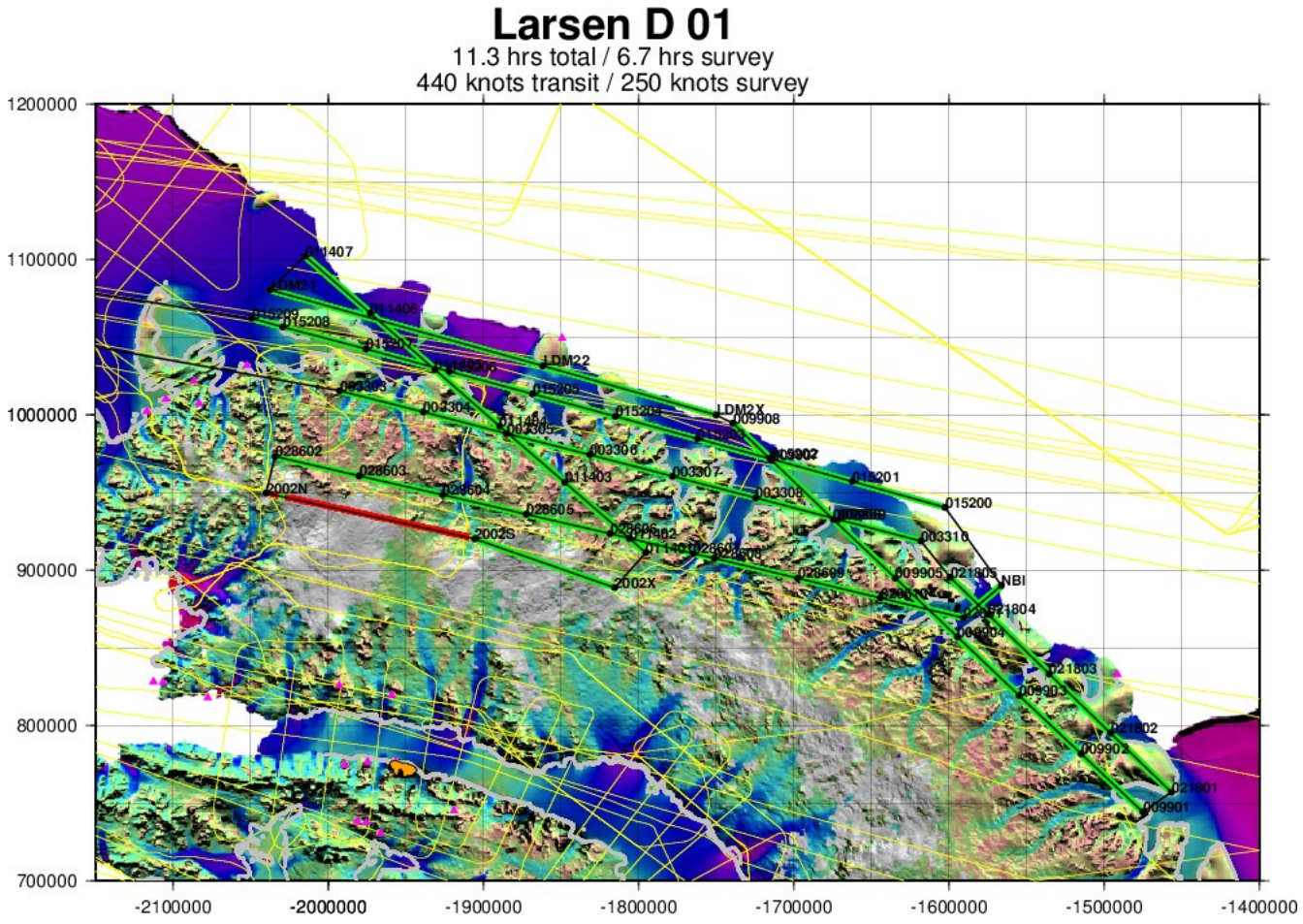
Flight Priority: BASELINE (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: portions in 2011
Remaining Design Issues: none



Land Ice – Larsen D 01

This is a new flight, 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, supplemented by a 2002 NASA-Chilean line along the Peninsula's ridgeline and a new extension to the south. This mission is a condensed version of the three missions designed for this area for the 2012 OIB campaign but never flown.

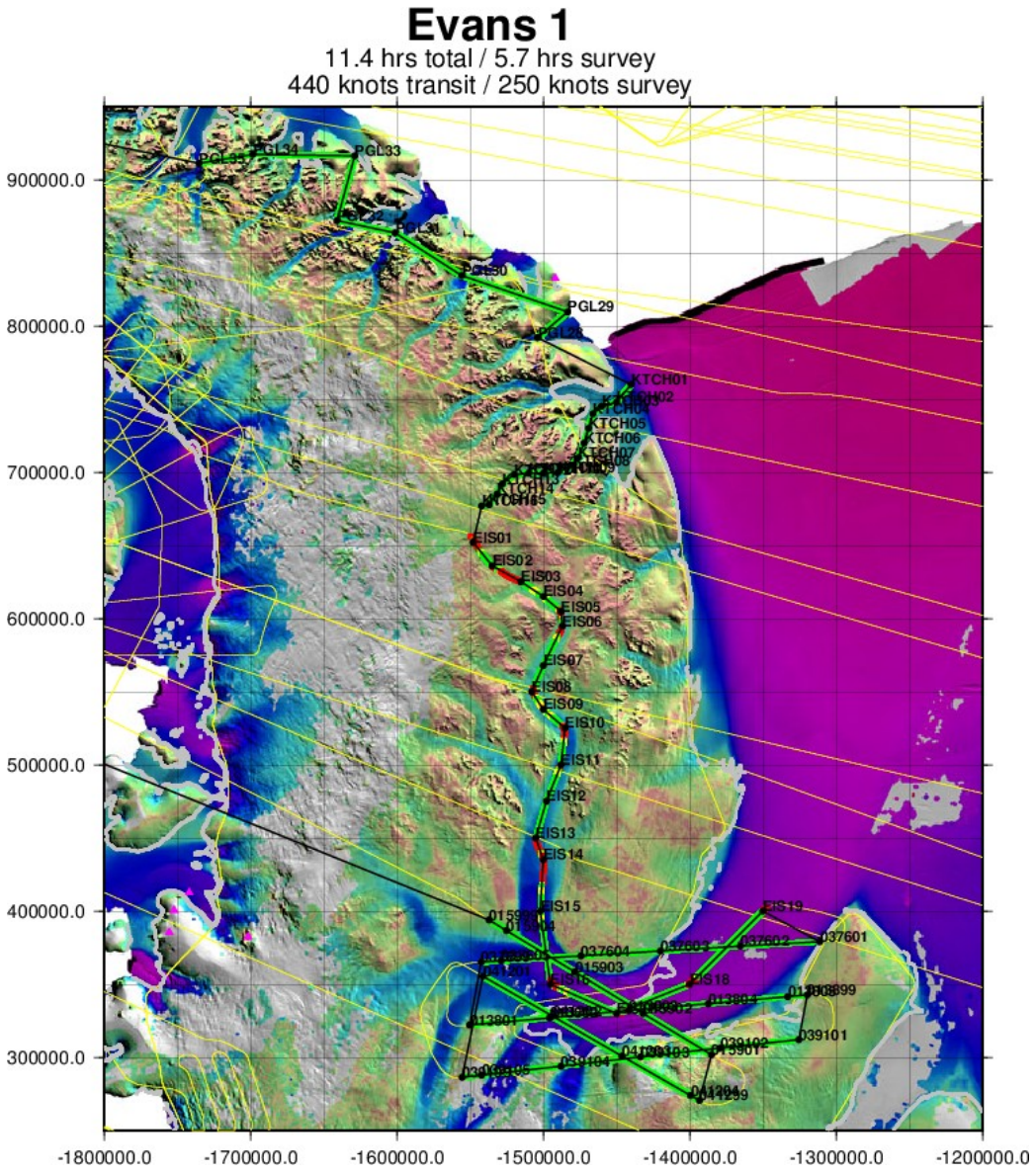
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0033,0218,0099,0114,0286,0152 (IceSat-1)
Last Flown: new flight, ridgeline in north was last flown in 2002
Remaining Design Issues: none



Land Ice – Evans 1

This flight is a near-repeat of the 15 November 2009 IceBridge flight (called “Pen 4” at that time). It is intended to track changes in the Evans Glacier area, by comparison mainly along ICESat ground tracks. In addition, we add a portion of the grounding line along the southeastern side of the Peninsula, and a centerline flight up the Ketchum Glacier. The mission is slightly long but can readily be shortened by cutting the ends of pairs of the ICESat lines if necessary in real-time.

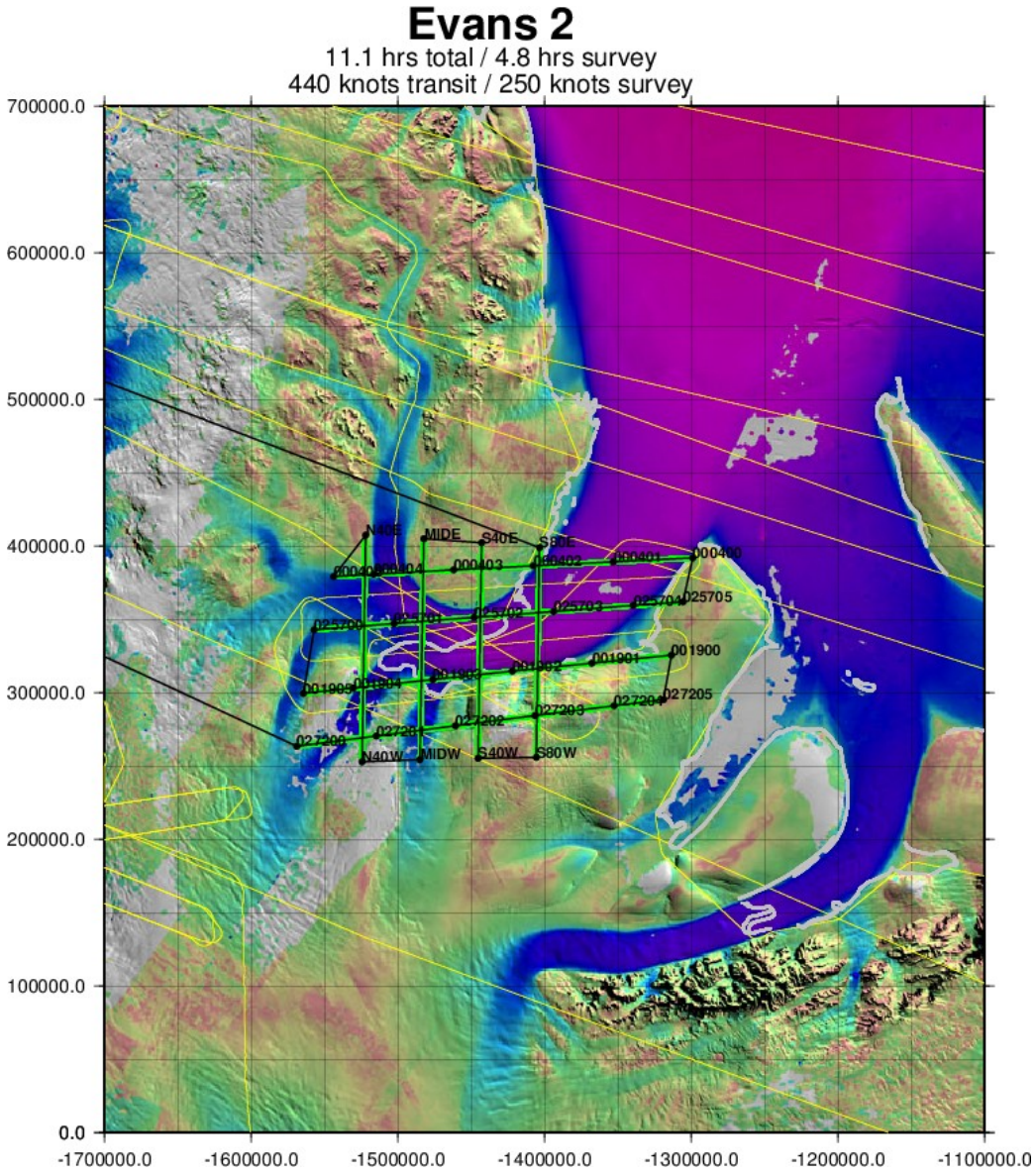
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0376,0138,0391,0412,0159 (IceSat-1)
Last Flown: 2009
Remaining Design Issues: none



Land Ice – Evans 2

This is a new flight. It is intended to supplement the radar, gravity and altimetry coverage of the lower Evans Glacier obtained with the 2009 Evans 1 OIB flight, with four additional IceSat-1 groundtrack overflights and four crossing lines at approximately right angles to the IceSat tracks.

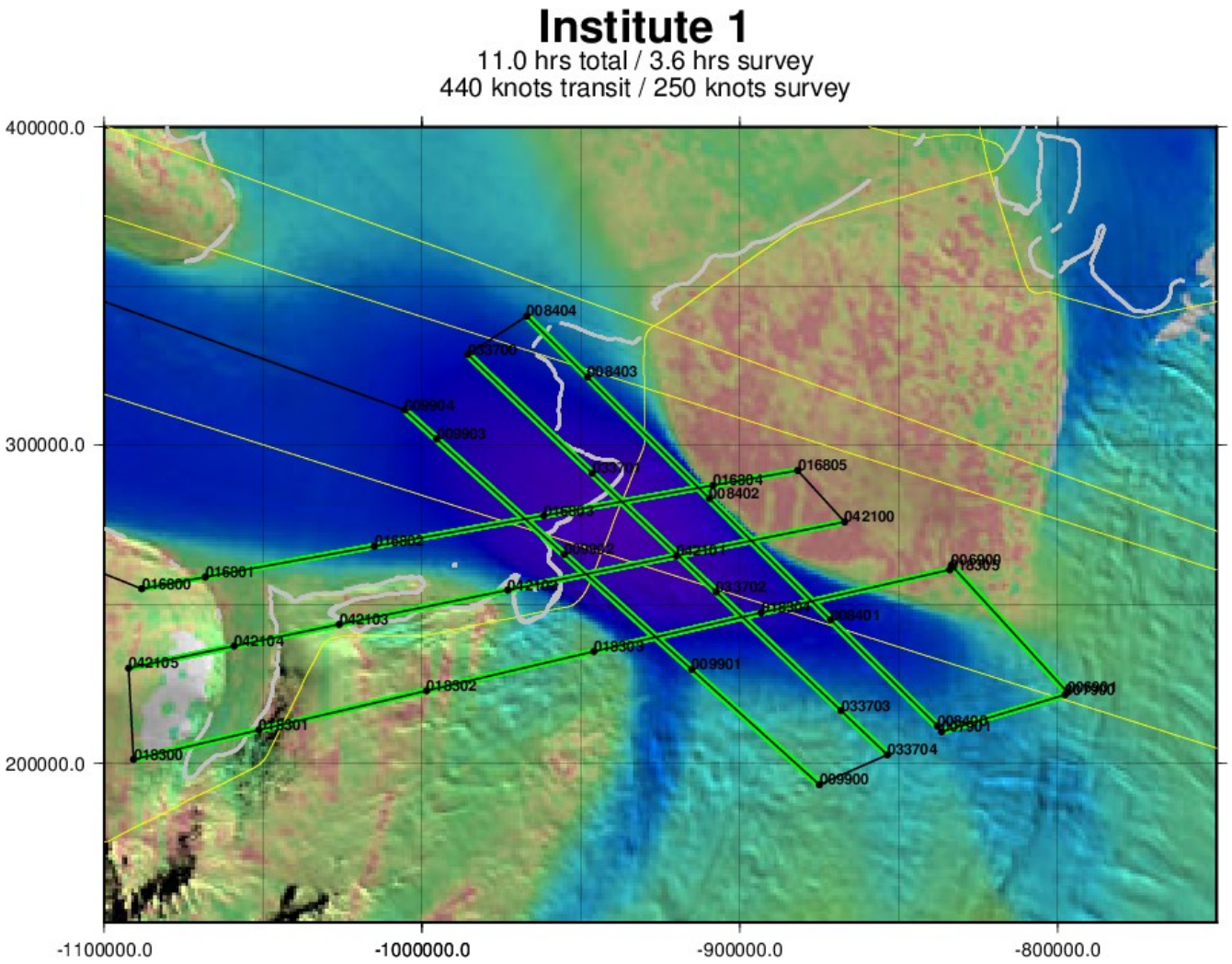
Flight Priority: high
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0272,0019,0257,0004 (IceSat-1)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Institute 1

This is a new flight. It is intended to supply altimetry, radar and gravity data over the lower Institute Ice Stream, entirely along IceSat-1 ground tracks straddling, and upstream of, the grounding line. This area has been traversed by only a single OIB line to date, an approximation of the grounding line flown in 2012. Prior geophysical work in the area included a SPRI/NSF/TU-Denmark airborne campaign in the 1970s, an AWI effort in the 1990s, and several ground traverses dating from the late 1950s.

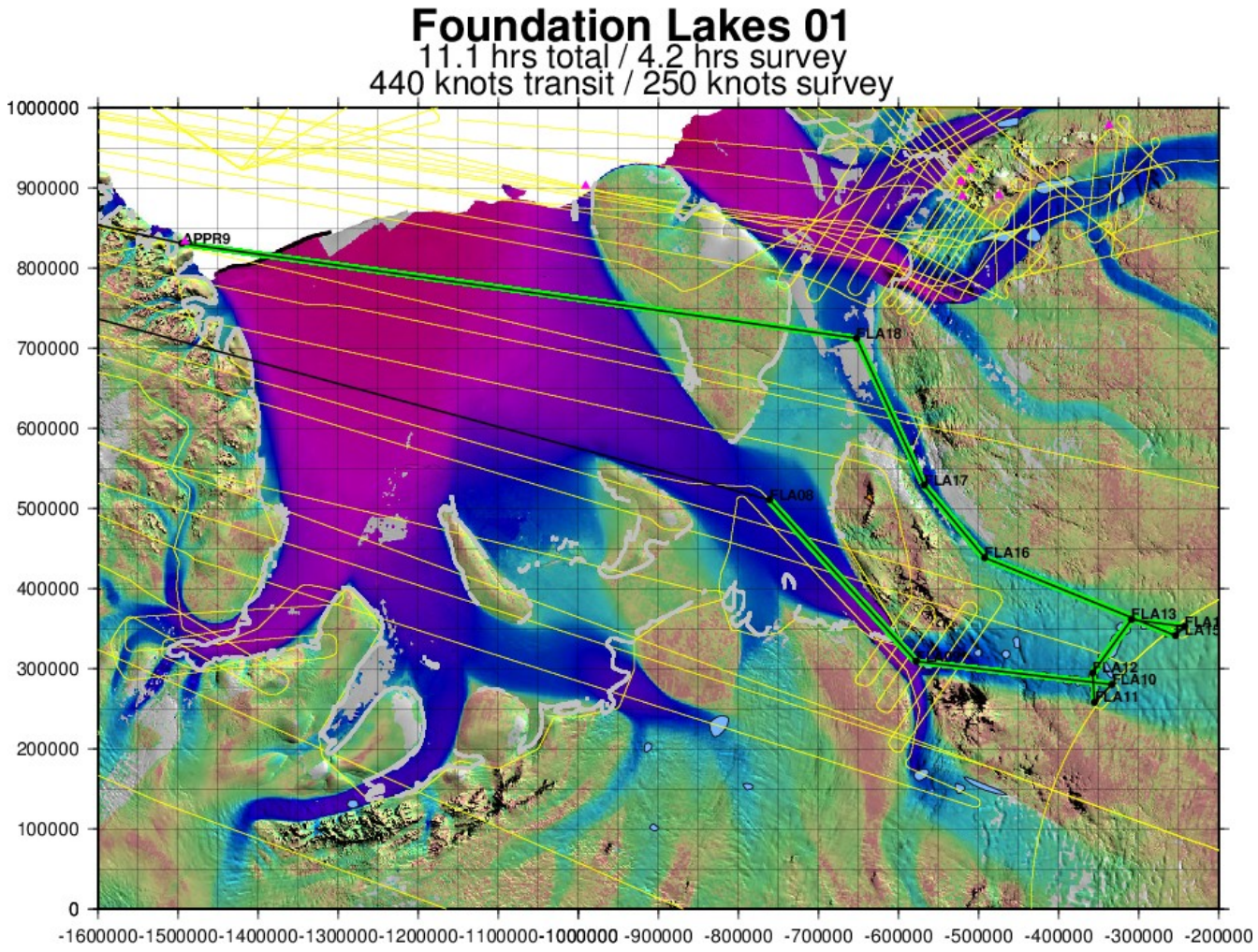
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0168,0421,0183,0069,0079,0084,0337,0099 (IceSat-1)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Foundation Lakes 01

This flight is a dh/dt repeat of the identical 15 October 2012 flight. It occupies straightened approximations of the Foundation and Support Force ice streams, and crosses several subglacial lakes in their upper portions. We also collect high-altitude gravity data across the Ronne Ice Shelf en-route to the area.

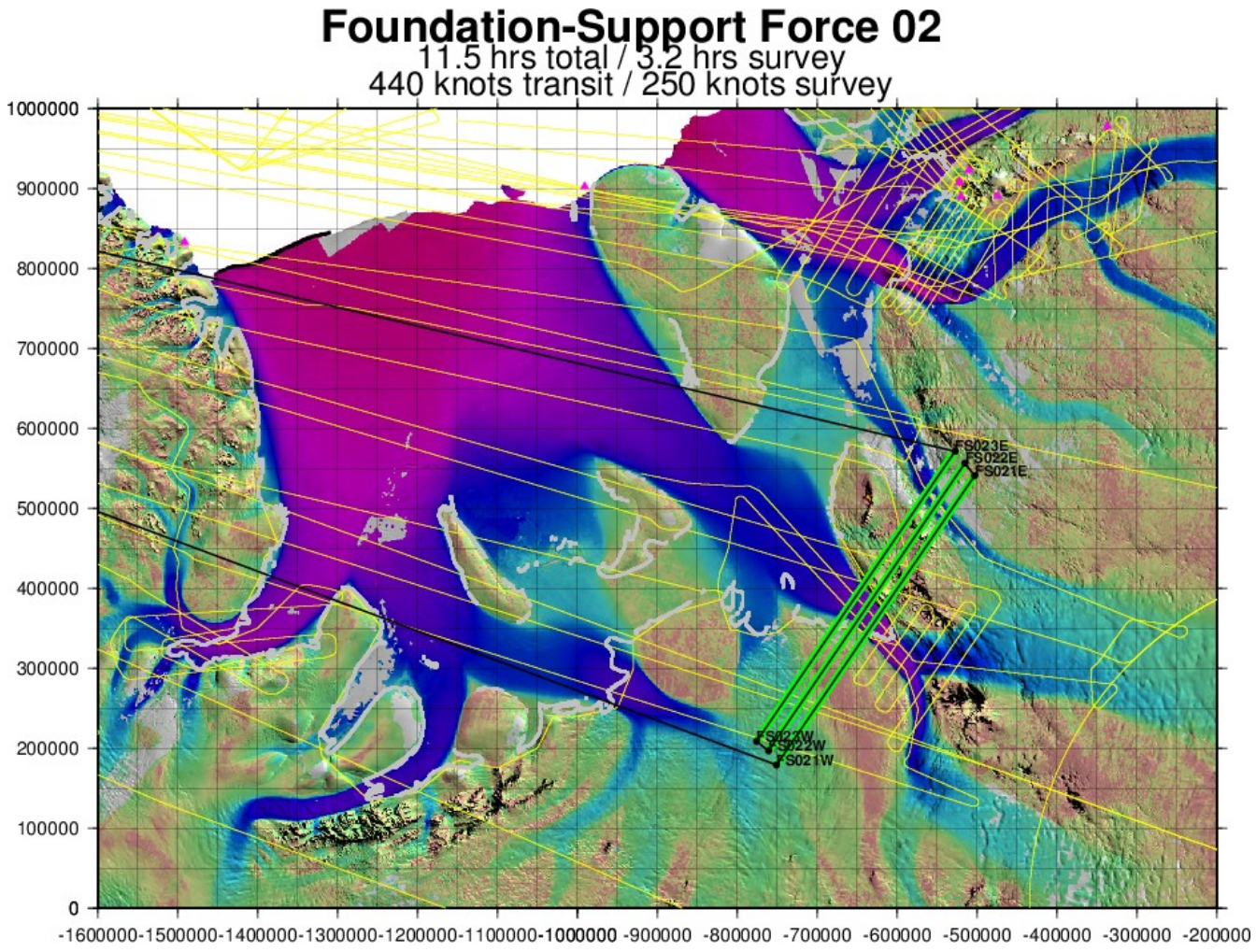
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: 2012
Remaining Design Issues: none



Land Ice – Foundation-Support Force 02

This flight is a new design, one of a suite of five flights designed to sample the bedrock, sub-ice shelf bathymetry and surface topography of the Foundation and Support Force ice streams on a 20 km grid. This particular flight targets the area at and just below the grounding lines of these ice streams.

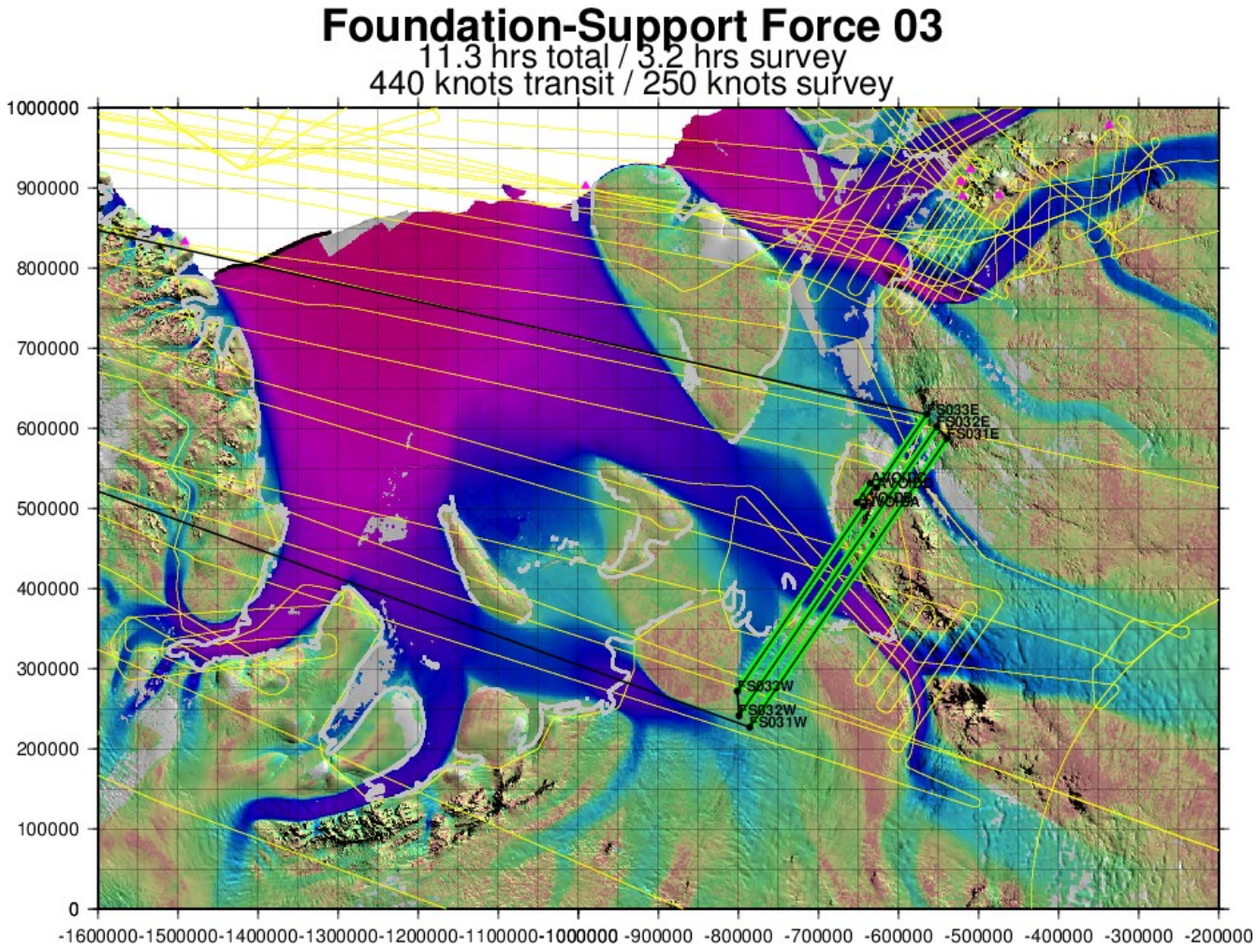
Flight Priority: medium
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Foundation-Support Force 03

This flight is a new design, one of a suite of five flights designed to sample the bedrock, sub-ice shelf bathymetry and surface topography of the Foundation and Support Force ice streams on a 20 km grid. This particular flight continues the sampling toward the Ronne and Filchner ice shelves, downstream of the grounding lines.

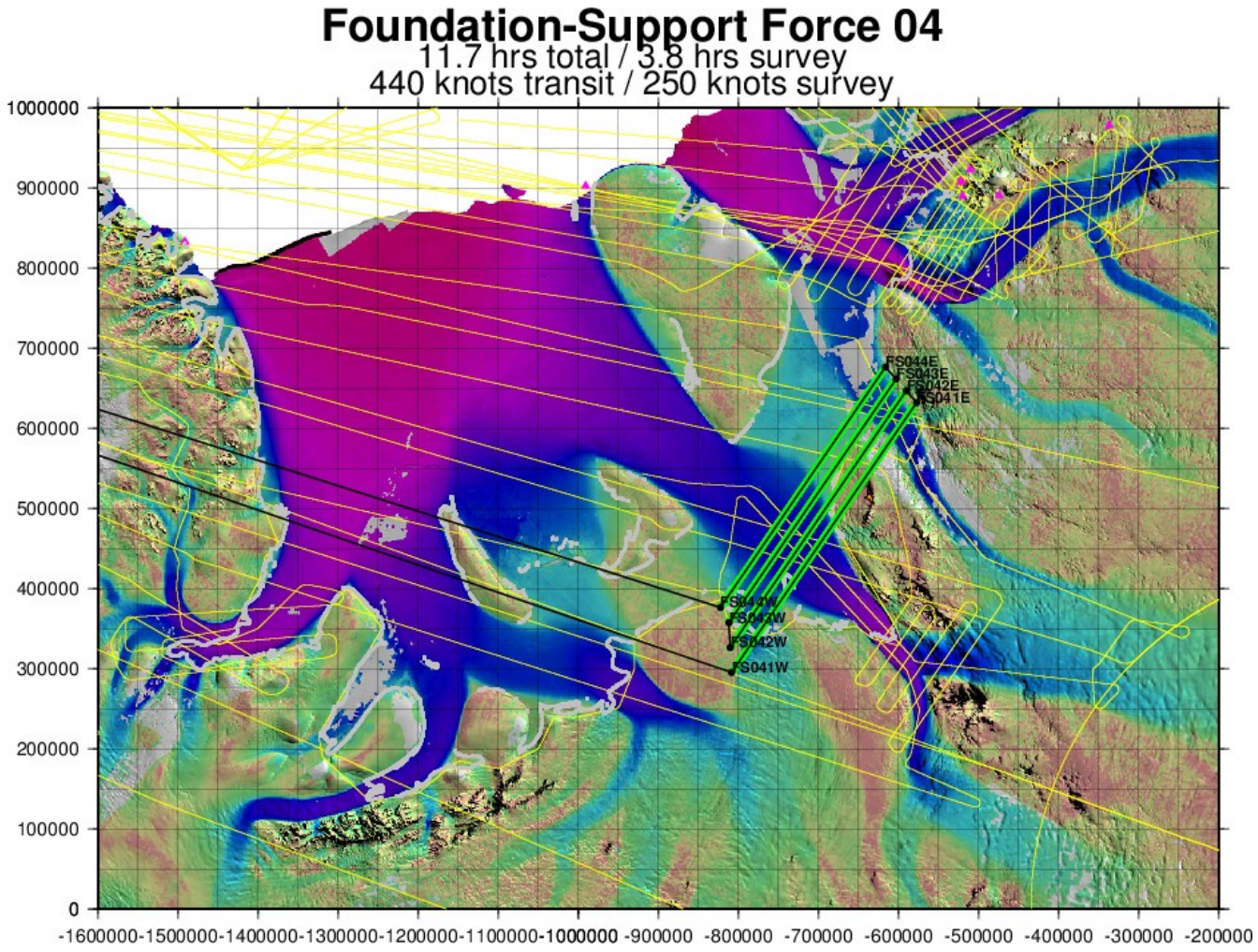
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Foundation-Support Force 04

This flight is a new design, one of a suite of five flights designed to sample the bedrock, sub-ice shelf bathymetry and surface topography of the Foundation and Support Force ice streams on a 20 km grid. This particular flight continues the sampling toward the Ronne and Filchner ice shelves, downstream of the grounding lines.

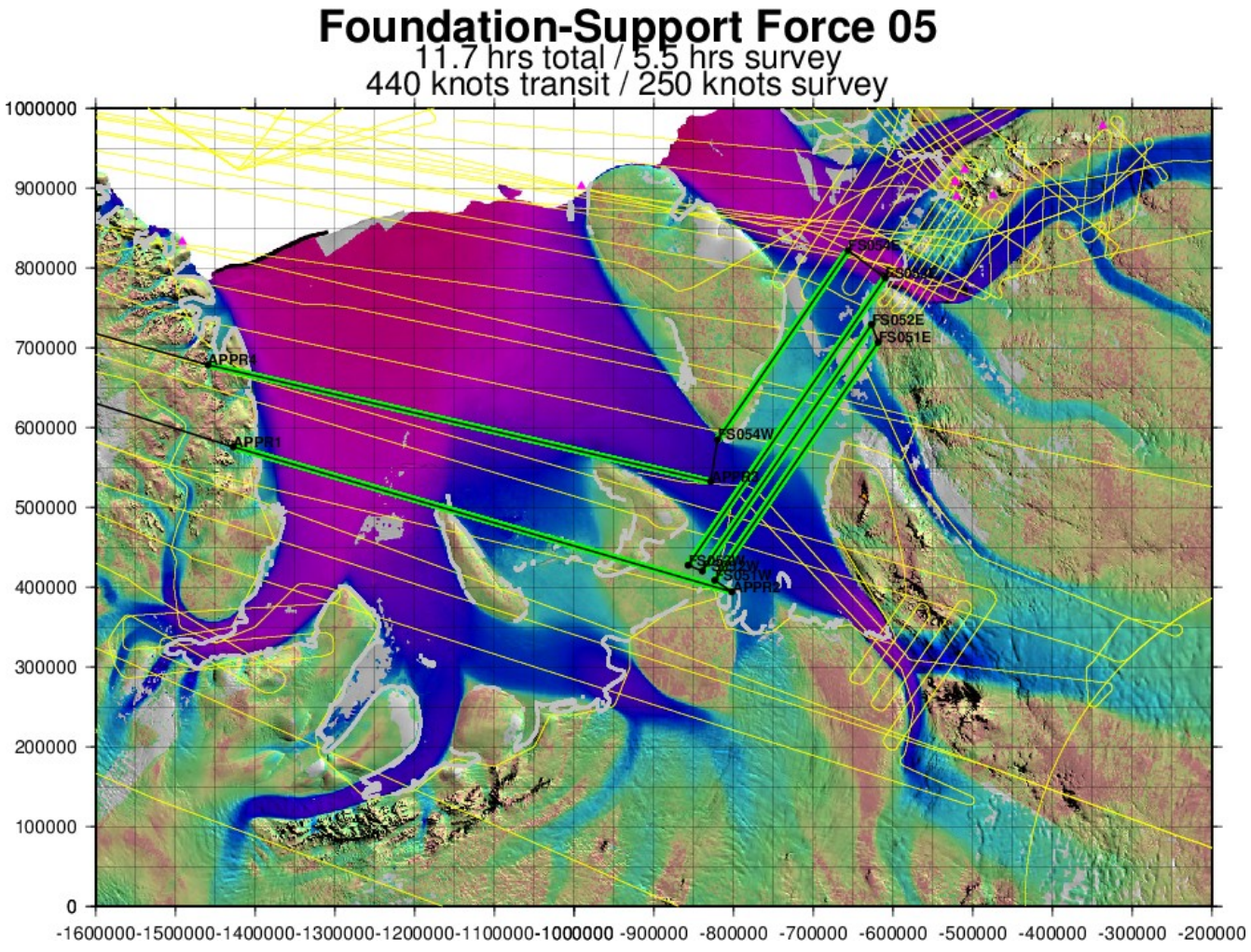
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Foundation-Support Force 05

This flight is a new design, one of a suite of five flights designed to sample the bedrock, sub-ice shelf bathymetry and surface topography of the Foundation and Support Force ice streams on a 20 km grid. This particular flight is the most downstream of the five missions, and its outboard-most line is displaced to Berkner Island coast specifically to sample a small embayment in the grounding line there. Finally we collect high-altitude gravity data over the Ronne Ice Shelf en-route to the area.

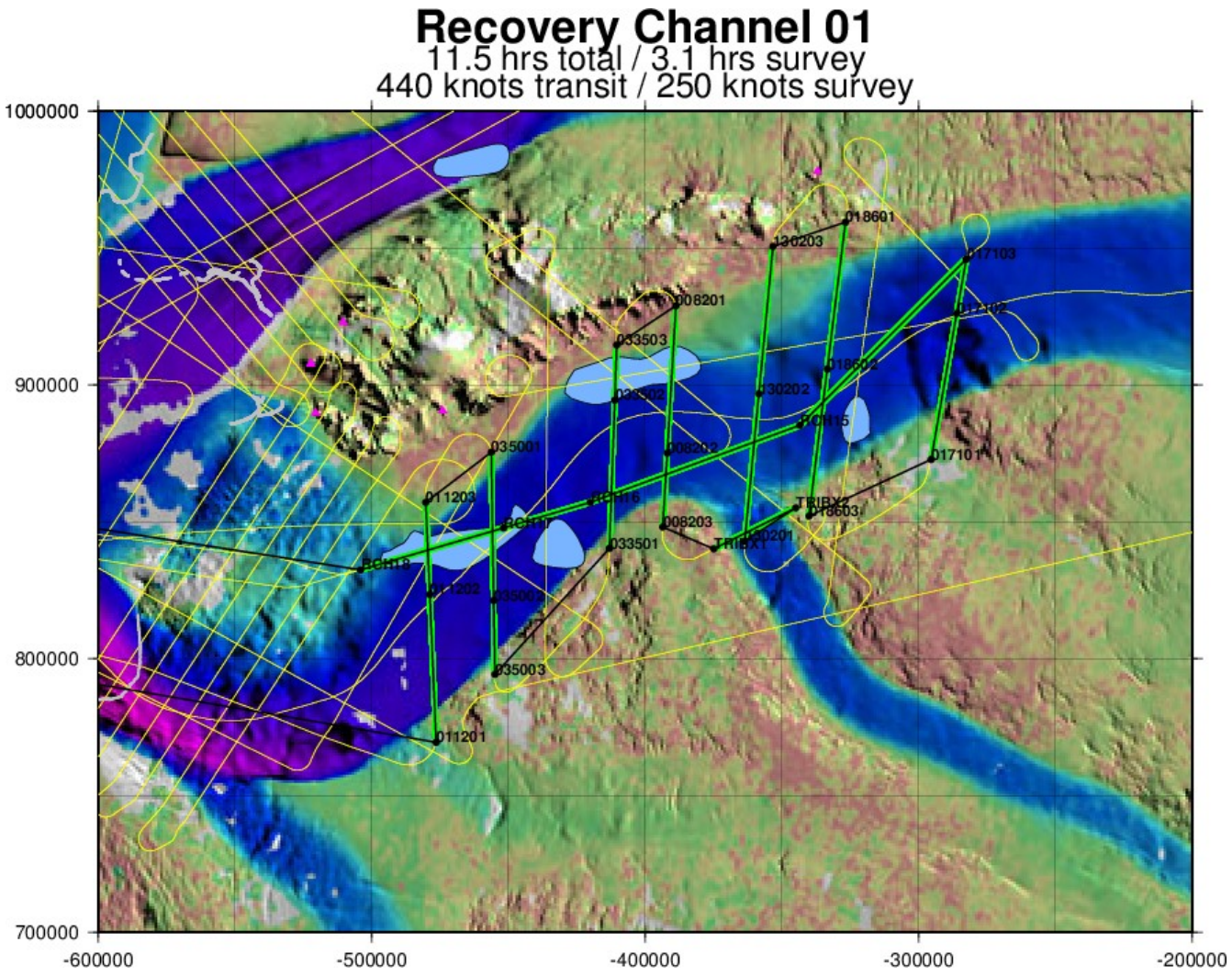
Flight Priority: low
Science Requirements Addressed: IS1,IS3,IS4,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Recovery Channel 01

This flight is a repeat of the identical 18 October 2012 flight, and its purpose is to obtain dh/dt measurements of Recovery Glacier. The mission is primarily designed along IceSat-1 ground tracks. We also fly a crossing of the tributary channel entering the main Recovery channel from the west.

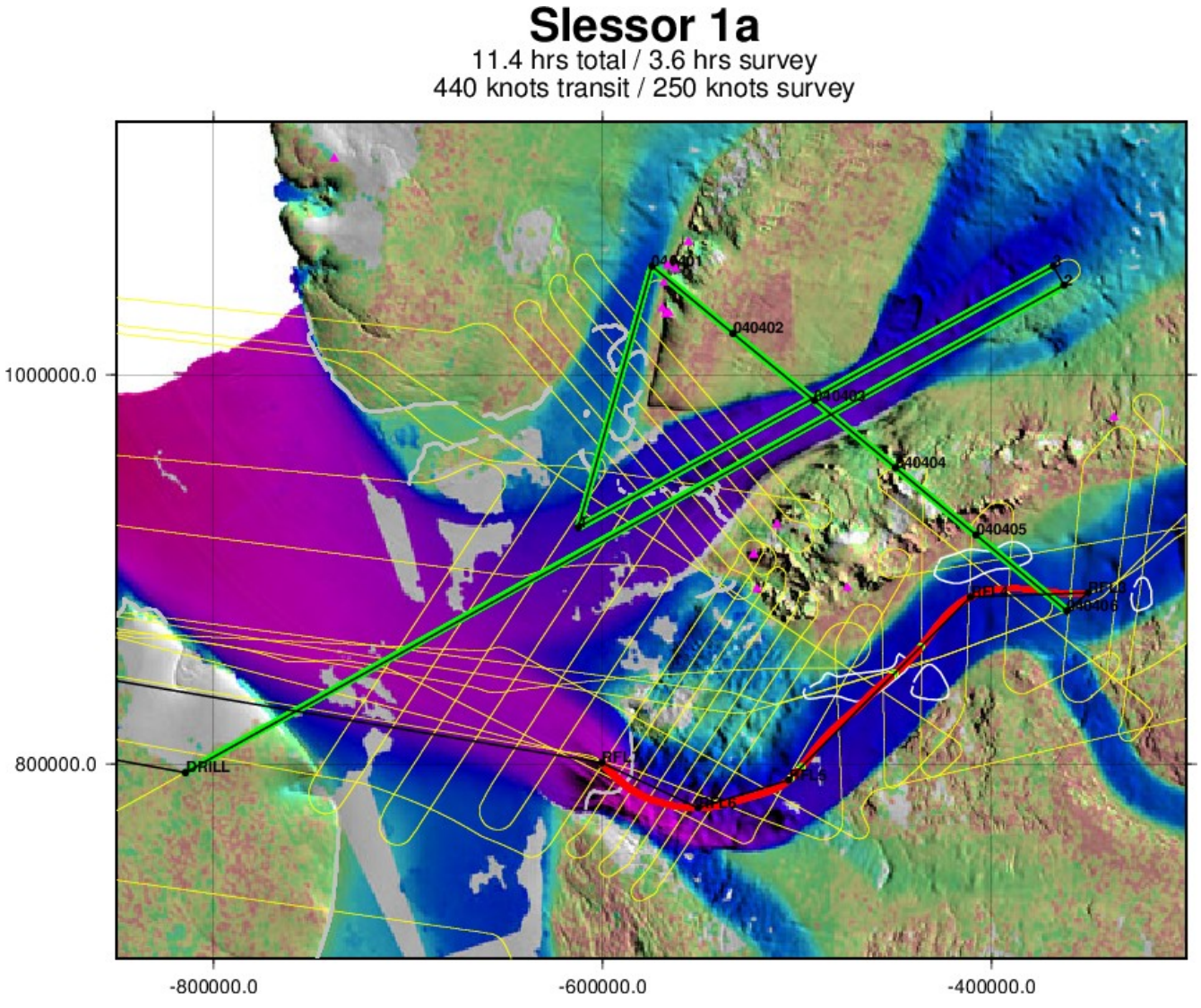
Flight Priority: low (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0112,0350,0335,0082,1302,0186,0171 (IceSat-1)
Last Flown: 2012
Remaining Design Issues: none



Land Ice – Slessor 1a

This flight is a near-repeat of the 21 October 2011 flight, and is intended to obtain dh/dt measurements of the lower Slessor, Bailey, and Recovery Glaciers. The 2011 flight is modified by replacing an IceSat track over Recovery Glacier with a centerline track, also from a 2011 flight. We also overfly an ICESat track connecting the three glacier basins. Finally, the mission overflies a Berkner Island drill site where ice cores have been recovered.

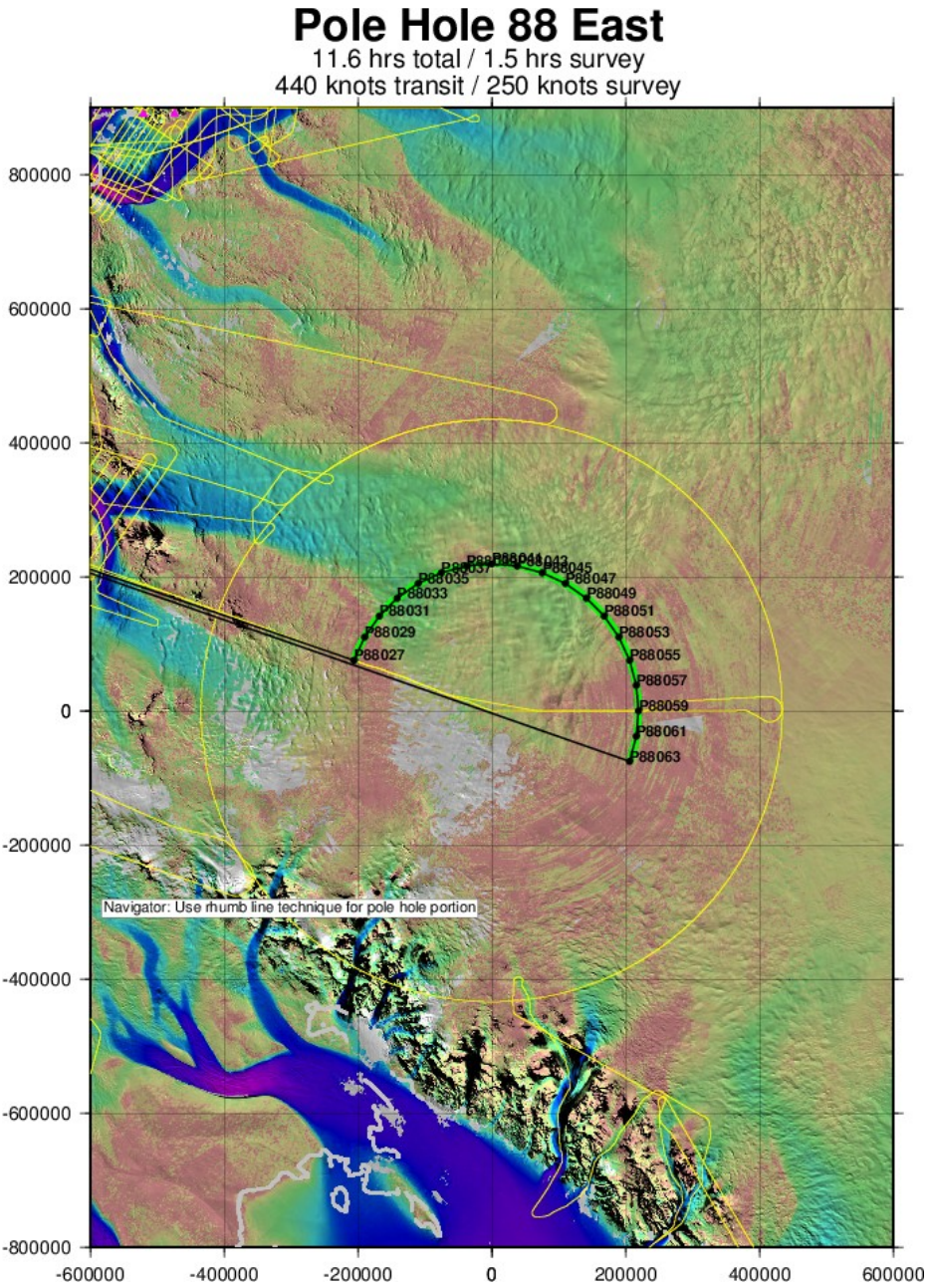
Flight Priority: high (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS6,IS7,IS11,IS12,IS13,IS15
Spacecraft Tracks: 0404 (IceSat-1)
Last Flown: 2011
Remaining Design Issues: none



Land Ice – Pole Hole 88 East

This flight is a new design, and its purpose is to sample the surface topography at the southern apex of half of all planned IceSat-II orbits. Specifically this flight samples the ground tracks on the east Antarctic plateau side of the Pole. In this way, we can provide "ground truth" for every IceSat-II orbit with just two flights, including Pole Hole 88 West as well as this one. The vertical stability of the surface must also be quantified for this approach to succeed, and this flight provides a baseline measurement for this purpose.

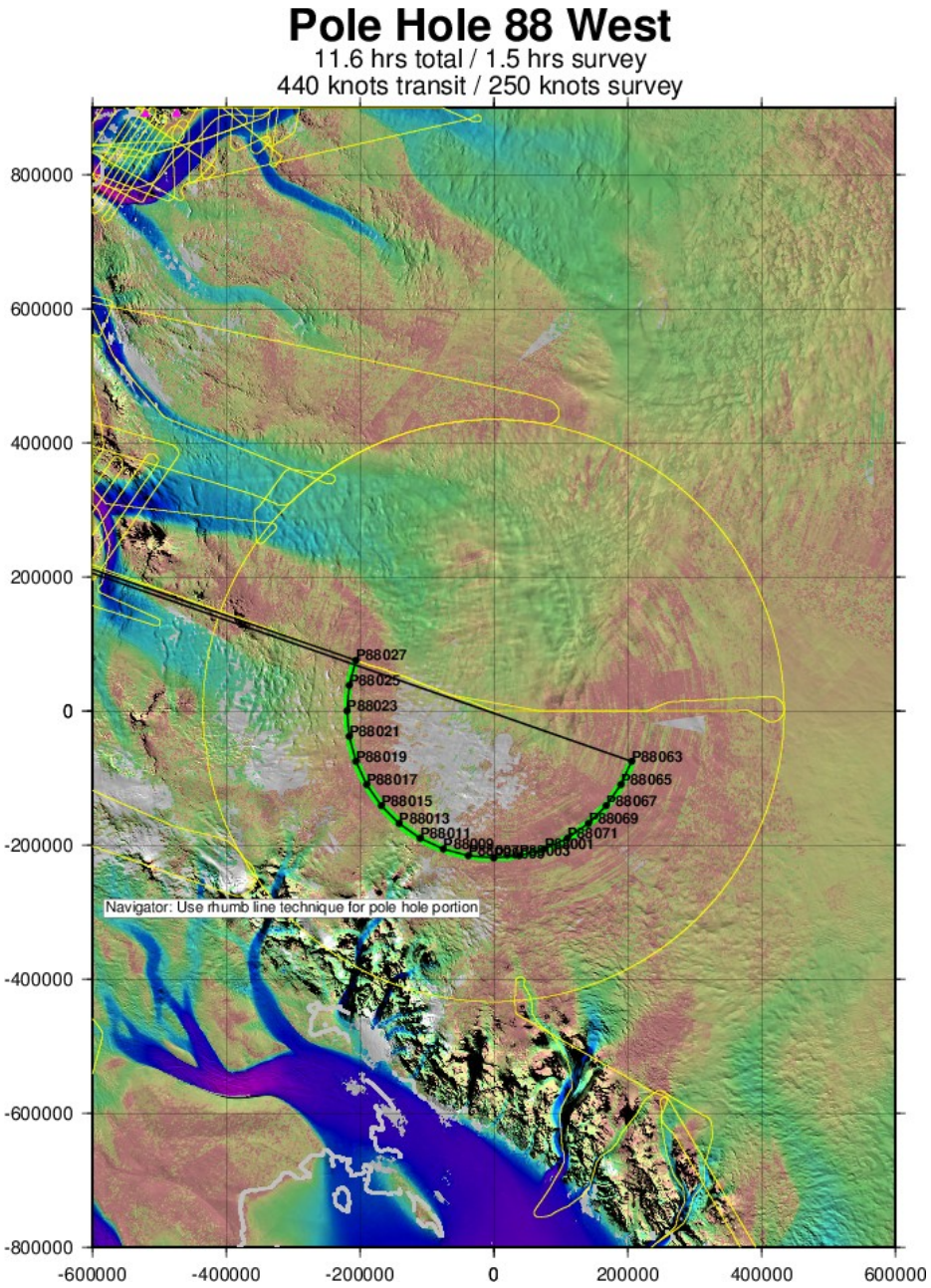
Flight Priority: medium (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS5,IS6,IS15
Spacecraft Tracks: samples half of all IceSat-2 tracks
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Pole Hole 88 West

This flight is a new design, and its purpose is to sample the surface topography at the southern apex of half of all planned IceSat-II orbits. Specifically this flight samples the ground tracks on the west Antarctica and Trans-Antarctic Mountains side of the Pole. In this way, we can provide "ground truth" for every IceSat-II orbit with just two flights, including Pole Hole 88 East as well as this one. The vertical stability of the surface must also be quantified for this approach to succeed, and this flight provides a baseline measurement for this purpose.

Flight Priority: BASELINE (multi-year repeat flight)
Science Requirements Addressed: IS1,IS2,IS3,IS4,IS5,IS6,IS15
Spacecraft Tracks: samples half of all IceSat-2 tracks
Last Flown: new flight
Remaining Design Issues: none



Appendix – 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.

We also expect that the DC-8 flight crew can display the wildlife locations and ASPAs/ASMAs on their flight instruments, providing an independent and redundant avoidance technique.