Fall 2017 IceBridge Basler Flight Plans
29 September 2017 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 a commercially-owned Basler aircraft, beginning in November and ending in late December 2017 or early January 2018. 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 three bases on the Antarctic continent: McMurdo, South Pole, and perhaps Dumont D'Urville. 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 typically 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. As of this writing, the precise navigation capability to be integrated aboard the Basler has not been definitely determined and we do not currently have a solid sense of how accurately the science lines can be flown.

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).

Note that this document shows 27 planned land ice and no sea ice missions. The entire suite of flight plans is depicted in the introductory material following this text. 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.

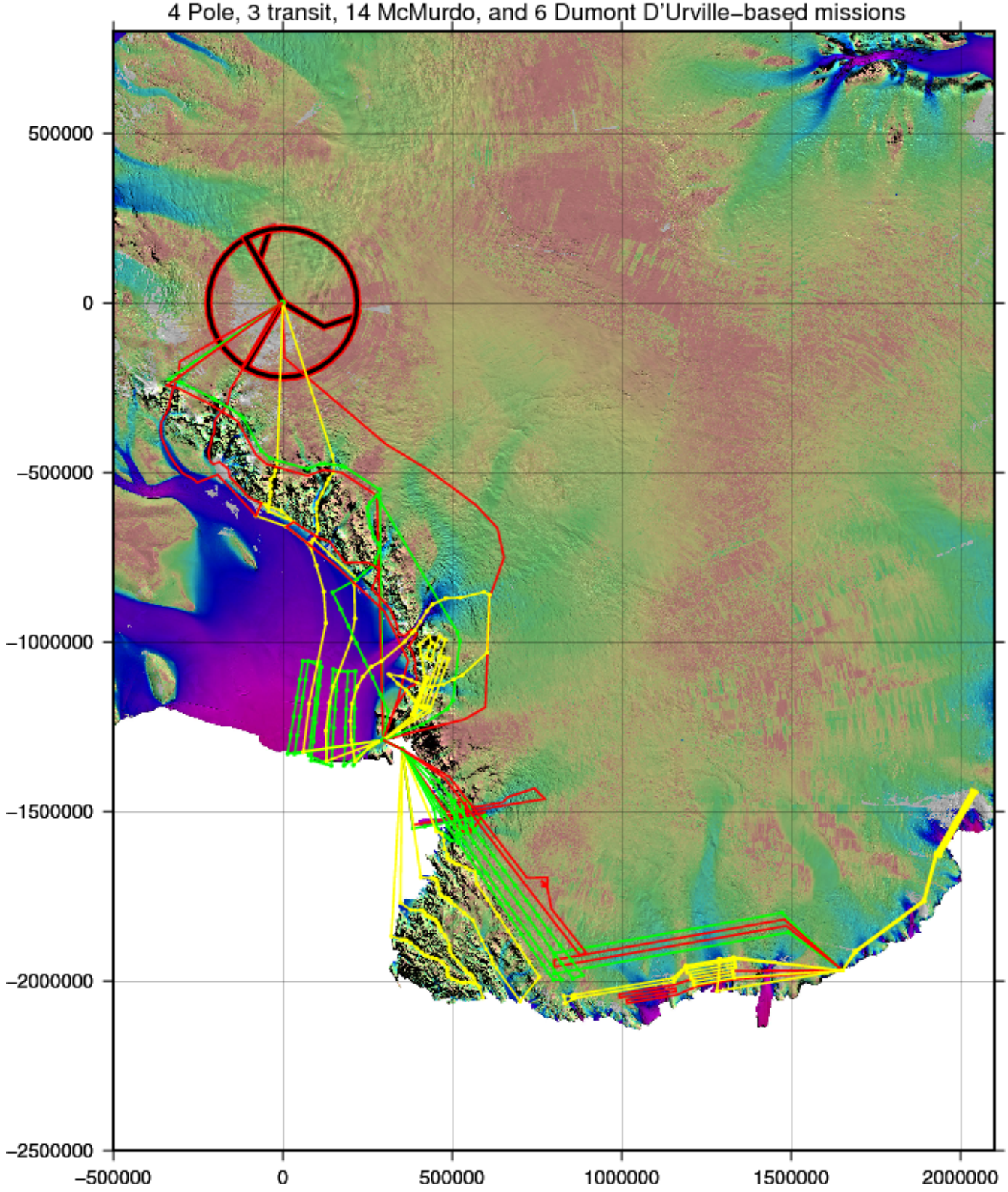
For previous Operation IceBridge campaigns, this document included composite maps, showing how multiple flight plans related to each other in specific regions. With the exception of the composite map of the entire study area given near the top of this document, we no longer include such maps. Instead,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

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.

2017 OIB Prioritized Basler Antarctic Flights

Red/Black=Baseline(2); Red=High(8); Yellow=Medium(9); Green=Low(8)

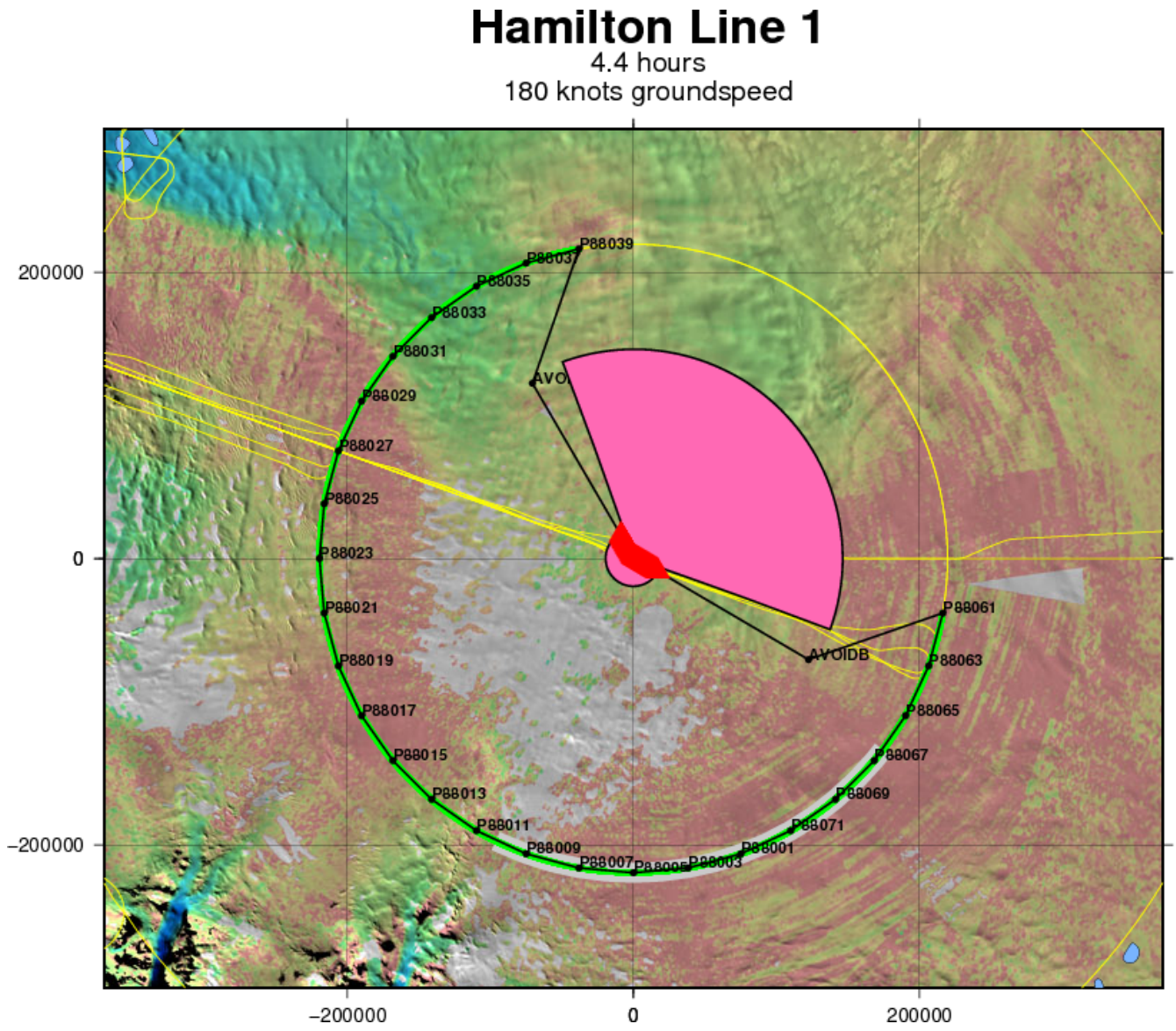
4 Pole, 3 transit, 14 McMurdo, and 6 Dumont D'Urville–based missions



Land Ice – Hamilton Line 1 / South Pole

This flight's purpose is to sample the surface topography at the southern apex of more than half of all planned IceSat-II orbits. In this way, we can provide "ground truth" for every IceSat-II orbit with just two flights, including the companion Hamilton Line 2 flight. The vertical stability of the surface must also be quantified for this approach to succeed, and this flight provides measurements for this purpose. Specifically this flight samples the ground tracks on the side of the Antarctic plateau primarily facing the Siple Coast and the Transantarctic Mountains. It also covers the Brunt-led 88S traverse route, shown on the map in light gray, overlapping with the Hamilton Line 2 flight there and for a short portion on the opposite side of the Pole. The flight is named in honor of Gordon Hamilton.

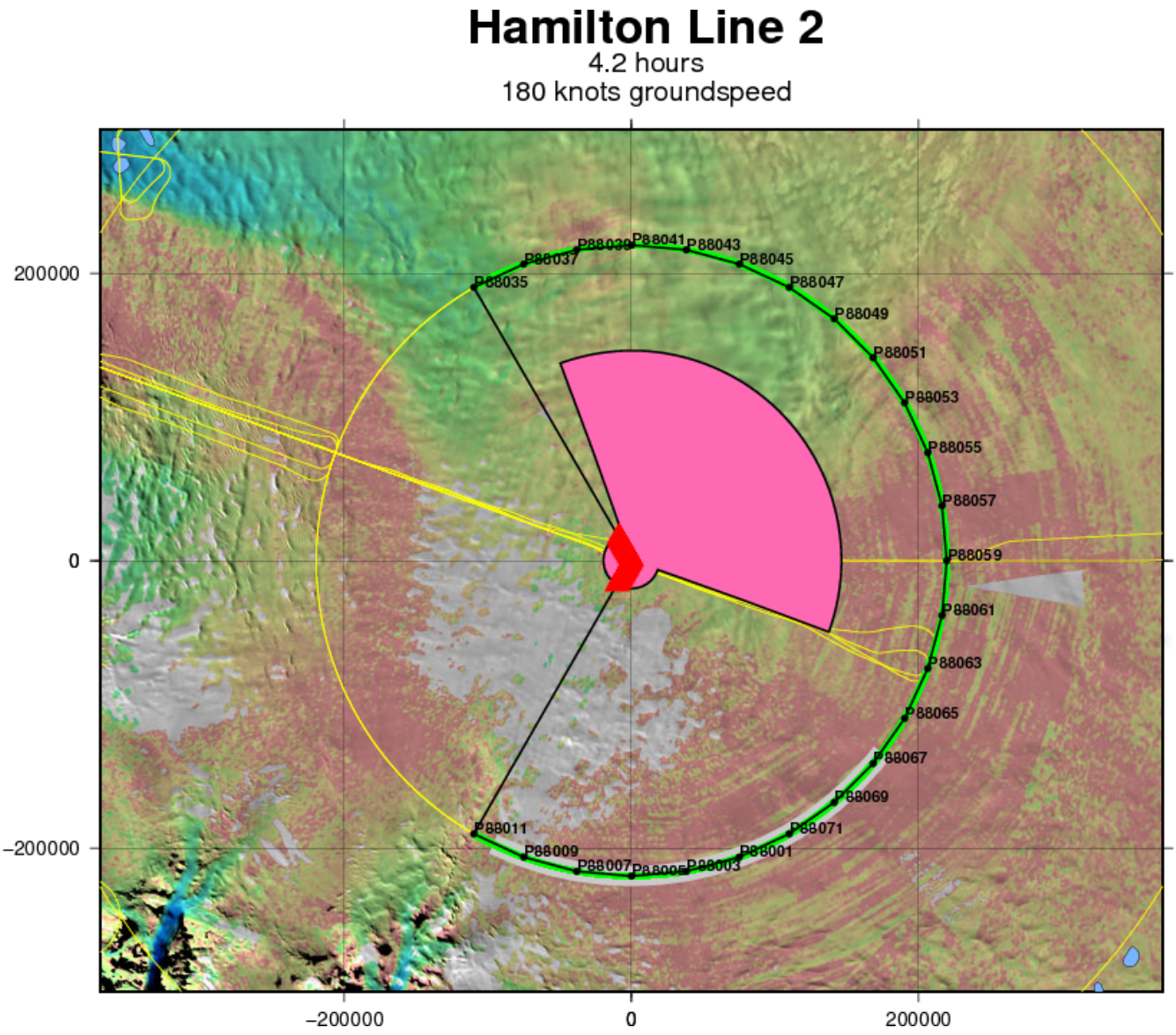
Flight Priority: BASELINE (Hamilton 1 is higher-priority than Hamilton 2)
Spacecraft Tracks: more than half of all IS-2 and CS-2 tracks
Last Flown: 2016
Remaining Design Issues: none



Land Ice – Hamilton Line 2 / South Pole

This flight's purpose is to sample the surface topography at the southern apex of more than half of all planned IceSat-II orbits. In this way, we can provide "ground truth" for every IceSat-II orbit with just two flights, including the companion Hamilton Line 1 flight. The vertical stability of the surface must also be quantified for this approach to succeed, and this flight provides measurements for this purpose. Specifically this flight samples the ground tracks on the East Antarctic side of the Pole. It also covers the Brunt-led 88S traverse route, shown on the map in light gray, overlapping with the Hamilton Line 2 flight there and for a short portion on the opposite side of the Pole. The flight is named in honor of Gordon Hamilton.

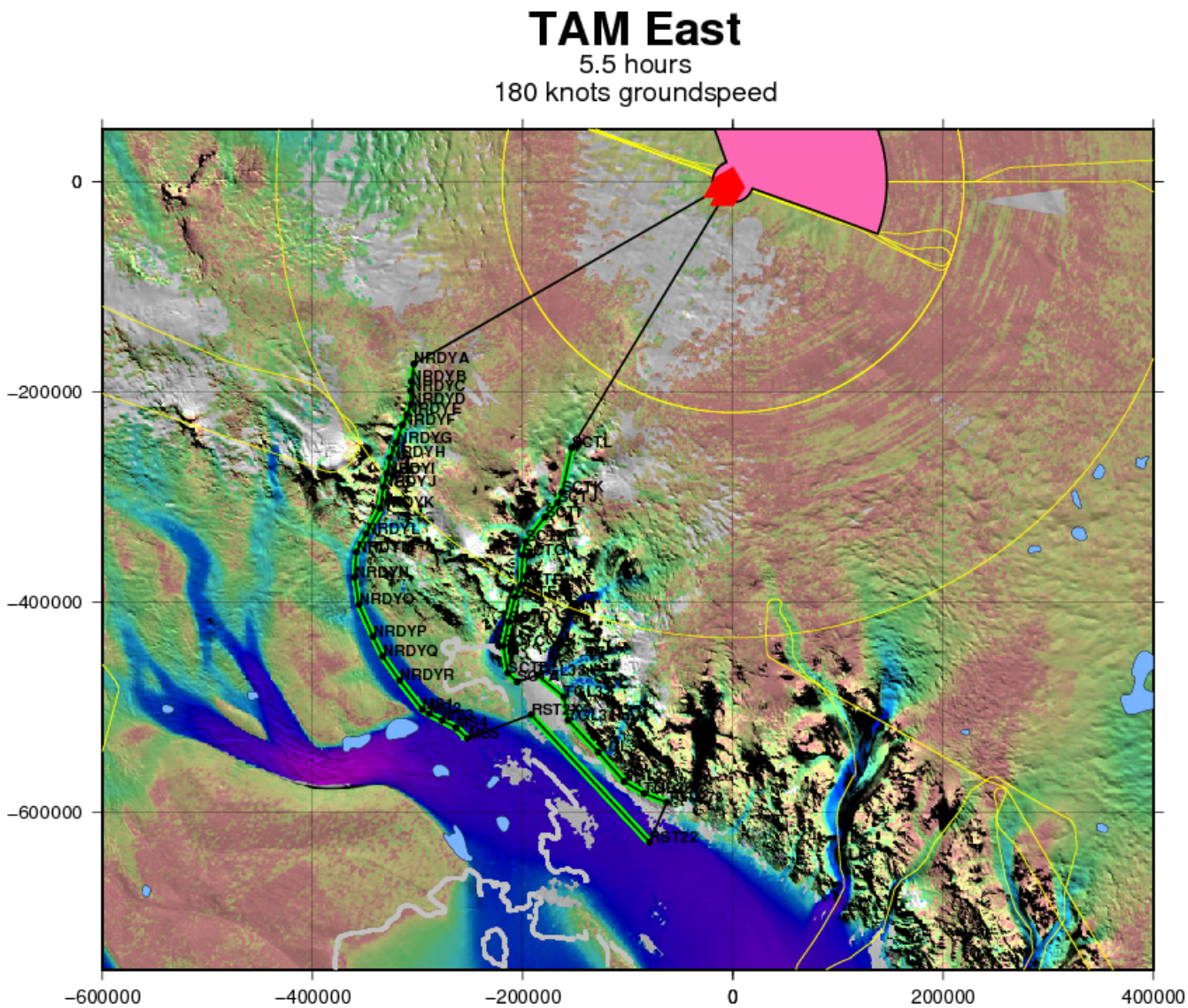
Flight Priority: BASELINE (Hamilton 1 is higher-priority than Hamilton 2)
Spacecraft Tracks: more than half of all IS-2 and CS-2 tracks
Last Flown: 2016
Remaining Design Issues: none



Land Ice – TAM East / South Pole

This mission flies the centerlines of the Reedy Glacier and Mercer Ice Stream in the east, and Scott Glacier in the west. We also overfly five long-duration GPS experiment sites at the foot of Mercer. We fly a Rosetta project line off the the lower Scott Glacier (scheduled to be flown in the late 2017 season) for the purpose of validating ocean tide models in that area. Working with the TAM Central and TAM GL West missions, it also establishes flight lines approximating the TAM grounding line and a second line approximately 20 km outboard of the grounding line.

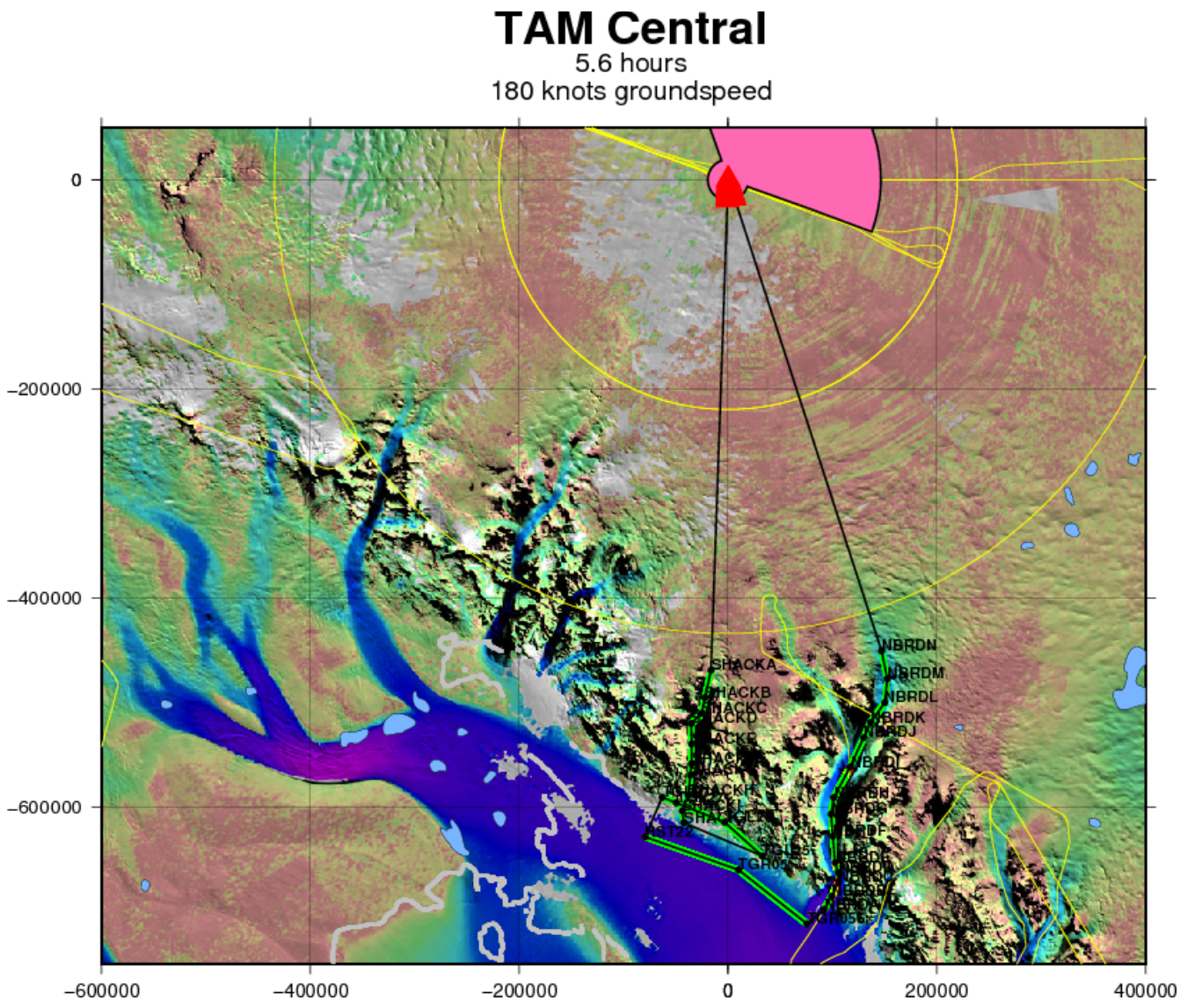
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – TAM Central / South Pole

This mission flies the centerlines of the Shackleton and Beardmore Glaciers. Working with the TAM East and TAM GL West missions, it also establishes flight lines approximating the TAM grounding line and a second line approximately 20 km outboard of the grounding line.

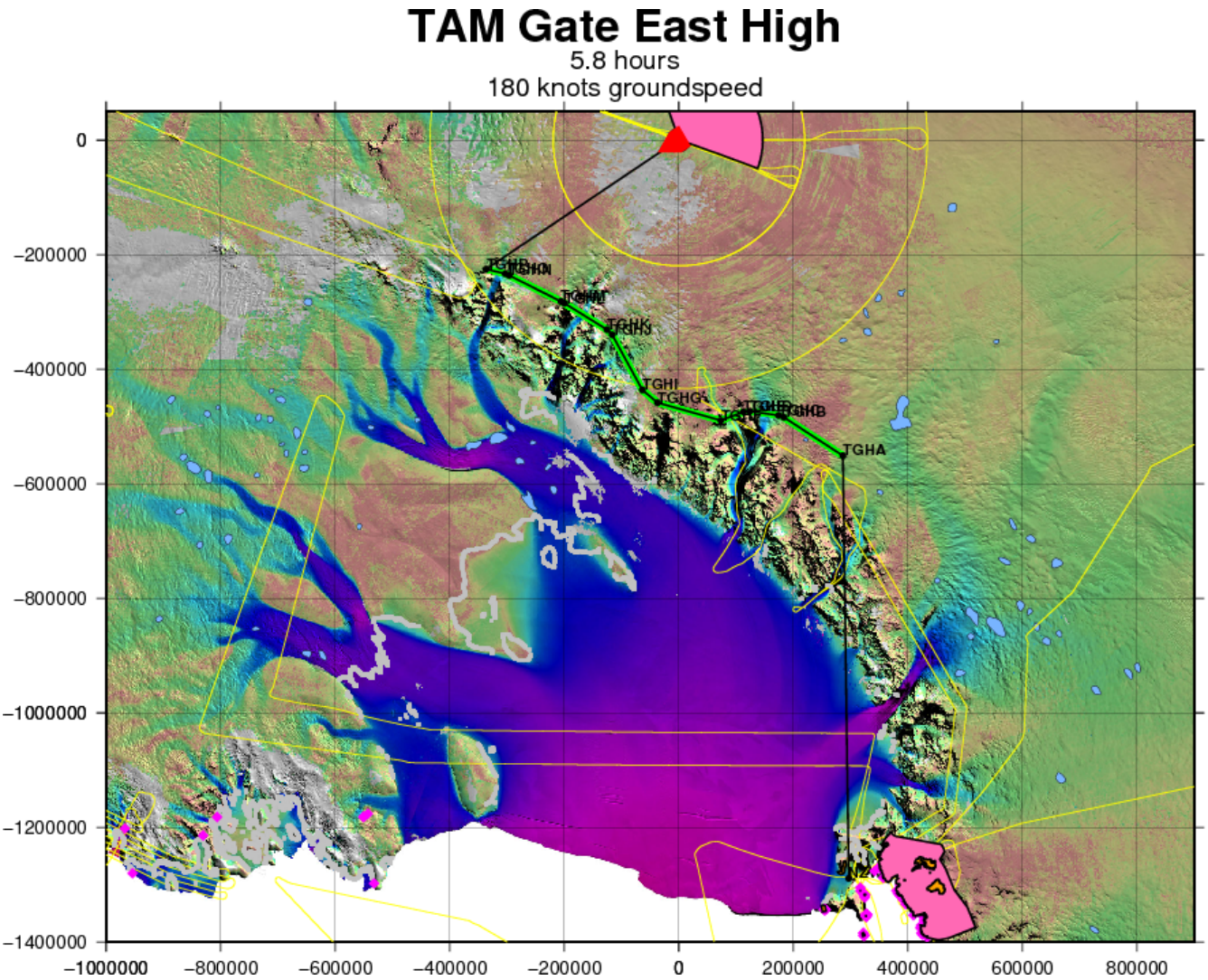
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: lower Beardmore in 2013; the rest is new
Remaining Design Issues: none



Land Ice – TAM Gate East High / South Pole-McMurdo

This mission, and the companion TAM Gate East Low flight, establish a pair of fluxgates above the Transantarctic Mountains, separated by 20 km. This particular mission covers the uppermost of the two fluxgates.

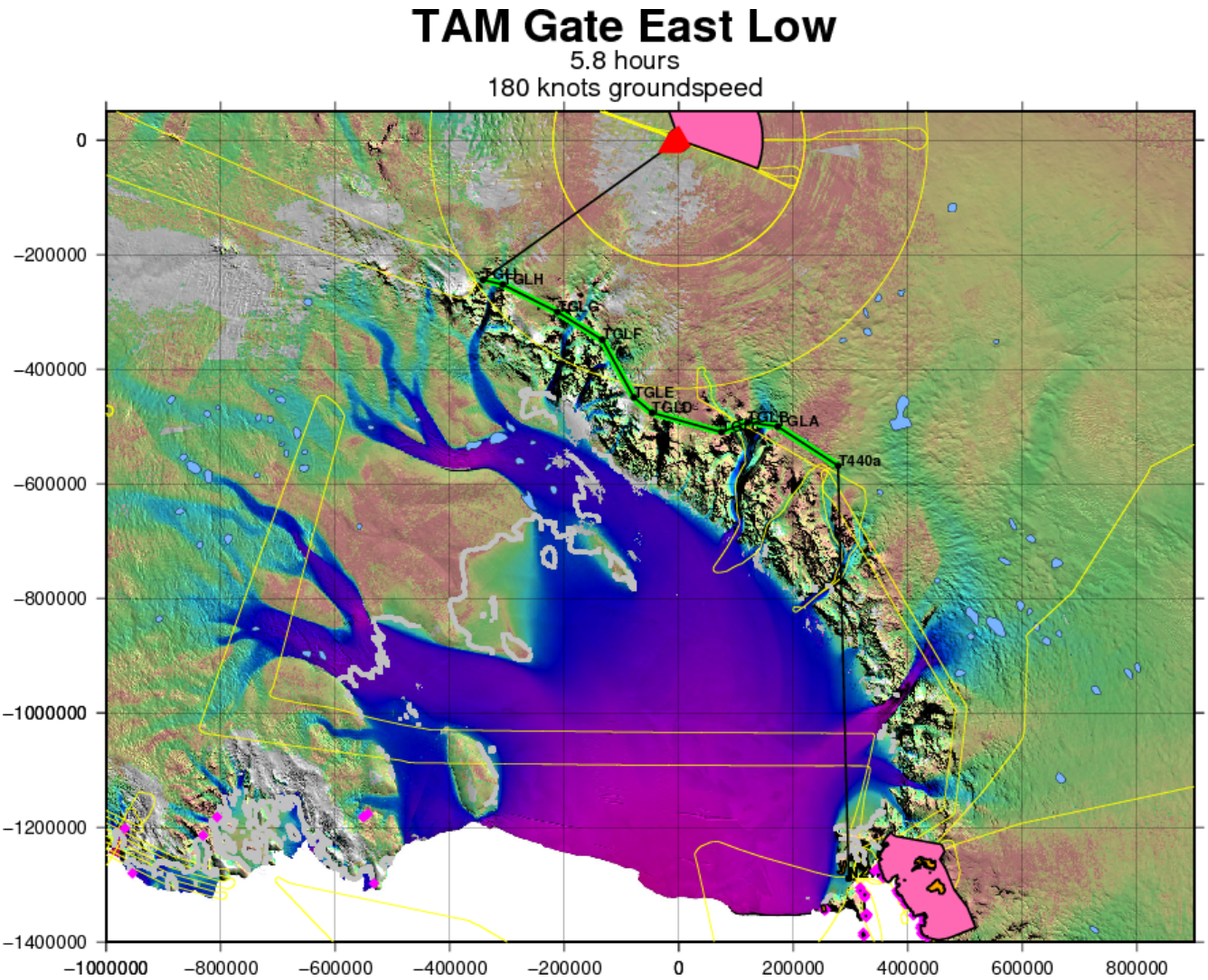
Flight Priority: low
Spacecraft Tracks: none
Last Flown: new mission
Remaining Design Issues: none



Land Ice – TAM Gate East Low / South Pole-McMurdo

This mission, and the companion TAM Gate East High flight, establish a pair of fluxgates above the Transantarctic Mountains, separated by 20 km. This particular mission covers the lower-most of the two fluxgates, and connects with a similar line flown in 2013 to the west and north.

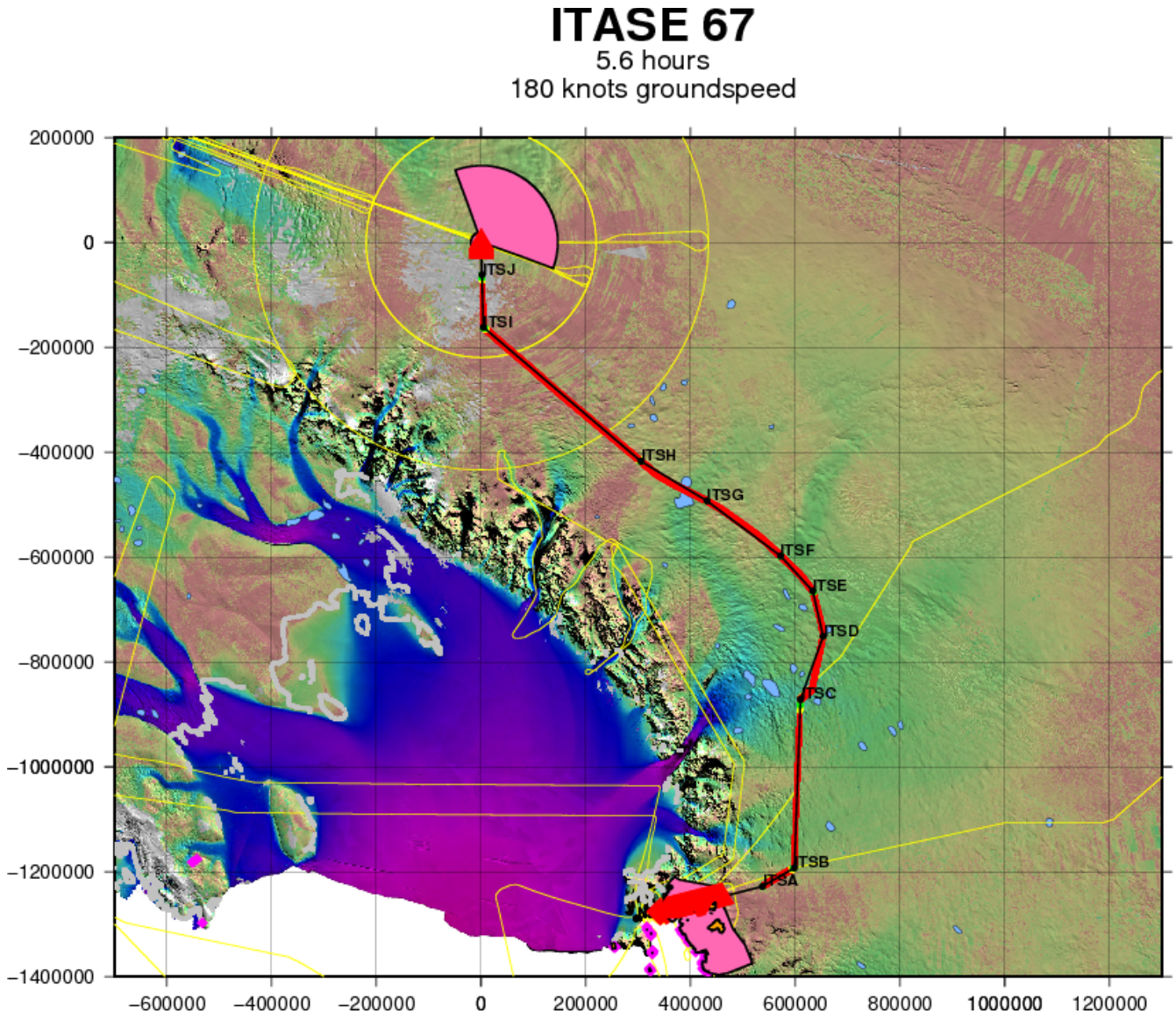
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new mission
Remaining Design Issues: none



Land Ice – ITASE 67 / South Pole - McMurdo

This mission flies the ITASE 2006-2007 traverse route between McMurdo and South Pole Station. It is ideally configured as a transit route between these two planned bases of operation for the Basler.

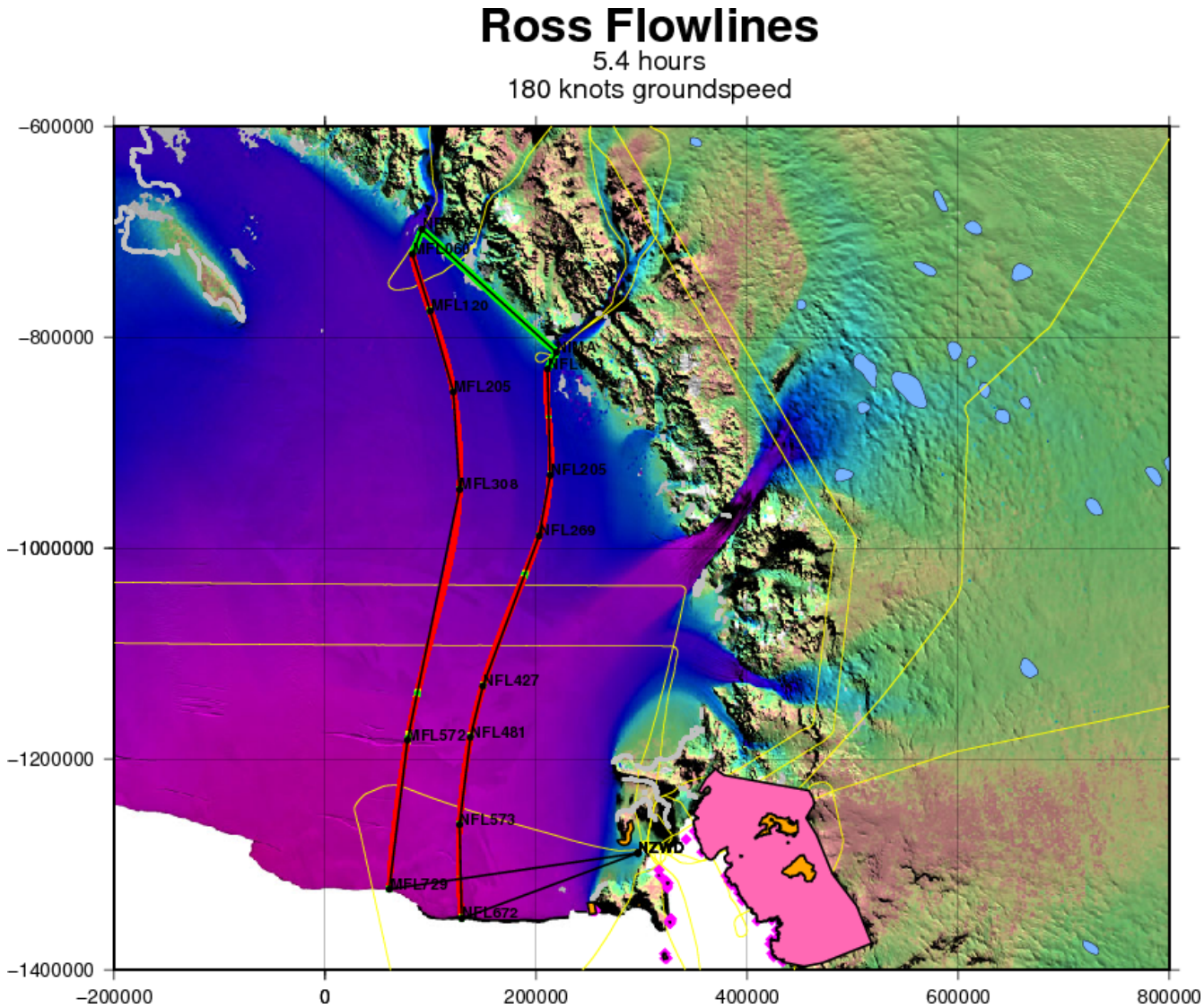
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new mission
Remaining Design Issues: none



Land Ice – Ross Flowlines / McMurdo

This mission flies flowlines of the Beardmore and Nimrod Glaciers, from the bases of each glacier (these connect directly to the centerlines flown in other missions) to the Ross ice front.

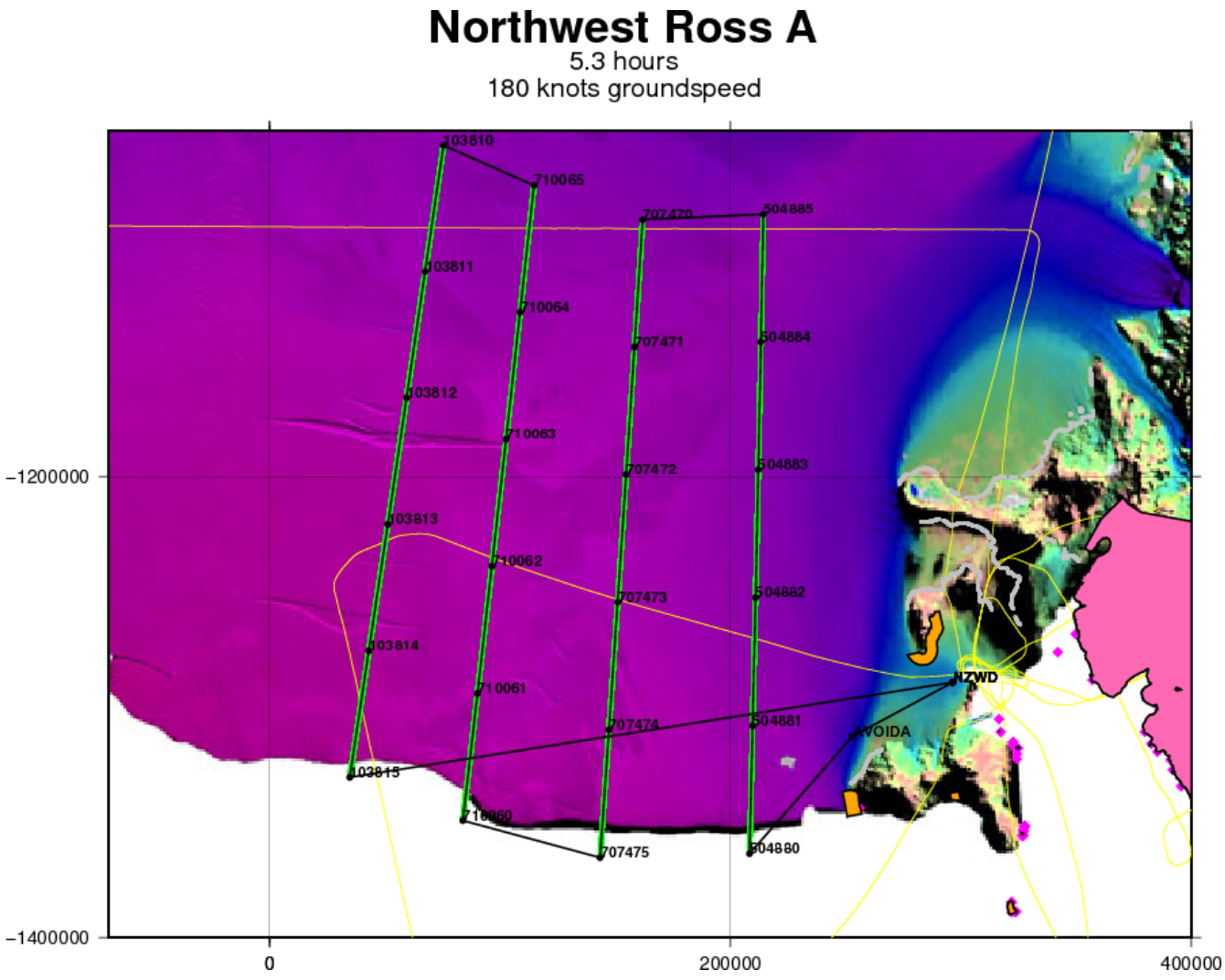
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Northwest Ross A / McMurdo

This mission surveys the northwestern Ross Ice Shelf along Icesat-2 ground tracks, selected to interlace with the north-south Rosetta grid lines in the area. This area has relatively high basal melt rates, and the purpose of this mission, and its companion Northwest Ross B, is to lay the foundation for understanding the evolution of the ice front through a combination of OIB, Rosetta, and IceSat-2.

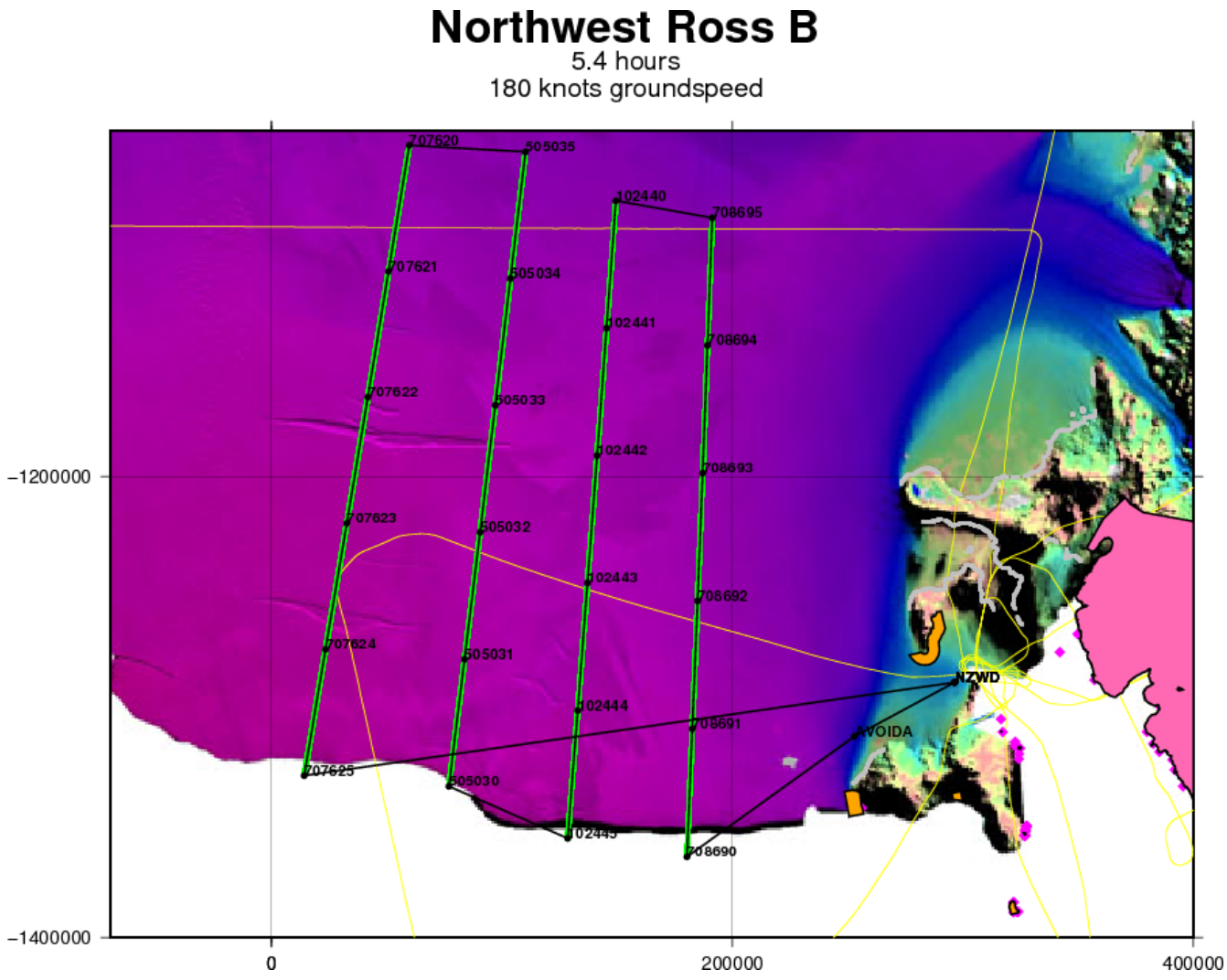
Flight Priority: low
Spacecraft Tracks: 70488, 70747, 71006,70381 (IceSat-2)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Northwest Ross B / McMurdo

This mission surveys the northwestern Ross Ice Shelf along Icesat-2 ground tracks, selected to interlace with the north-south Rosetta grid lines in the area. This area has relatively high basal melt rates, and the purpose of this mission, and its companion Northwest Ross A, is to lay the foundation for understanding the evolution of the ice front through a combination of OIB, Rosetta, and IceSat-2.

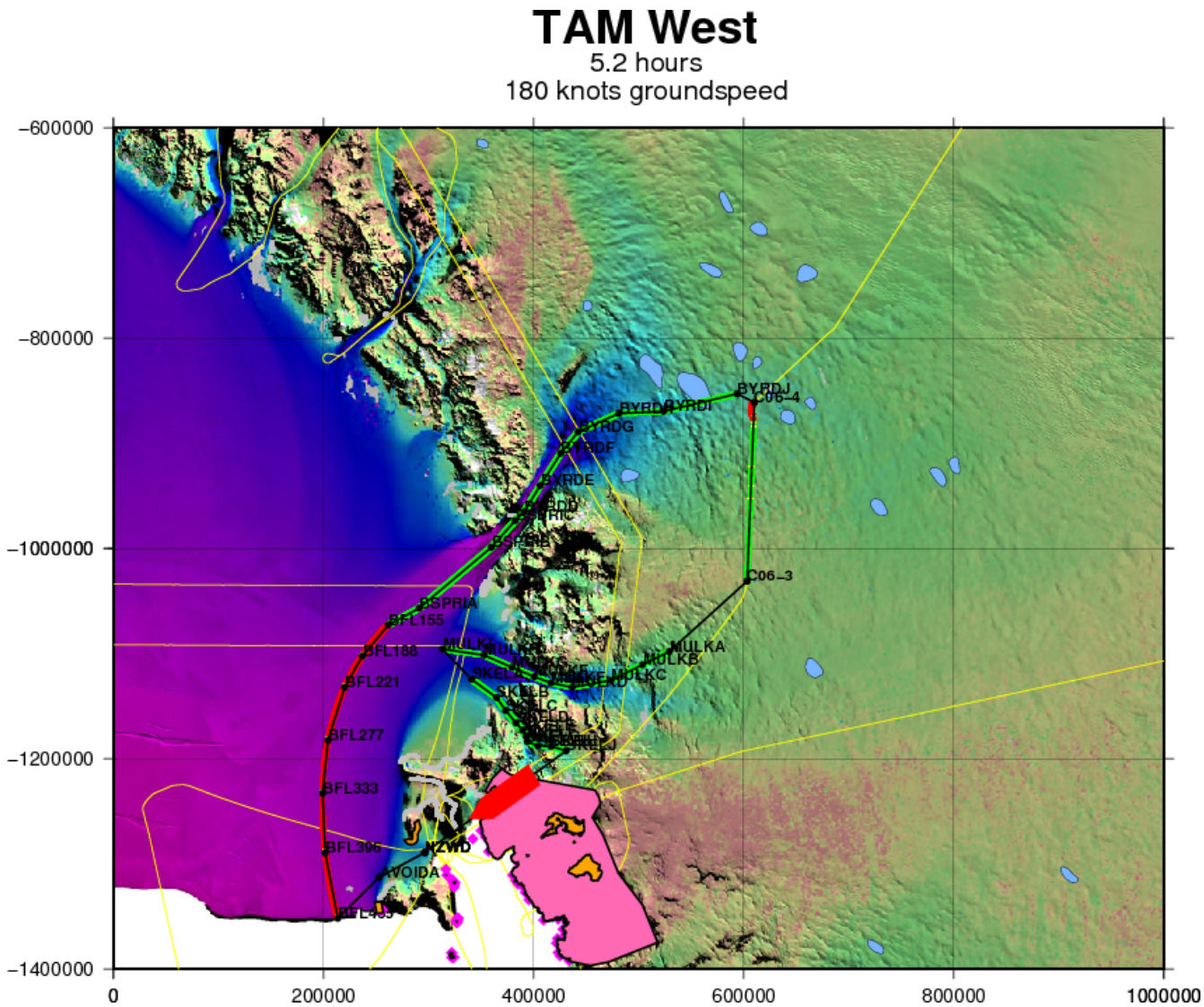
Flight Priority: low
Spacecraft Tracks: 70869,70244,70503,70762 (IceSat-2)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – TAM West / McMurdo

This mission flies the centerlines of the Byrd, Mulock and Skelton Glaciers, none of which were flown during the 2013 P-3 campaign. The lower portion of the Byrd centerline is designed to be coincident with a 1974 SPRI-NSF-TUD survey there. We also fly a Byrd flowline from the lower portion of the glacier all the way to the Ross ice front.

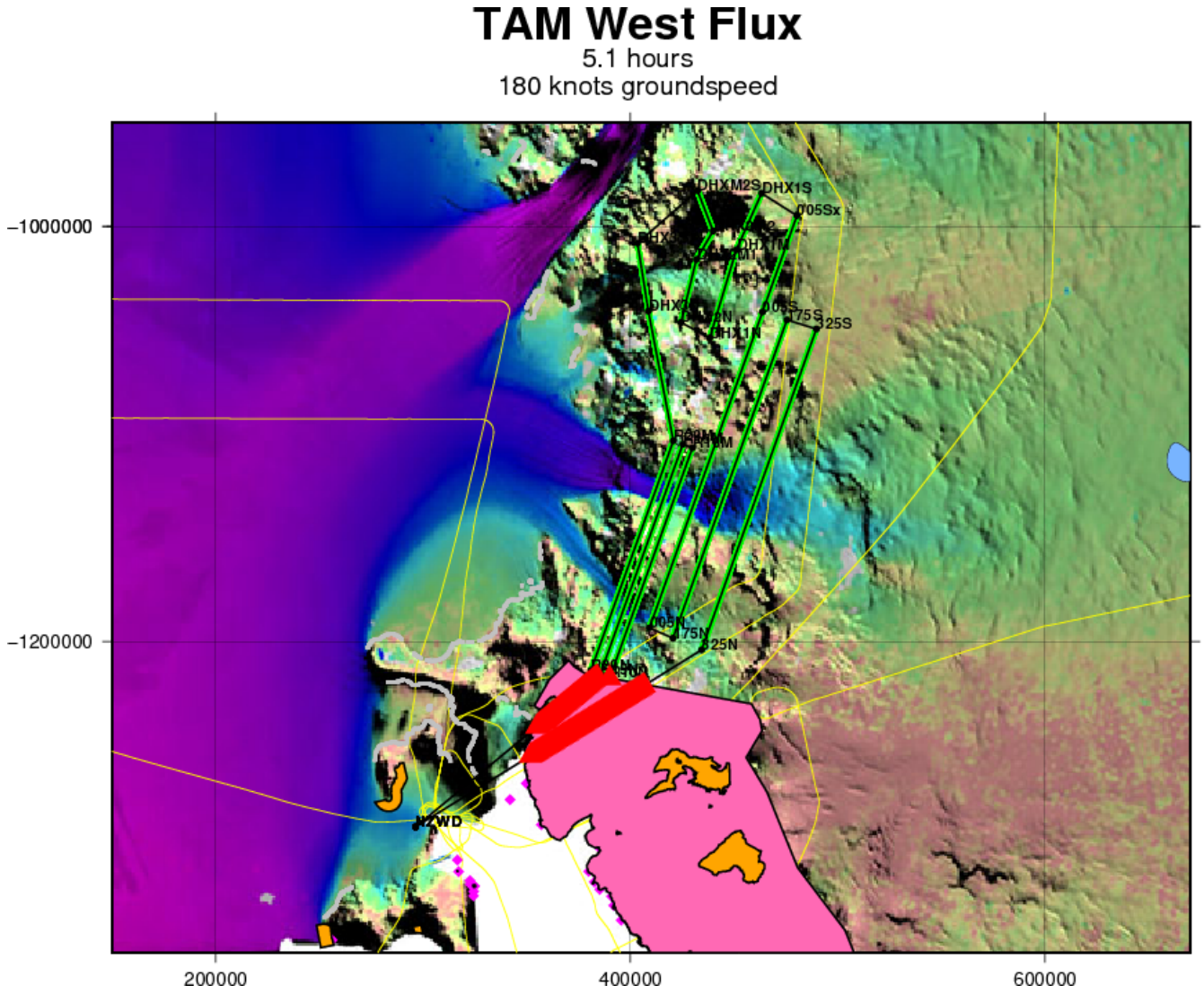
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – TAM West Flux / McMurdo

This mission flies fluxgates across the Skelton, Mulock, Darwin, and Hatherton Glaciers. For the most part, these new fluxgates are interlaced with previous UTIG lines in the area, yielding a 5 km combined grid spacing.

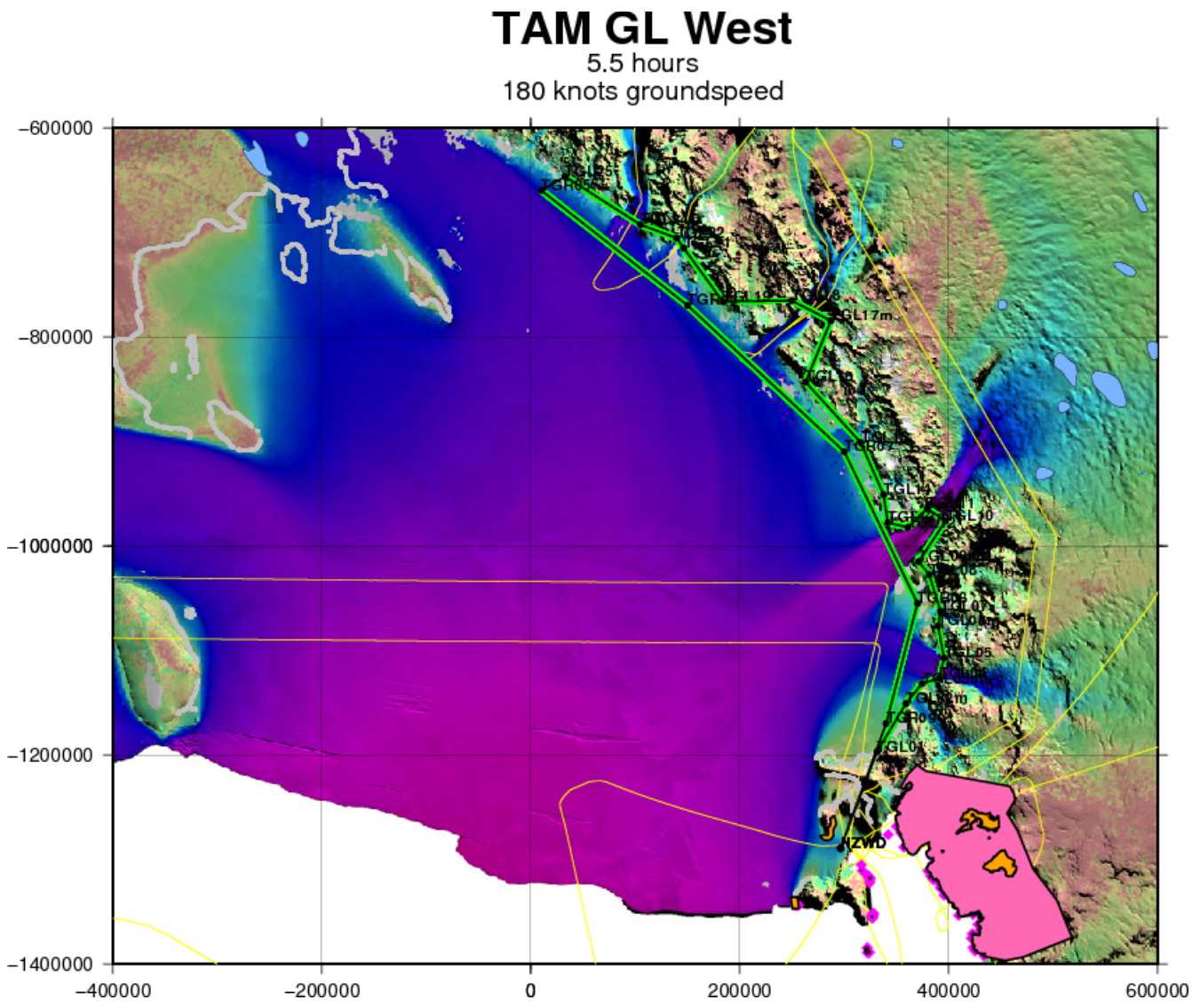
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – TAM Grounding Line West / McMurdo

This mission flies the an approximation to the Transantarctic Mountains grounding line, as well as a second line offset from that one by approximately 20 km. It connects with similar lines to the south and east in the TAM Grounding Line East and TAM East missions.

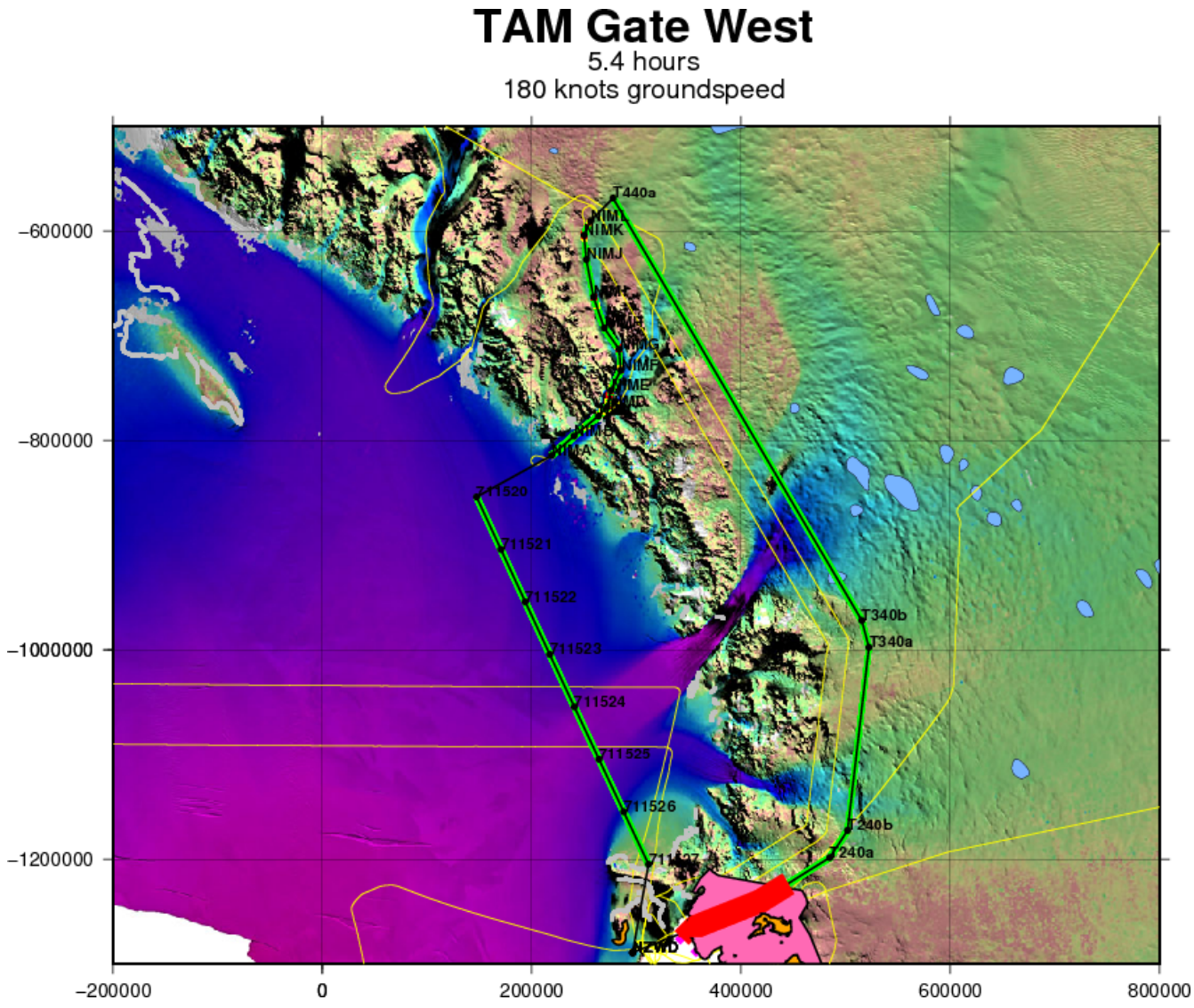
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new mission
Remaining Design Issues: none



Land Ice – TAM Gate West / McMurdo

This mission establishes a new fluxgate on the plateau above the western Transantarctic Mountains, 20 km above a pair of fluxgates established there during the 2013 OIB campaign. It connects with a similarly-designed fluxgate to the south and east in the TAM Gate East High mission. Finally, it reflies the centerline of the Nimrod Glacier, and returns to McMurdo along an IceSat-2 track over the Ross Ice Shelf.

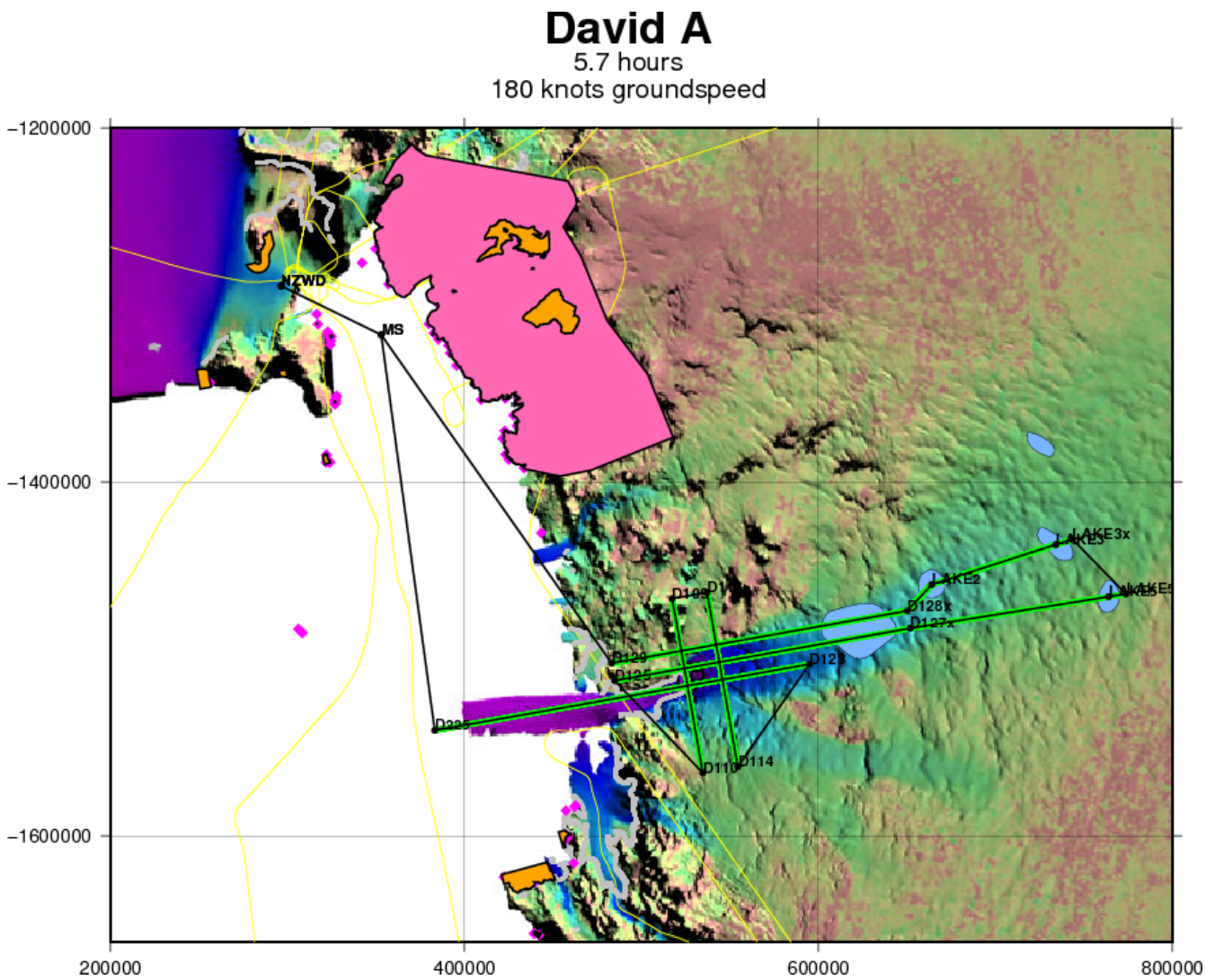
Flight Priority: low
Spacecraft Tracks: 1152 (IceSat-2)
Last Flown: Nimrod centerline in 2013, the rest is new
Remaining Design Issues: none



Land Ice – David A / McMurdo

This mission is designed to refly ICECAP flightlines over the David Glacier and Drygalski Ice Tongue which were adversely affected by instrumentation problems in those earlier flights. We also extend two lines east into the plateau to collect depth-sounder data over several subglacial lakes.

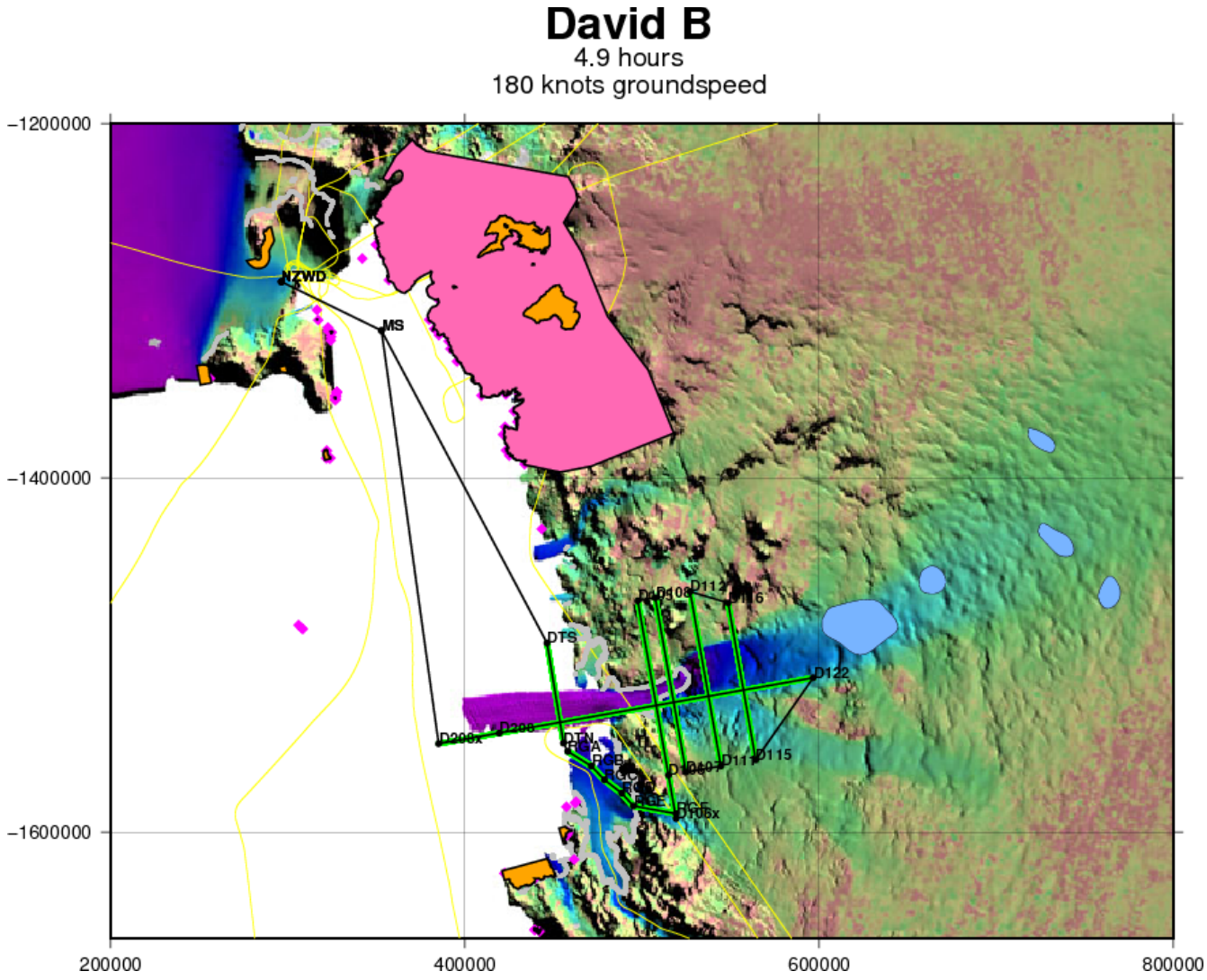
Flight Priority: high
Spacecraft Tracks: none
Last Flown: ICECAP, date unknown
Remaining Design Issues: none



Land Ice – David B / McMurdo

This mission is designed to refly ICECAP flightlines over the David Glacier and Drygalski Ice Tongue which were adversely affected by instrumentation problems in those earlier flights. We also capture a flowline down the Reeves Glacier.

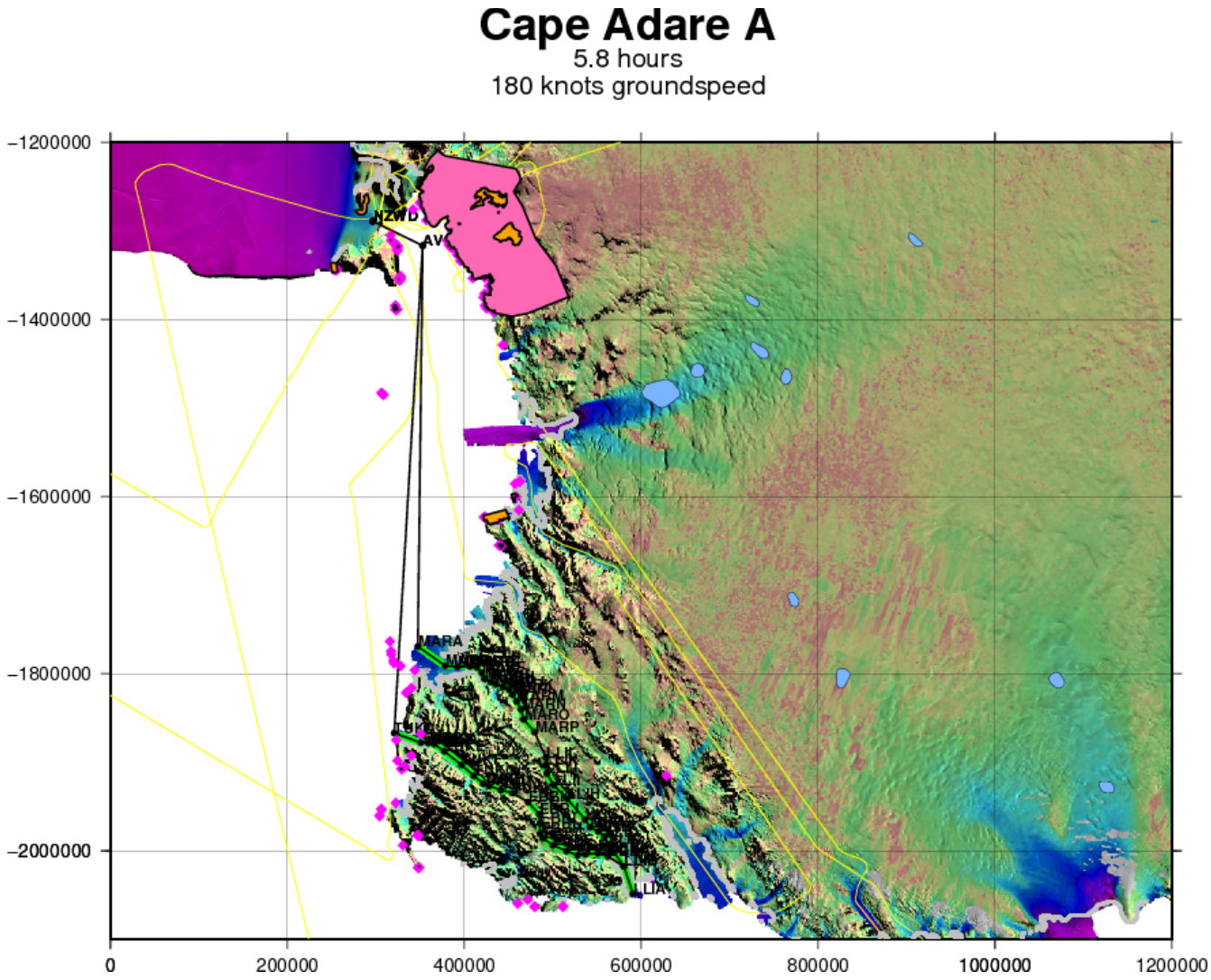
Flight Priority: low
Spacecraft Tracks: none
Last Flown: portions by ICECAP, date unknown
Remaining Design Issues: none



Land Ice – Cape Adare A / McMurdo

This mission is designed to fly the centerlines of the Mariner, Lillie, Ebbe, and Tucker Glaciers, all near Cape Adare.

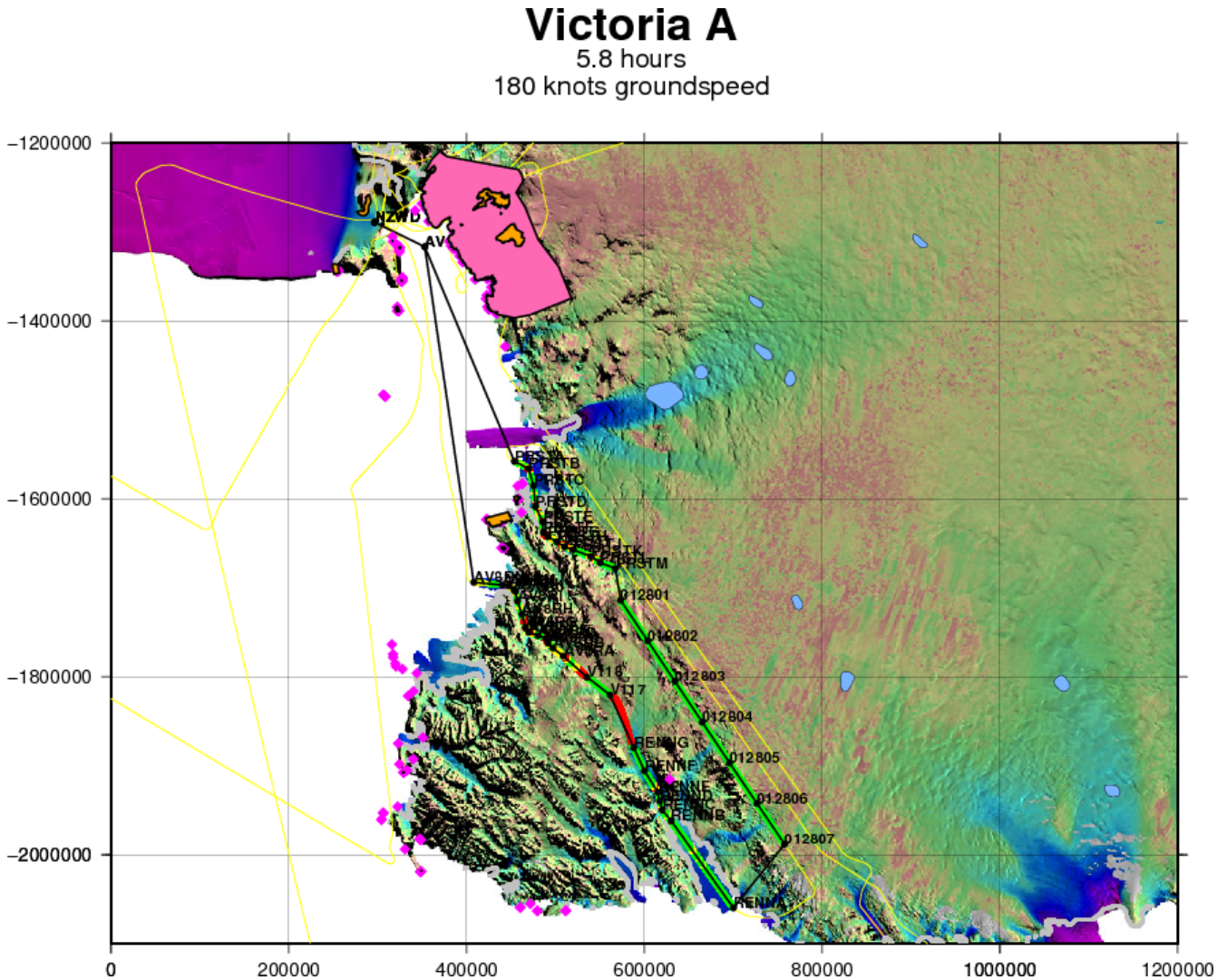
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Victoria A / McMurdo

This mission is designed to sample an ICESat track stretching across Victoria Land from David Glacier to the northern coast. It also flies the centerlines of the Rennick, Aviator, and Priestley Glaciers.

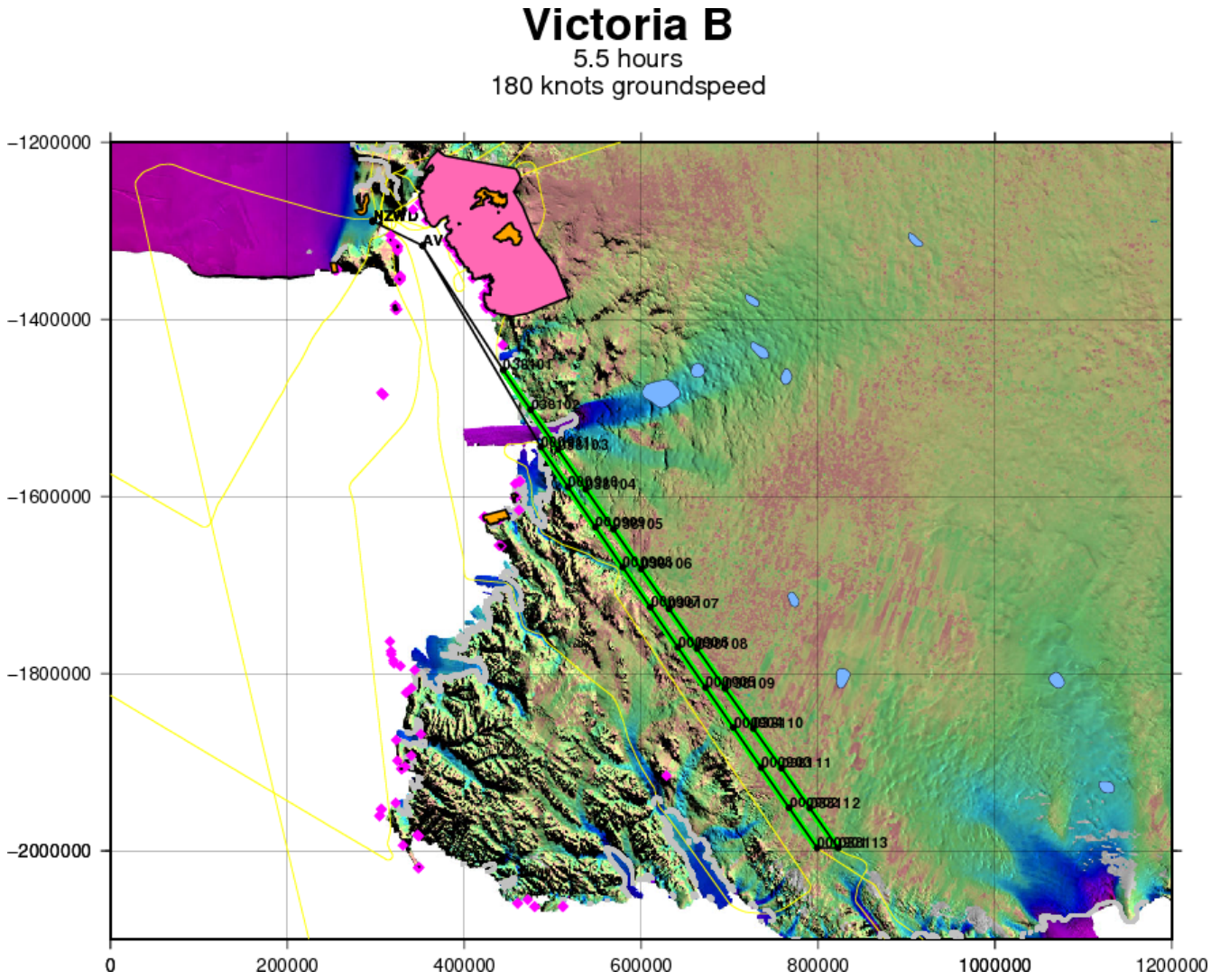
Flight Priority: medium
Spacecraft Tracks: 0128 (IceSat-1)
Last Flown: 2013
Remaining Design Issues: none



Land Ice – Victoria B / McMurdo

This mission is designed to sample a pair of ICESat tracks stretching across Victoria Land from David Glacier to the northern coast, in the region between the Victoria A and Victoria C flights.

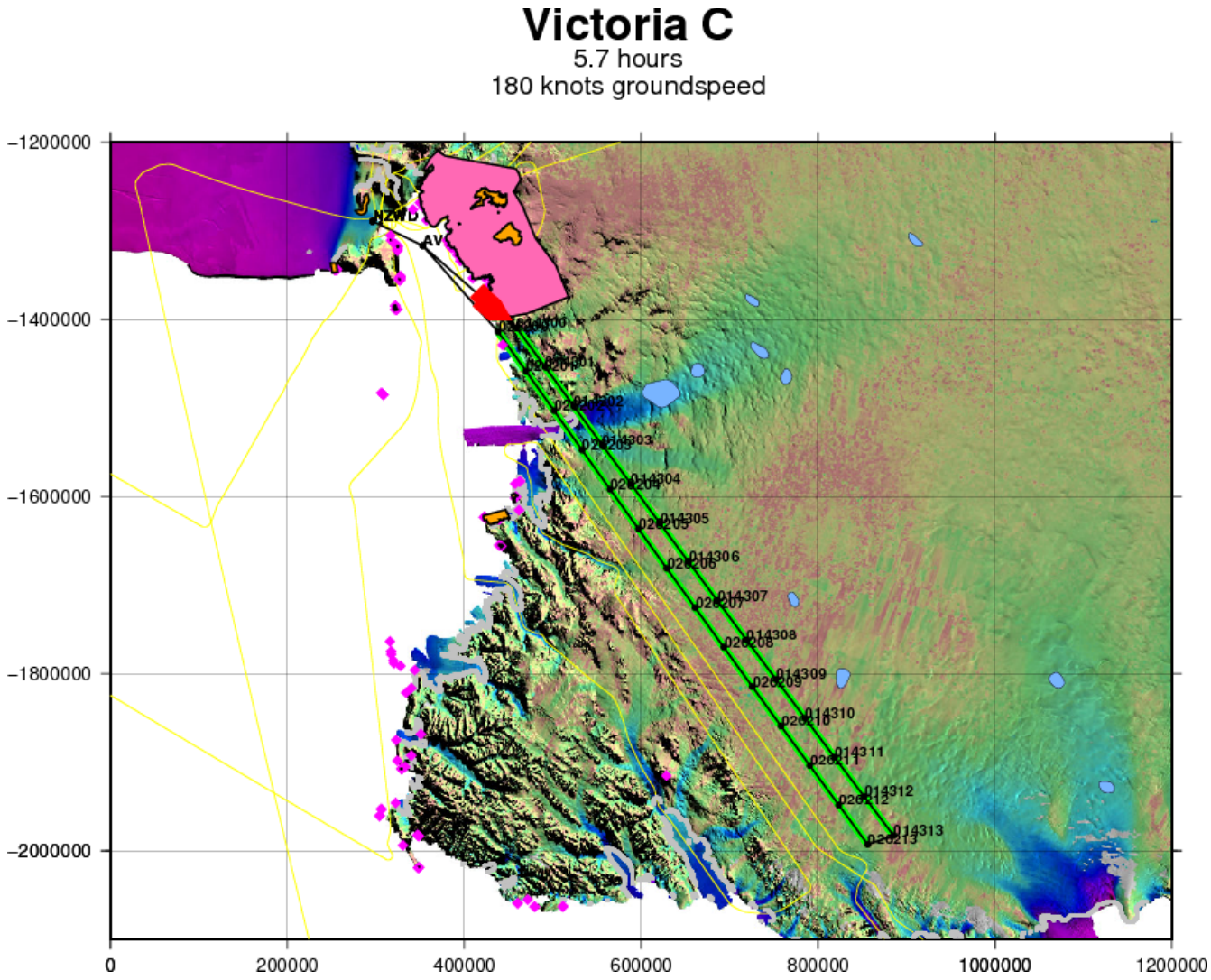
Flight Priority: low
Spacecraft Tracks: 0381,0009 (IceSat-1)
Last Flown: 2013
Remaining Design Issues: none



Land Ice – Victoria C / McMurdo

This mission is designed to sample a pair of ICESat tracks stretching across Victoria Land from David Glacier to the northern coast, in the region between the Victoria B and Victoria D flights.

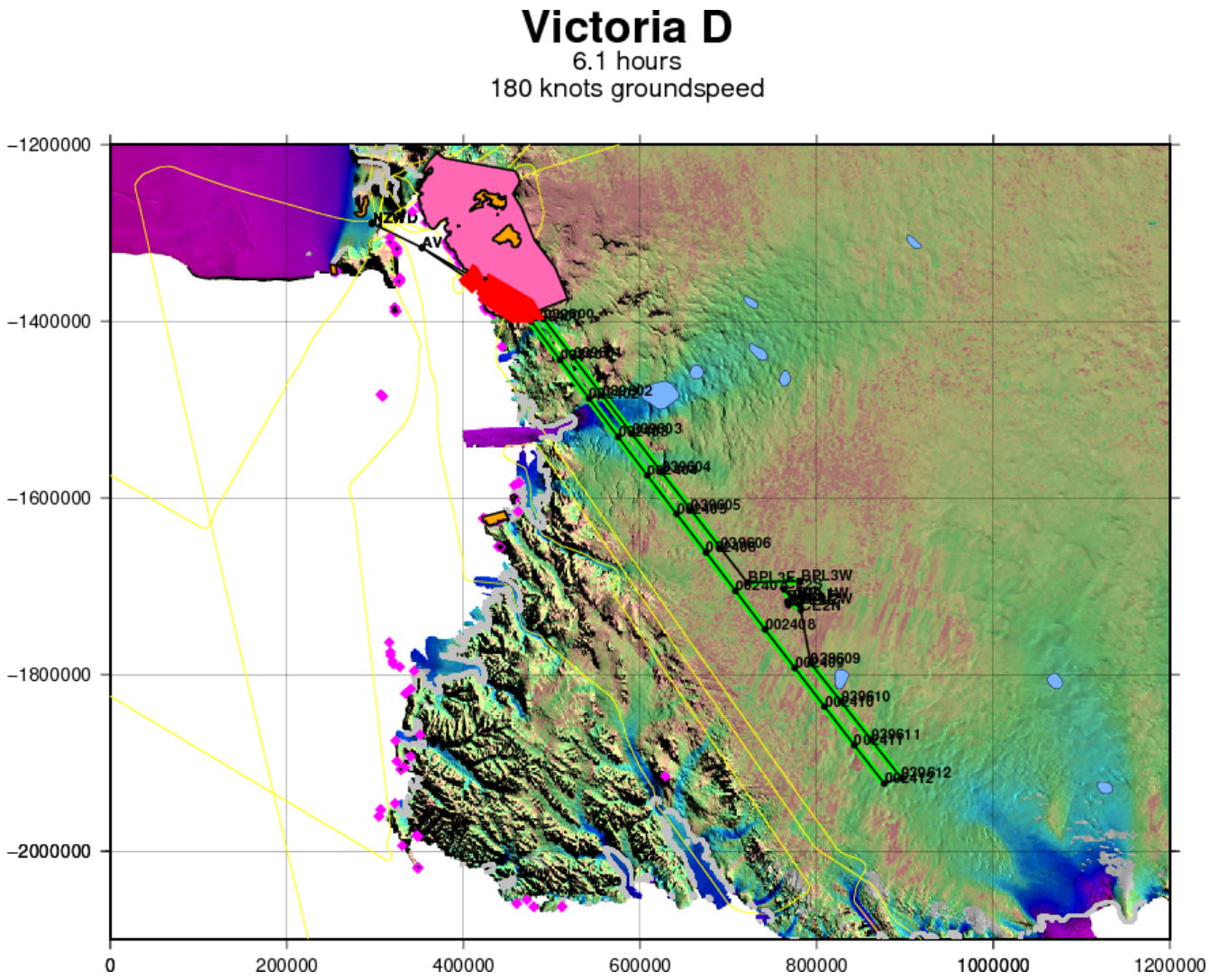
Flight Priority: low
Spacecraft Tracks: 0143,0262 (IceSat-1)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Victoria D / McMurdo

This mission is designed to sample a pair of ICESat tracks stretching across Victoria Land from David Glacier to the northern coast, in the region between the Victoria B and Victoria D flights. We also divert from one of the IceSat lines in order to overfly the Cook E2 subglacial lake along several lines designed to improve knowledge of the lake's geometry.

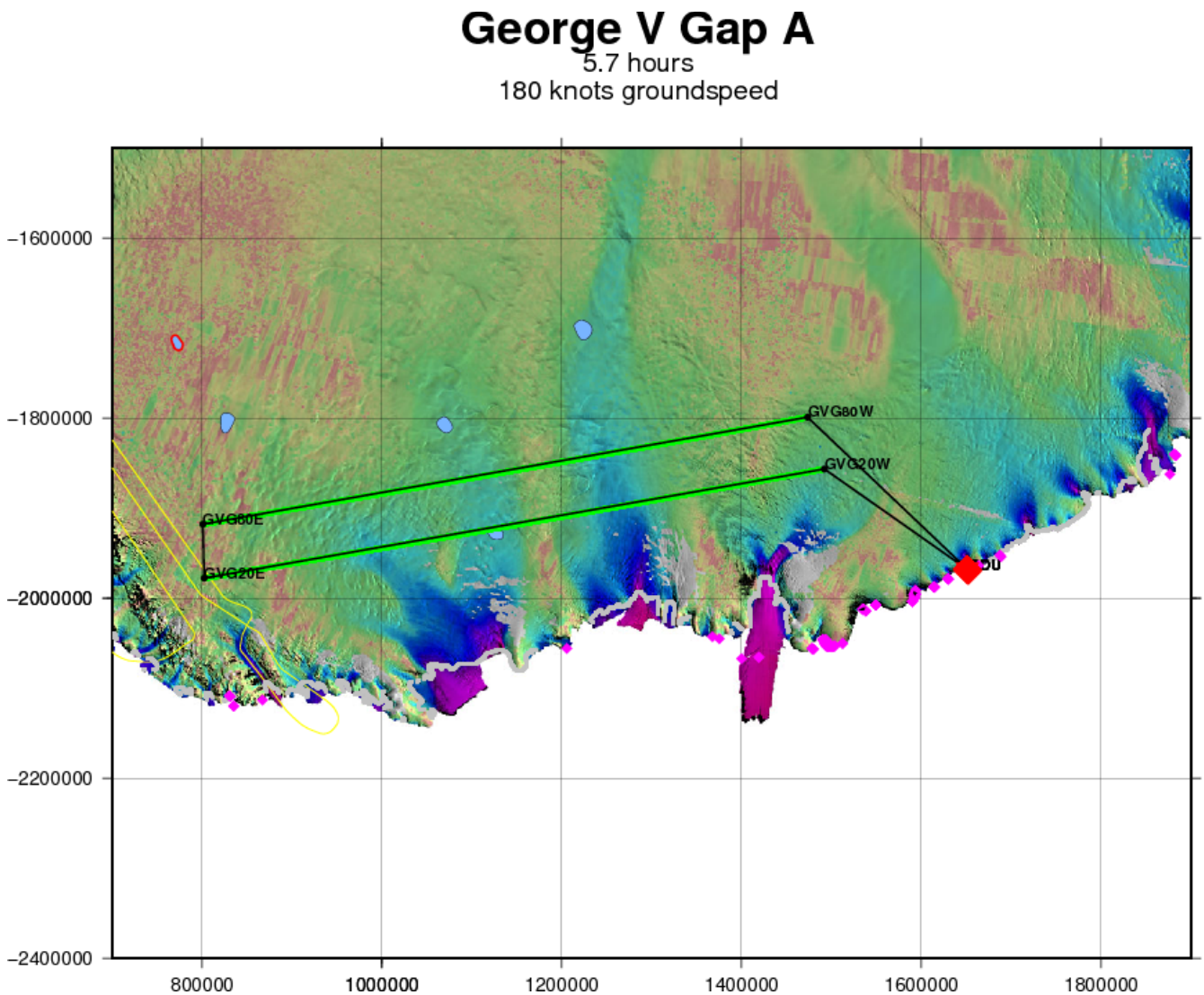
Flight Priority: high
Spacecraft Tracks: 0396,0024 (IceSat-1)
Last Flown: new flight
Remaining Design Issues: none



Land Ice – George V Gap A / Dumont D'Urville

This mission, along with its companion George V Gap B, fills a gap in all-sensor coverage of this portion of Antarctica between prior BAS and ICECAP airborne surveys. The lines in this particular mission lie closer to the the existing coverage on both sides of the gap than those in George V Gap B.

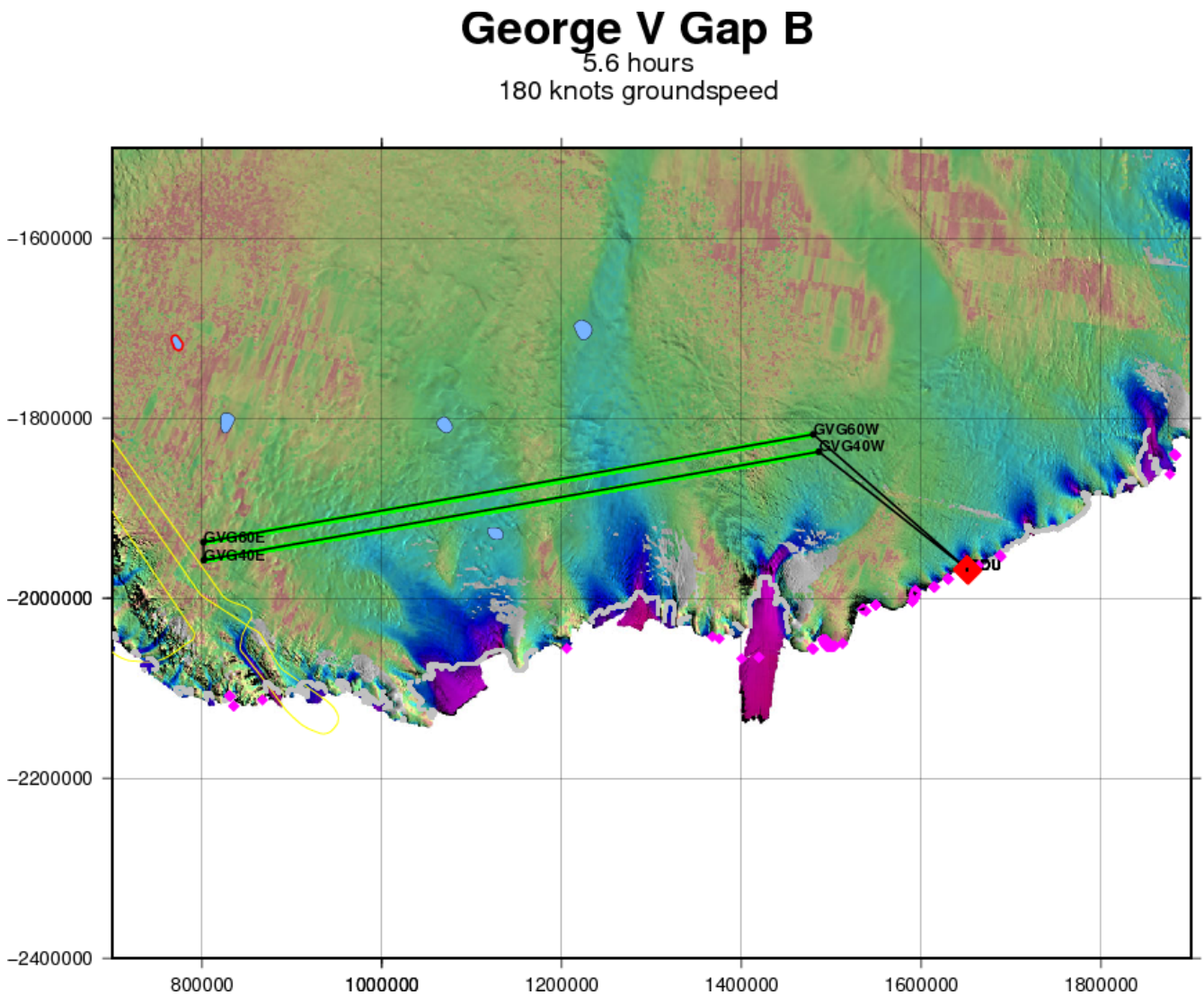
Flight Priority: low
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – George V Gap B / Dumont D'Urville

This mission, along with its companion George V Gap A, fills a gap in all-sensor coverage of this portion of Antarctica between prior BAS and ICECAP airborne surveys. The lines in this particular mission lie in the center of the coverage gap.

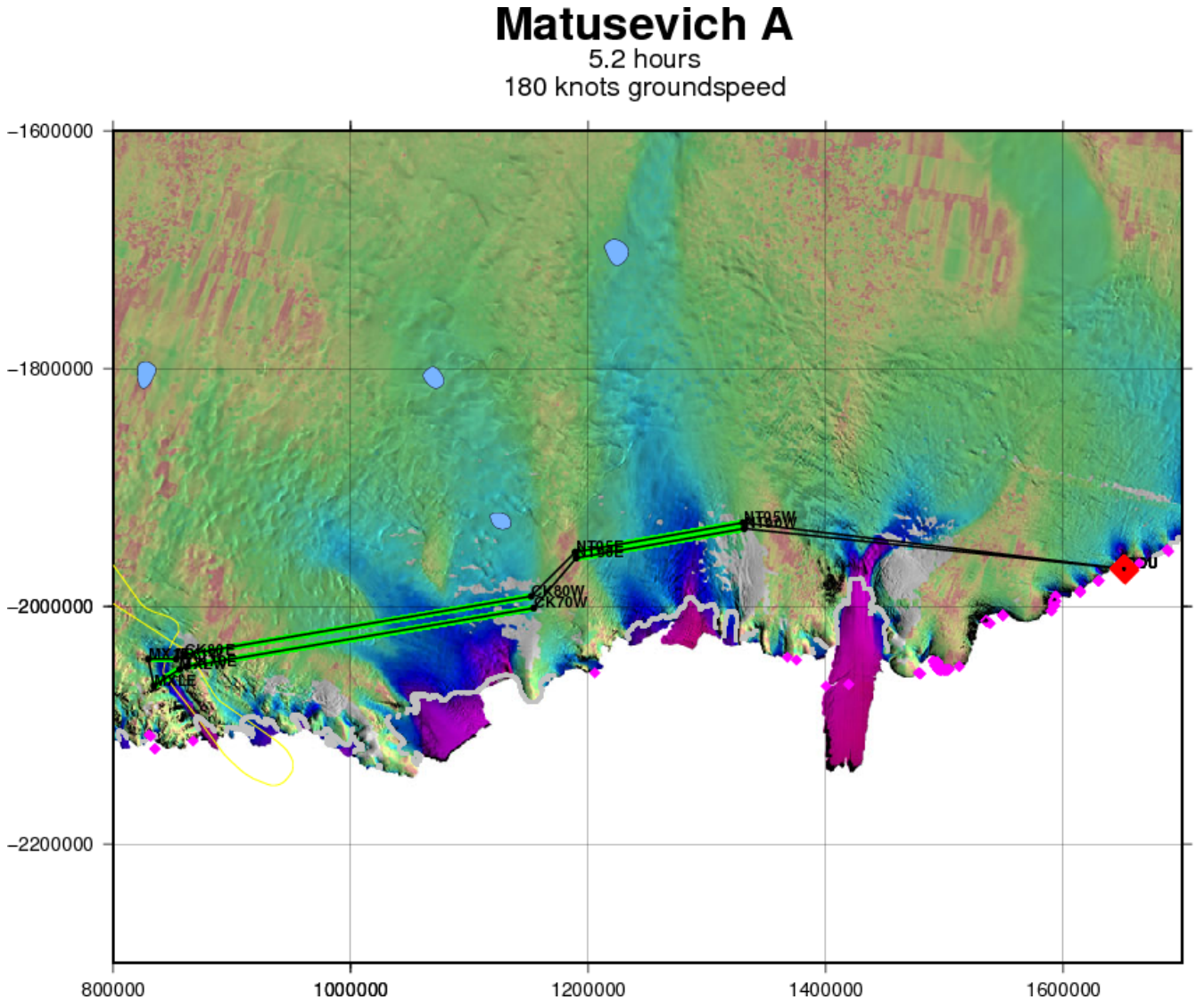
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Matusevich A / Dumont D’Urville

This mission extends the coast-parallel grid densification on Ninnis and Cook Glaciers upstream (improving the ~10 km UTIG grid spacing to 5 km), and also establishes two channel crossings of the Matusevich Glacier.

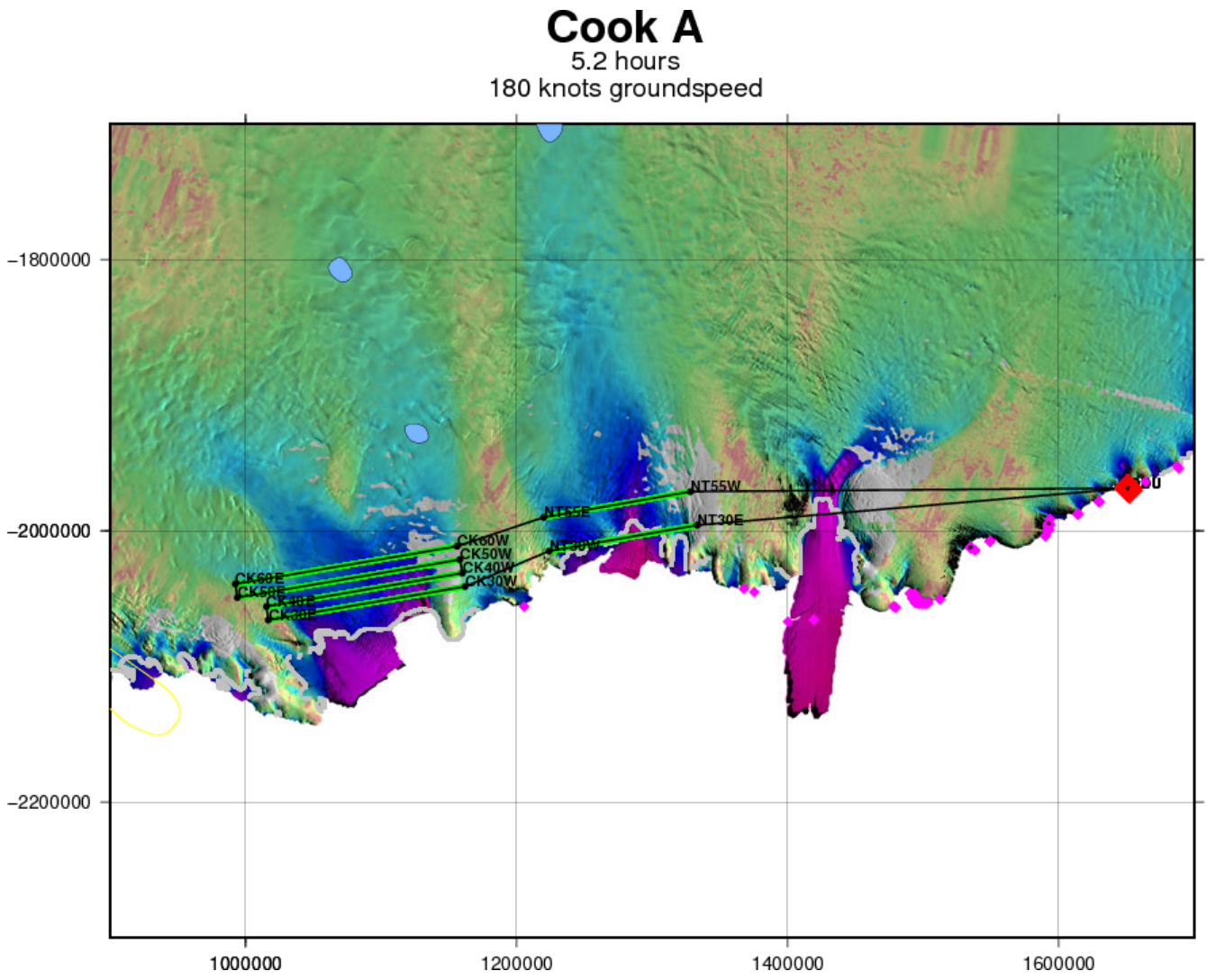
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Cook A / Dumont D'Urville

This mission samples the lower Cook Glacier, improving the density of the initially grid created by UTIG to a spacing of 5 km across the lower portion of the glacier. It also cross the lower Ninnis Glacier along a prior UTIG line for dh/dt and radar intercomparison purposes,and creates a new grid line on Ninnis as well.

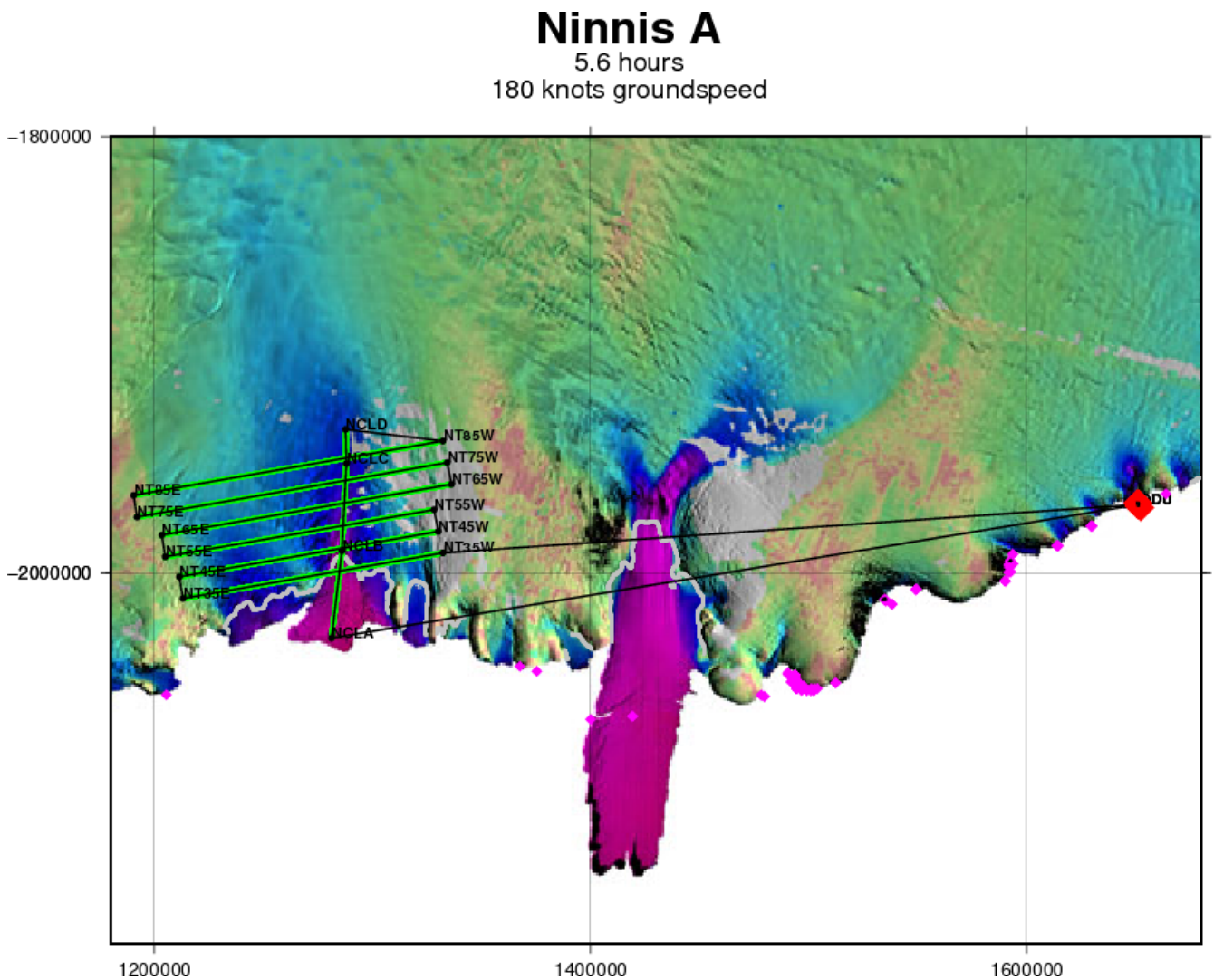
Flight Priority: high
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Ninnis A / Dumont D'Urville

This mission samples the lower Ninnis Glacier along its centerline. It also samples the lower Ninnis along a coast-parallel grid parallel to, and interspersed with, ICECAP flight lines in the vicinity. This grid and the UTIG grid together create a 5 km coast-parallel grid over the lower portion of the glacier.

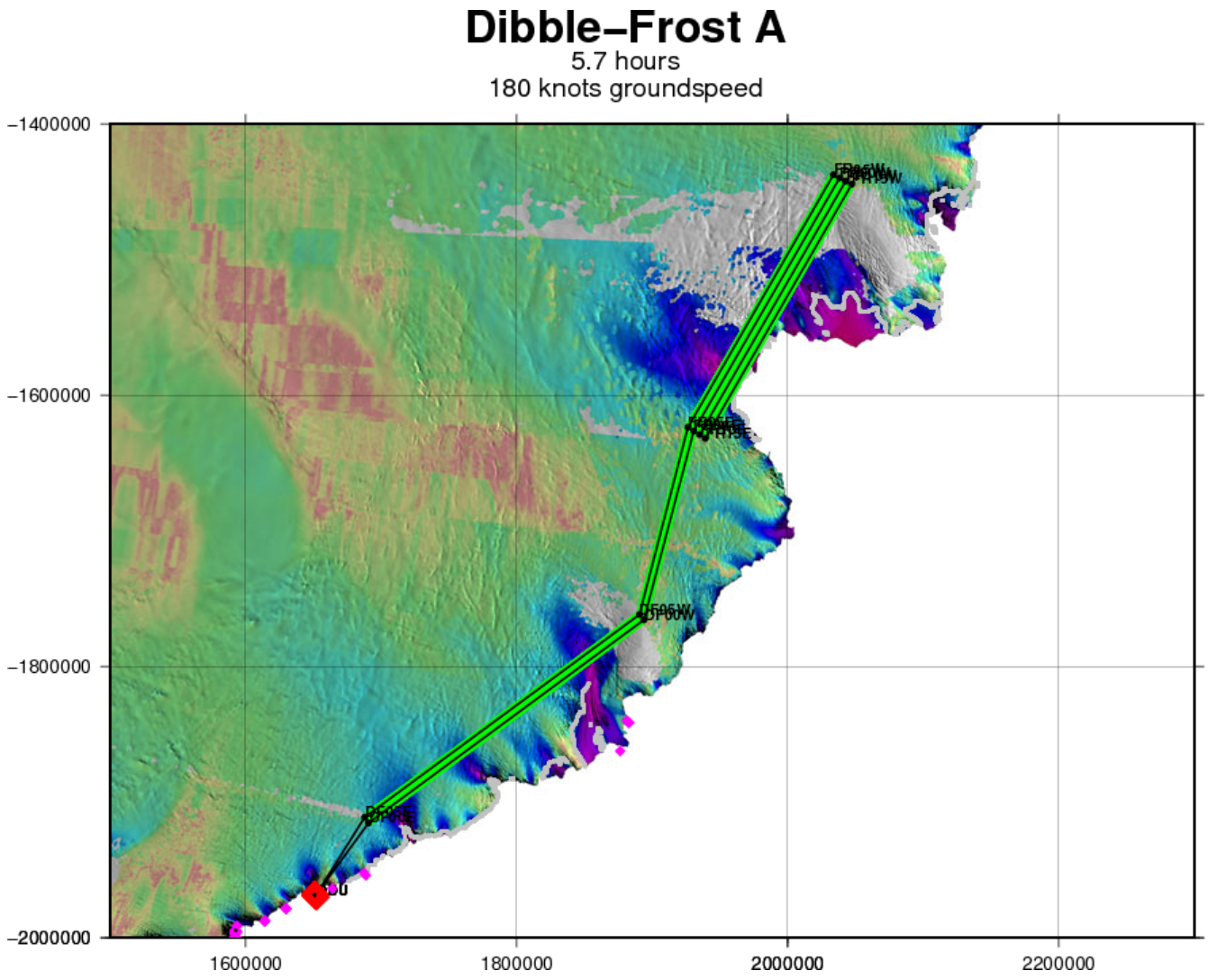
Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
Remaining Design Issues: none



Land Ice – Dibble-Frost A / Dumont D'Urville

This mission samples the Adelia and Clarie Coasts, and is targeted specifically at cross-channel measurements of the Dibble and Frost Glaciers. We also sample the upper portions of the De Haven and Holmes Glaciers. This grid was designed in reference to the previous flights from UTIG in the area, and this flight and the UTIG grid together create a 5 km coast-parallel grid in the area.

Flight Priority: medium
Spacecraft Tracks: none
Last Flown: new flight
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.

At a minimum, flight and science crews will be provided with detailed maps of (a) all science lines, and (b) all terminal (airfield) areas. These maps will show the locations of all known wildlife colonies, ASPAs and ASMAs. ASPAs and ASMAs in these maps will be labeled to conveniently detail any restrictions relevant to flight operations near or above them. The science maps presented in this document, in fact, show most of this content, with wildlife shown as magenta diamonds, ASMAs as pink-filled polygons, and ASPAs as orange-filled polygons. Flight crews, in conjunction with scientists onboard, will pre-plan approach and departure procedures in order to avoid the colonies and comply with the ASMA/ASPA restrictions. They will do the same for turns and other maneuvers around science lines, to ensure that the aircraft does not enter any areas which could cause a conflict.

We also plan to operate a wildlife awareness-oriented moving-map system aboard the Basler aircraft, which is very similar to the technique we rely on for large-aircraft (DC-8 and P-3) operations over Antarctica. This system continuously displays the relative locations of the aircraft and all wildlife colonies and ASPAs/ASMAs both to the flight crew (via yoke-mounted displays) and to the science crew in the aft cabin.

In summary, 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. Otherwise we fly around the protected area in question.