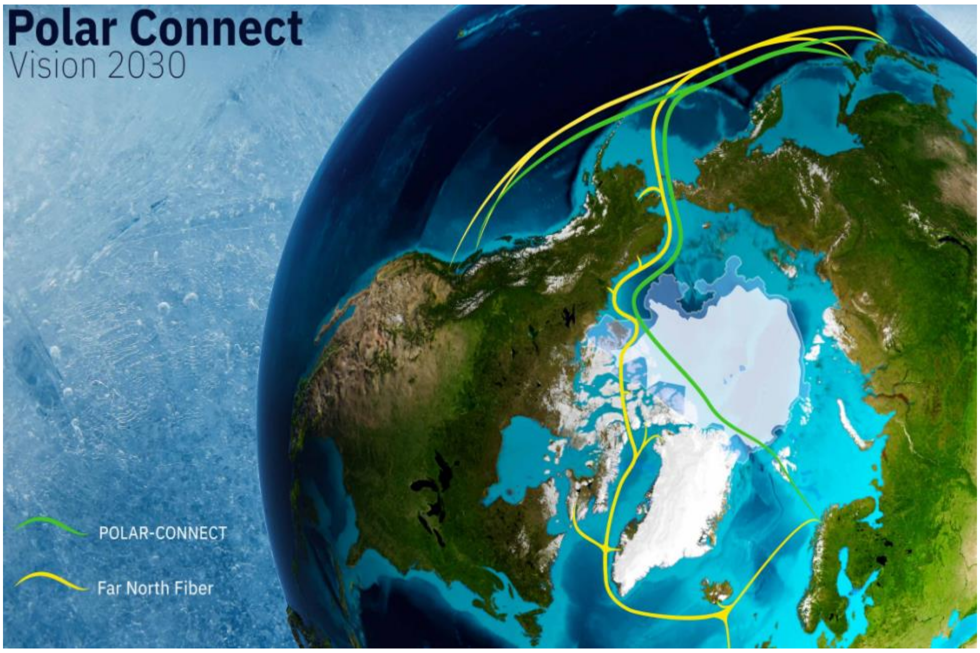

Cable-laying project from Svalbard to the Bering strait through the Arctic Ocean

15 December 2023

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POLARFORSKNINGS SEKRETARIATET
SWEDISH POLAR RESEARCH SECRETARIAT

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Introduction

A submarine cable system is being planned between Europe, Asia and North America via the North Pole[1]. The Swedish Polar Research Secretariat (SPRS) is to provide the ice-breaking solution for this cable-laying project from Svalbard to Bering Strait, Figure 1.

This phase of the project should occur in August or September, as these months typically present the least challenging ice conditions. Still, there will be a lot of heavy ice to handle, including multi-year ice, ridges, and ice drift. Ice conditions refer to ice concentration, thickness, composition, and drift. This, together with weather forecasts, forms the basis for decisions about how the preparatory icebreaking shall be performed.

For the operation to be carried out as safely and efficiently as possible, an Ice Management system[2] must be prepared and in place. The intended Ice Management method is based on knowledge and experience gained in previous polar expeditions by SPRS.

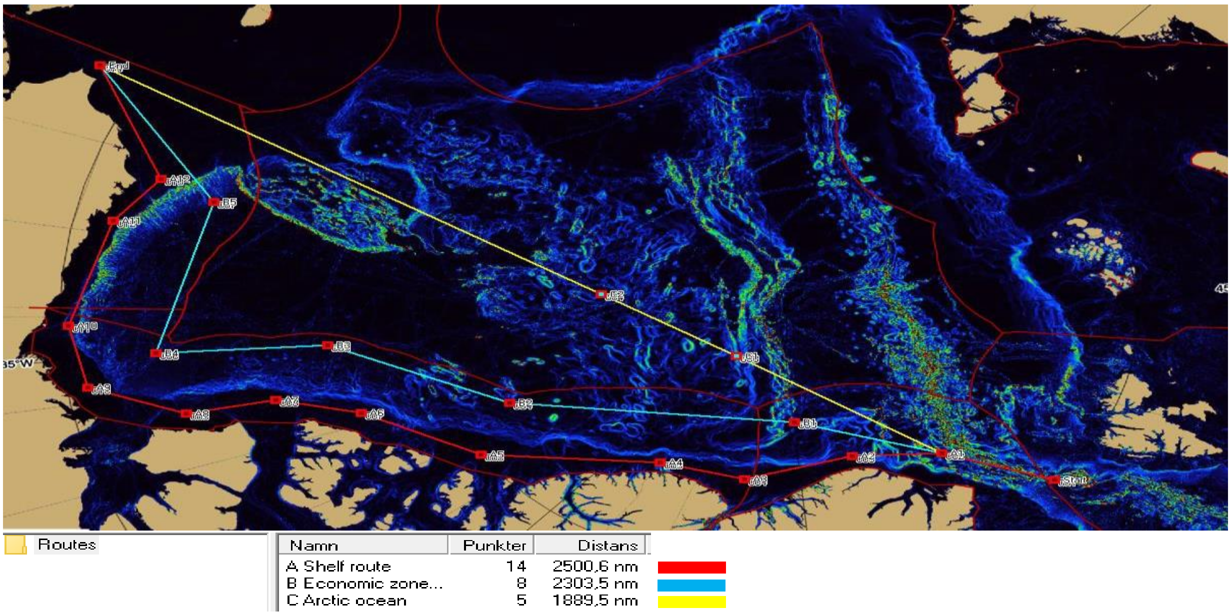


Figure 1. Three potential possible routes for the cable-laying project from Svalbard to Bering Strait

The project is to include a cable-laying vessel Polar-class (PC) 3 or stronger, and two, possibly three, Polar-class icebreakers. Identified vessels that have the potential to act as the cable-laying vessel could be one of the Finnish icebreakers Fennica or Nordica, converted into a cable-laying vessel. The Swedish polar icebreaker Oden will be one of the required icebreakers, and the second Polar icebreaker should be the new Swedish Heavy Polar Research Vessel (hereinafter SHPRV). However, the SHPRV is still not ordered, and the name is not by any means decided, but the ship is expected to be delivered and in service 3-4 years after signing a building contract. A third icebreaker may be needed to provide necessary redundancy during the operation.

[1] More information about the Polar Connect initiative is available at the NORDUnet website.
[2] Ice Management is defined as any activity carried out for the purpose of managing surrounding ice and protecting another entity (in this case, the cable-laying vessel).

Hence, the project requires a set of vessels of which only the two weaker class icebreakers and IB Oden are available outside Russia. Thus, a prerequisite for the project is the completion of the entire process for the new SHPRV, from design, ordering, construction, delivery, and testing to its availability. This comprehensive preparation is necessary due to the severe ice conditions expected in the intended operational area. To ensure the safe and efficient execution of the project, a vessel such as the SHPRV with substantial icebreaking capabilities is crucial, in addition to the other icebreakers.

The duration of the cable-laying operational phase of the project is estimated to be approximately 60 days, excluding the time required for vessel preparation (such as installing equipment), transit to and from the Arctic, demobilization, and other related tasks.

A very rough cost estimate for this phase of the cable-laying project is approximately 1.5 – 2.5 billion SEK. This cost range is attributed to the unpredictable ice conditions in the area, as well as whether the project is completed within the first season or extended to two.

Project timeline (see figure 2):

- Year Zero, ordering the new SHPRV,
- Year 3, icebreaker Oden to map the seabed along the entire planned cable-laying route,
- Year 4, SHPRV together with icebreaker Oden to map the possibly revised cable-laying route, and to gain experience from co-operation in ice-management between the two vessels
- Year 5, the actual cable-laying operation from Svalbard to Bering Strait.

The seabed mapping (Year 3 and Year 4) is necessary to gain knowledge and experience of the seabed conditions and expected ice conditions for all involved parties to be as well prepared as possible.

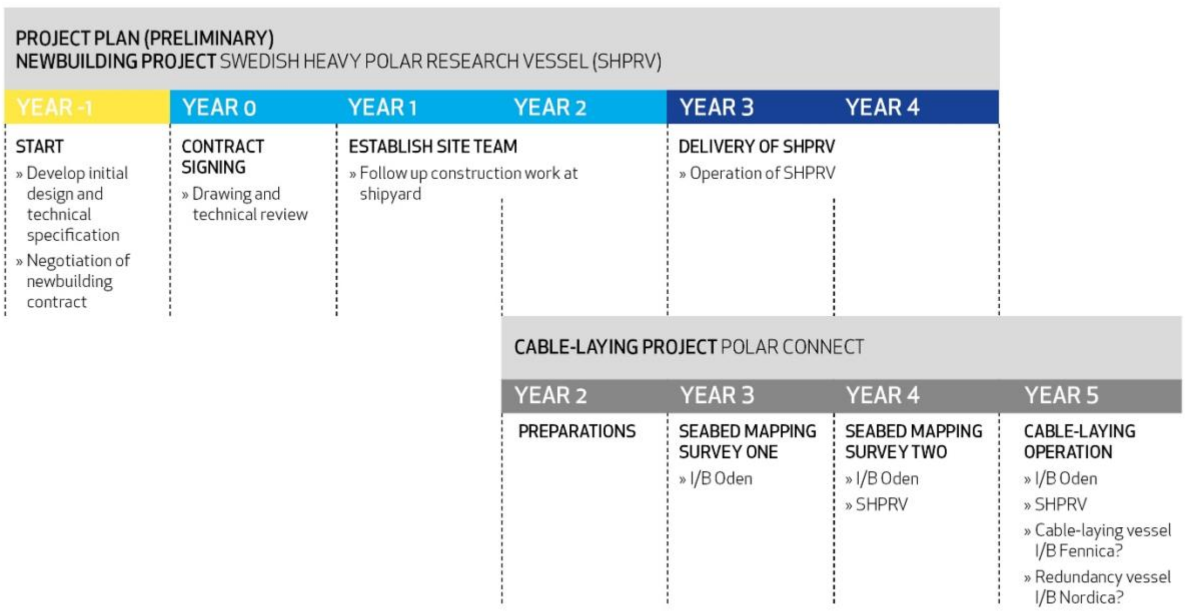


Figure 2. Project Timeline.

Challenges with the Arctic environment

The cable-laying operation is to be carried out from Svalbard to Bering Strait through the Arctic Ocean as close as feasible to the North Pole to get the shortest route. See Appendix I – Cable routes.

Operations in the Polar region must be safe. Therefore, the following must be taken into consideration:

- Ice conditions in this area are amongst the toughest in the world, if not the toughest. The closer we get to the northern part of Greenland, the tougher the ice conditions will be.
- Statistics based on ice charts indicate that the operation should be scheduled to take place from the beginning of August to the end of September, as the ice coverage usually reaches its minimum extent during this period.
- The ice conditions will include severe incursions of first-year, second-year, and multi-year ice. First-year ice is soft and plastic; second-year ice has survived one melting season, making it harder and less plastic; and multi-year ice has endured at least two melting seasons, rendering it as hard as concrete. Additionally, the ice comprises of ice ridges, growlers, icebergs, hummocks, rubble ice, and other elements. These features drift around within the ice, and their presence isn't always readily apparent.
- In the Arctic, good visibility can quickly change to poor visibility due to fog and snowstorms.

Consequently, the Arctic poses challenges for predictability in operating areas, requiring consideration of actual ice conditions when planning operations. This consideration is crucial not only for long-term planning but also, perhaps more significantly, for short-term adjustments—meaning daily and/or even hour-by-hour adaptations—during operations, depending on the actual ice condition at the time.

Ice drift in the Arctic refers to the movement of sea ice across the Arctic Ocean. This movement is primarily driven by ocean currents and wind patterns. There are several factors influencing the Arctic ice drift. One is the Beaufort Gyre, a major clockwise ocean circulation pattern causing a circular ice drift. Another factor is the Transpolar Drift Stream, which is a major ocean current that transports ice from the Russian Arctic to the Canadian Arctic Archipelago. Furthermore, wind patterns also have a significant impact on ice drift. Strong winds can push ice to move faster and in specific directions causing ice to pile up as well as create leads and cracks in the ice.

Ambient temperatures for the operational time period are not considered to be an issue even though it will be below zero degrees Celsius. However, ice aggregation on the vessel's superstructure[3] might occur under certain conditions. Water temperatures will be just above or below zero degrees Celsius.

[3] The superstructure is the ship's main area, which holds the accommodation and bridge of the ship.

Cable laying route

The planning of the project begins with defining different routes. The first one is off the coast of Greenland, Canada, and the US, the second lies within the economic zone of Greenland, Canada and the US, and the third route goes through the western part of the Arctic Ocean. Information on the distance and ice coverage of the defined routes are gathered, giving a statistical basis for the expected ice conditions and duration of the cable-laying operation. The defined routes are also evaluated from the seabed condition along the respective route. It may be necessary to work with a "best/medium/worst" scenario due to the large differences in ice conditions between different years. See Appendix I – Cable routes.

It goes without saying that the cable-laying route should be the route that is the shortest feasible, that has the most optimal ice conditions, and have acceptable seabed condition.

Possible routes (see Appendix 1)

The first route is concentrated on the shelves of Greenland, Canada, and the USA. This route is the most unrealistic and unsuitable for both the cable and impossible for the ships that will perform the offshore operation. The seabed on this route is affected by grounded icebergs and sea ice that forms ice ridges that can be as deep as it can affect the seafloor. A large portion of the seabed on this route is also unknown. The nature of the ice in this part of the Arctic Ocean is the toughest in the whole Arctic region, regarding glacial and sea ice. It is also the longest route, about 2500 Nm.

The second route is within the economic zone of Greenland, Canada, and USA. This route is better in one way and that is that the cable will be laid in deeper waters. The disadvantage of this route is that a very large part of it is unmapped and affected by severe ice conditions. This route is about 200 Nm shorter than the shelf route, about 2300 Nm.

The last and the most favorable of the three routes is the one that crosses through the western part of the Arctic Ocean. The ice situation on this route is still severe and will be challenging for the offshore operation, but it is not as unrealistic as the first two routes. This route is about 1900 Nm and thus 600-400 Nm shorter than the other two.

Preliminary conclusions on the cable laying route (see Appendix 1)

When it comes to calculating time consumption for all the routes, it is necessary to do a more thorough study regarding seafloor nature, i.e., subsea obstructions and hazards such as mountains, slopes, canyons, volcanic or other seismic action. The ice on the sea surface also needs to be studied in terms such as the amount of glacial ice, the amount of old, medium, and young ice, and ice formations such as ridges, hummocks, thickness, etc.

Just to give an idea about the time for laying the cable, this study has used two-speed options of 1 kn[4] and 2 kn. None of these speeds can be guaranteed without further studies and field tests; one must bear in mind that nature rules in this part of the world. What seems to be possible one year can be totally impossible the next.

Route 1. 2500 Nm = with 1 kn. = 104 days with 2 kn. = 52 days (Unrealistic)
Route 2. 2300 Nm = with 1 kn. = 95 days with 2 kn. = 47 days (Extremely hard)
Route 3. 1900 Nm = with 1 kn. = 79 days with 2 kn. = 39 days (Hard but most favorable)

[4] Knot (kn) – a unit of speed equal to one nautical mile per hour.

Vessels required for the cable-laying operation

In order for the cable-laying operation to be carried out, it is estimated that the fleet for the operation should consist of 1) a cable-laying vessel with the capacity to operate in Arctic ice conditions, 2) an "Oden-class" Polar icebreaker (IB Oden), and 3) a heavy Polar icebreaker (SHPRV). An additional icebreaker may be required for redundancy purposes.

Cable-laying vessel

Cable-laying vessels for operating in Polar ice conditions are difficult to find. A possible solution could be to install cable-laying equipment on an icebreaking vessel such as IB Fennica or IB Nordica. The company that will produce, deliver, and lay the cable has to confirm the feasibility of the vessel, i.e., that the vessel has enough deck space, deadweight, stability and power for the cable-laying equipment, including storage of the cable itself. It is also important to install equipment that protects the cable from ice when it passes through the water's surface.

Technical features (IB Fennica and IB Nordica)

Ice class Icebreaker POLAR 10 (equivalent to PC3), Special Purpose Ship (SPS), Accommodate 77 persons onboard, Icebreaking capacity continuous speed in 1.8 m first-year ice thickness,

Main particulars

Length overall	about 116.00 m
Breadth at main deck	about 26.00 m
Draught, design	about 8.40 m
Propulsion power	15 MW (two thrusters with nozzles)
Installed power	about 21 MW

The Polar Icebreaker Oden

Technical features

Ice class Icebreaker POLAR 20, equivalent to IACS Polar Class (PC2), Special Purpose Ship (SPS), Certified for 75 persons, Icebreaking capacity 3 knots in 1.9 m first year ice thickness, Endurance 100 days, Heeling system, Water lubrication system.

Main particulars

Length overall	about 108.00 m
Breadth at main deck	about 29.40 m
Draught, design	about 8.50 m
Propulsion power	18 MW (two CP Propellers in nozzles)
Installed power	about 23 MW

The Swedish Heavy Polar Research Vessel (SHPRV)

(Could be delivered from a shipyard minimum 3 years after signing the new building contract.)

Technical features

Ice class PC2 +, DP2, Special Purpose Ship (SPS), Cabins (40 single beds, 30 double beds), Icebreaking capacity 3 knots in 2,5 m first year ice thickness, Endurance 100 days, Open deck area 2000 sqm, Moonpool 7,2 m x 7,2 m, Heeling and anti-rolling system, Water lubrication system.

Main particulars

Length overall	about 160.00 m
Breadth at main deck	about 32.00 m
Draught, design	about 10.50 m
Propulsion power	40 MW (two azimuthing thrusters each 13 MW and one center propeller 14 MW)
Installed power	about 42 MW methanol/diesel gensets and 5 MWh battery

See Appendix 2 Pre-feasibility study for a polar research vessel POLAR RESEARCH VESSEL, DATA SHEET

Description of the project timeline (figure 2)

Year -1 Decision to order SHPRV

Develop Initial Design and Technical Specification. Negotiation of Newbuilding Contract. Nomination of Shipyard.

Year 0 Contract signing with the Shipyard for the Construction of the SHPRV

Drawing and technical review by the ship-owner's representatives

Year 1 Establish Site Team at the Shipyard

Follow up construction work at Shipyard until delivery from shipyard.

Year 2 Start preparations for the Cable-Laying Project

Establish ice management and cable-laying procedures and identify cable routing alternatives.

Year 3 Seabed Mapping I

Mapping of the seabed conditions along the intended route using IB Oden. Evaluate ice conditions and cable routing. The seabed mapping will benefit from previous sea floor mapping with IB Oden performed in some parts of the area since 2007.

Year 4 Seabed Mapping II

Mapping of the seabed condition along the revised intended cable routing using the new SHPRV together with IB Oden. Evaluate ice conditions and cable routing.

Year 5 Cable-Laying Operation

The cable-laying operation using the prepared route and ice management procedure.

Year 6.

Option for all vessels to be chartered similar to Year 5. This option is to be executed if the cable-laying operation in Year 5 must be interrupted.

The reasons for the above preparations during years 2, 3 and 4 are:

- Thorough mapping of the seabed condition for the intended cable-laying route. Possibility for re-routing.
- Knowledge and experience gathering for the crews under actual conditions. Crews from all three/four vessels to participate during these preparation runs.
- Making sure that the new SHPRV have tested all its systems under actual conditions prior to the cable-laying operation.
- Familiarization of the crew onboard the new SHPRV.

The Cable-Laying Operation

The distance from Svalbard to Bering Strait is estimated to be about 2,000 nautical miles and will probably be longer due to both ice and sea bottom conditions. A distance of approximately 2,500 nautical miles has to be expected. It can be assumed that the operation can maintain an average speed of 2 knots, giving a duration of the operation of approximately 60 days, whereas at least half of it will be in heavy ice-covered waters.

From Svalbard, the cable-laying vessel follows the planned route along the mapped seabed. Three different options are discussed in Appendix 1. The vessel is accompanied by IB Oden, which is responsible for removing any minor ice obstacles that might occur. Meanwhile, SHPRV has started reconnaissance of ice conditions in the ice-covered area along the planned route.

As the cable-laying vessel and IB Oden approach the “ice edge”, there is already an ice broken area created by the new SHPRV, where Oden and the cable-laying vessel can enter the ice-covered area, Figure 3. The operation now shifts to ensuring that the cable continues to be laid according to the planned route, taking into account prevailing ice conditions. The new SHPRV goes first for reconnaissance and a first breaking of heavier ice. Next comes IB Oden, who ensures that the cable-laying vessel is able to proceed through the ice without getting stuck. When the “convoy” finally leaves the ice-covered area, one of the icebreakers might leave and the other one follows to protect the cable-laying vessel from drifting ice. Also, a third icebreaker is recommended to be used for additional “scouting” purposes, to identify and manage severe ice obstacles (not included in pictures 3 and 4 a-b).

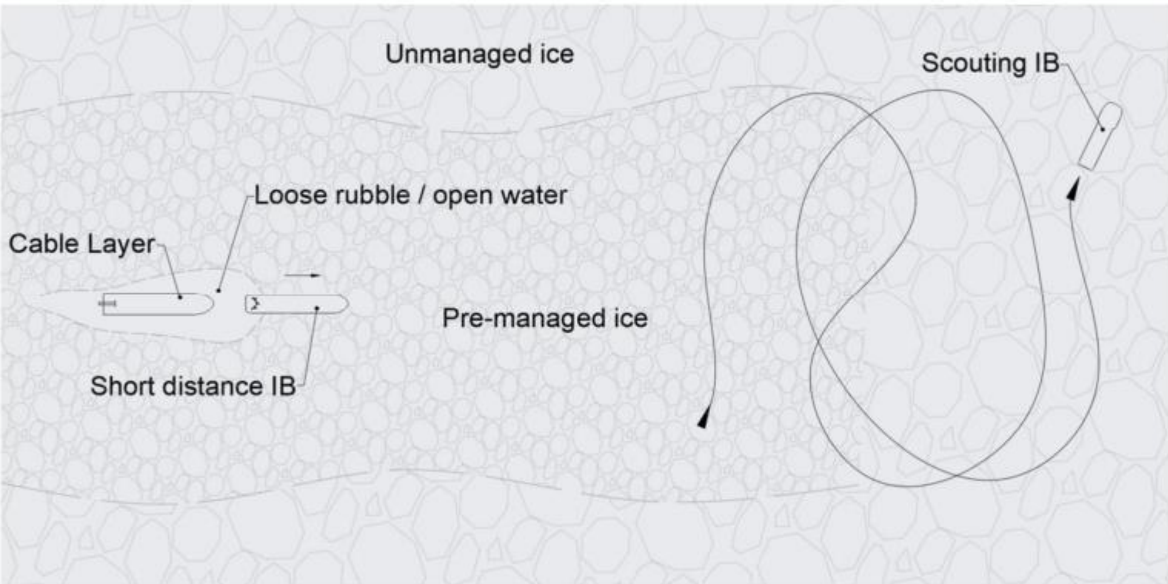


Figure 3. As the cable-laying vessel and IB Oden approaches the “ice edge” there is already an ice broken area where IB Oden and the cable-laying vessel can enter the ice-covered area.

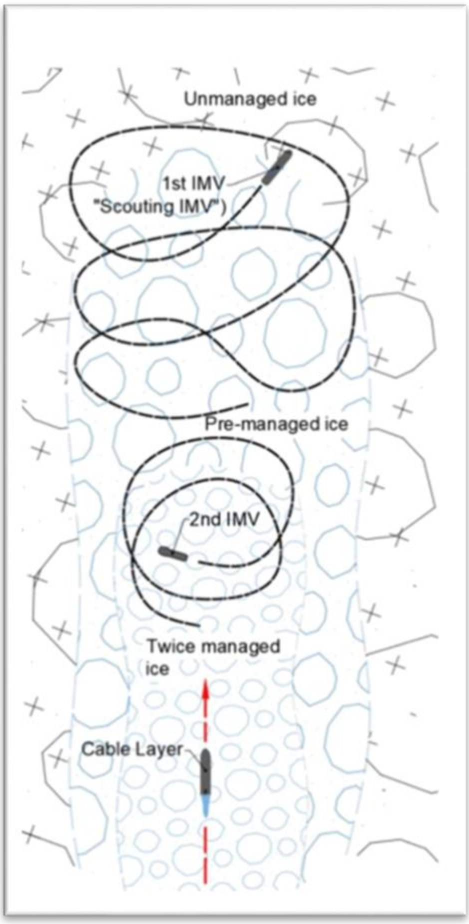


Figure 4a. Normal Ice Management.

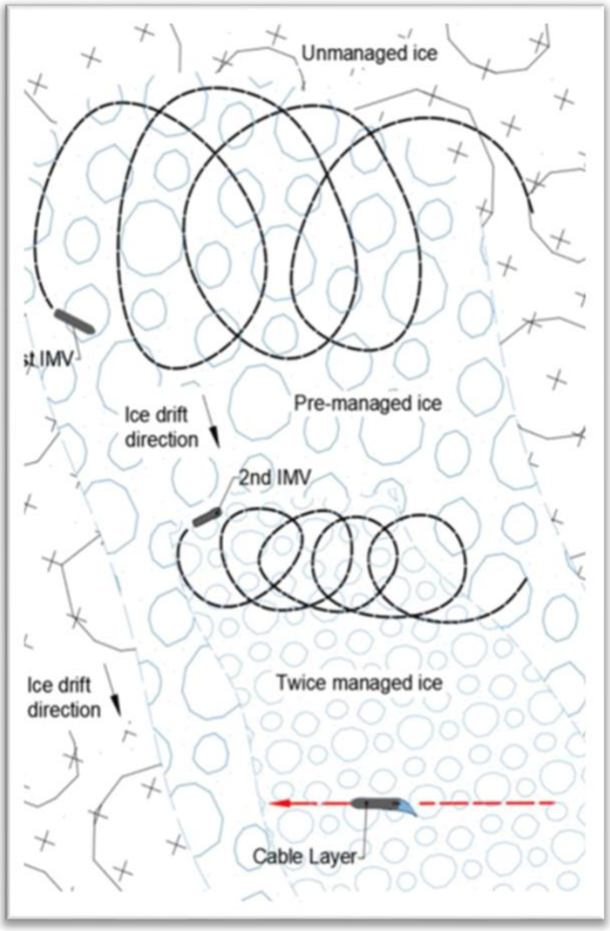


Figure 4b. Ice Management for drifting ice from other directions than ahead.

In order for the operation to be carried out as efficiently as possible, extraordinarily accurate weather and ice forecasts are required, both long term but above all short term for the immediate area where the cable is to be laid. The method intended to be used to predict and handle the ice conditions is based on knowledge and experience gained in previous expeditions by SPRS with regard to "Ice Management (IM)". In addition, data collected during the expeditions in Year 3, Seabed Mapping I, and Year 4, Seabed Mapping II, are to be incorporated.

See Appendix 3 Pre-feasibility study for a polar research vessel CABLE LAYER ICE MANAGEMENT PROTECTION.

The purpose of IM is to ensure that, as far as possible, the unpredictable Arctic ice conditions become as predictable as possible to ensure that the project of laying the communication cable is carried out as efficiently and safely as possible.

If the ice conditions get too severe and the cable vessel cannot follow the intended mapped route, there will be a procedure for cutting and disconnecting the cable. The cable shall be able to be retrieved and reconnected at a later stage, when ice conditions are manageable again. This reconnection might be done a few days later or, in the worst case, not until next year's season. Therefore, an option to employ all involved vessels for a second year needs to be in place and considered by the project. The employment is to be similar to Year 5.

Charter of vessels

The first vessel to be chartered by the Polar Connect project is IB Oden. It will conduct "Year 3 Seabed Mapping I" (see figure 2) to investigate the suitability of the seabed for the cable-laying route. At the same time, it will document the encountered ice and environmental conditions along the route. Data will be used to decide if the route has to be altered and form a basis for the ice management system to be further developed. The duration of the employment is estimated to be about 4 months.

"Year 4 Seabed Mapping II" will be performed by IB Oden together with the new SHPRV. This Seabed Mapping is performed to verify the "final" cable-laying route and to refine the ice management system under actual conditions. The new SHPRV and its systems will also be tested under field conditions. Data to be used for increased refining of the Seabed conditions for the cable-laying and the Ice Management procedures. The vessel employment duration is estimated to be 4 months each.

During the above two expeditions, crew members from all employed vessels in the project should be onboard to gain knowledge and experience of the ice conditions that they will encounter during the cable-laying operation. They will also get an understanding of what is required to lay a cable under these conditions and an insight into the Ice Management System.

"Year 5 Cable-Laying Operation" is planned as follows. First, it is worth to note that there is no cable-layer in the required ice class on the market. To ice strengthen an existing cable-layer would require taking it out of service for a certain period before the assignment execution in Polar Connect, in order to perform the ice-strengthening work on a shipyard. The modifications would result in an increase in the costs of the Polar Connect project since the project would have to cover the loss of income for the cable-layer during the time it cannot be used for other commercial projects.

Secondly, any damage that may occur even to an ice-strengthened cable-layer in the extreme polar environment means that planned commercial projects for the cable-layer after the Polar Connect project may be jeopardized.

Thirdly, an ice strengthened cable layer would be less suitable for future operations that not require an ice-strengthened vessel.

With that in mind, it is an advantage to use an existing icebreaker in a sufficient ice class and to temporarily convert that icebreaker into a cable-layer. An already built icebreaking vessel is easier to make available for the conversion because some icebreakers are idle off season when the cable-laying vessel conversion, the cable-laying operation and the de-conversion must take place. A capable icebreaker, like the Finnish IB Fennica or IB Nordica, hence needs to be converted into a cable-laying vessel.

The chosen vessel has to be contracted by the project so that it is available at least four months before the actual cable-laying operation is due to start. The total employment time for one of the two Finnish type vessels is estimated to be about 9 months.

IB Oden, the new SHPRV and the third icebreaker for redundancy purpose, e.g. one of the two Finnish type vessels, have to be employed for 4 months each.

Year 6: If the cable-laying operation in Year 5 must be interrupted for any reason, the option to employ all involved vessels for an additional year has to be in place to be able to finalize the cable-laying operation.

Charter cost summary

Charter: Oden

Year 3: 4 months
Year 4: 4 months
Year 5: 4 months
Total: about 12 months, cost approx. 350 MSEK

Charter: New SHPRV

Year 4: 4 months
Year 5: 4 months
Total: about 8 months, cost approx. 550 MSEK

Charter: Cable-Layer Vessel (including time for conversion)

Year 5: 9 months
Total: about 9 months, cost approx. 250 MSEK excluding cost for cable-laying equipment, installation and removal of the same

Charter: Icebreaker for redundancy

Year 5: 4 months
Total: about 4 months, cost approx. 100 MSEK

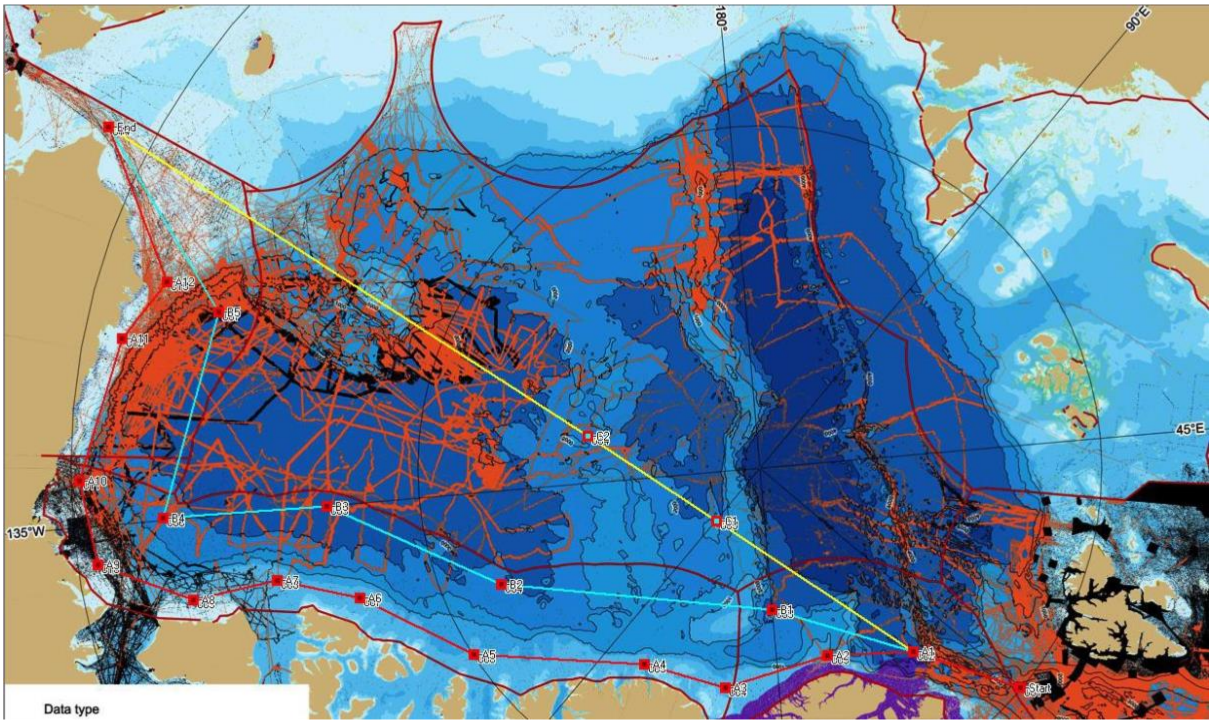
Required steps

For the realization of the project, the following steps must be executed.

1. Decision to order the new SHPRV (see Appendix 2)
2. Decision on cable-laying route (see Appendix 1)
3. Decision to order the cable
4. Negotiate chartering contracts with the involved vessels
5. Specify cable-laying equipment, including a description of the installation
6. Develop detailed operational procedures for the cable-laying
7. Develop operational procedures for Ice Management

Appendix 1. CABLE ROUTES

This is a rough study regarding three different routes for a fiber cable to be laid through the Arctic Ocean. Due to the current geopolitical situation, the study must keep the routes on the western part of the Arctic Ocean.



Red route (on Shelf) 2500nm, **Blue route** (in economic zone) 2300nm and **Yellow route** (International water) 1900nm.

The first route is concentrated on the shelves of Greenland, Canada, and the USA. This route is the most unrealistic and unsuitable for both the cable and impossible for the ships that will perform the offshore operation. The seabed on this route is affected by grounded icebergs and sea ice that forms ice ridges that can be as deep as it can affect the seafloor. A large portion of the seabed on this route is also unknown. The nature of the ice in this part of the Arctic Ocean is worst in the whole Arctic region, regarding glacial and sea ice. It is also the longest route, about 2500 Nm.
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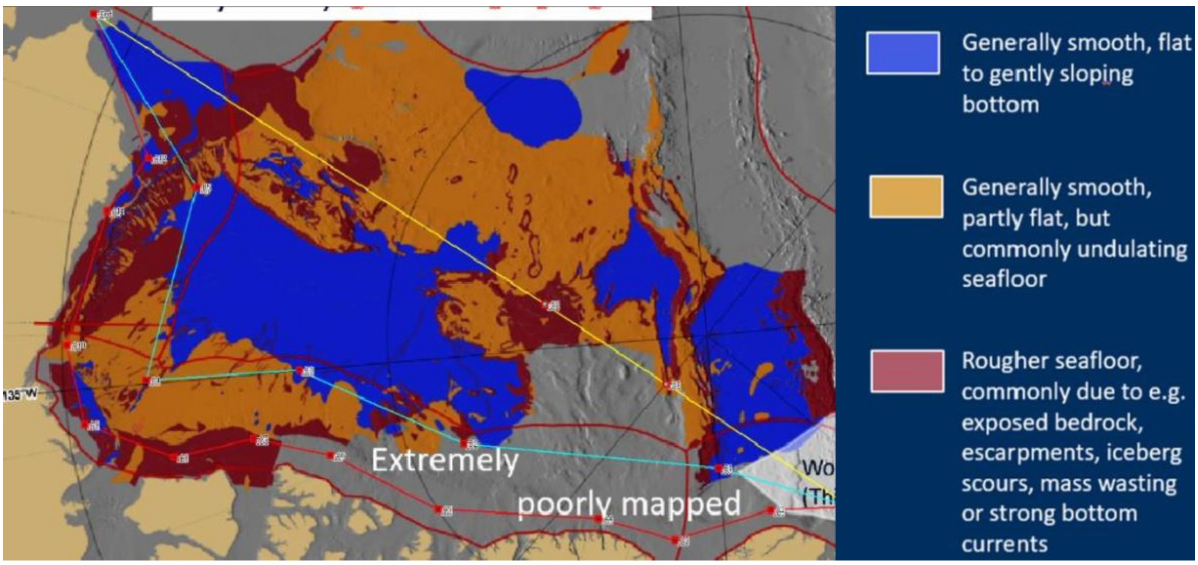
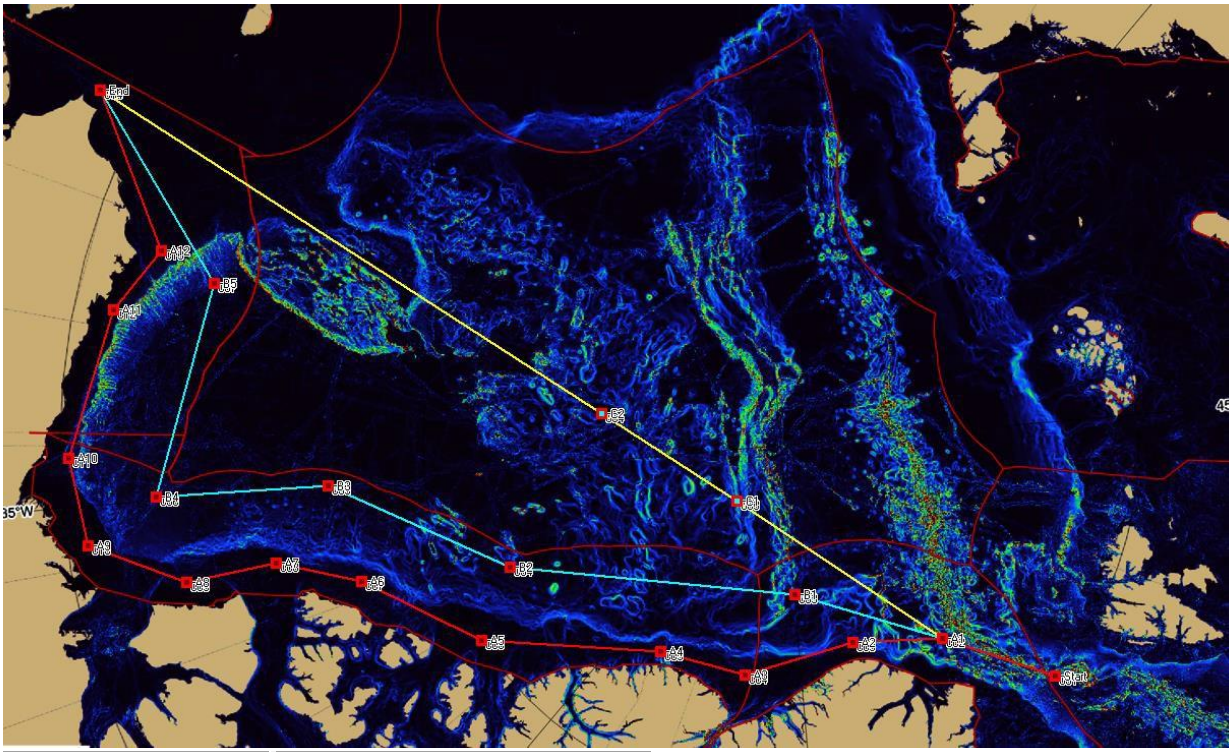


The last and the most favorable of the three routes is the one that crosses through the western part of the Arctic Ocean. The ice situation on this route is still severe and will be challenging for the offshore operation but is not unrealistic as the first two routes. This route is about 1900Nm and thus 600-400Nm shorter compared to the other two.

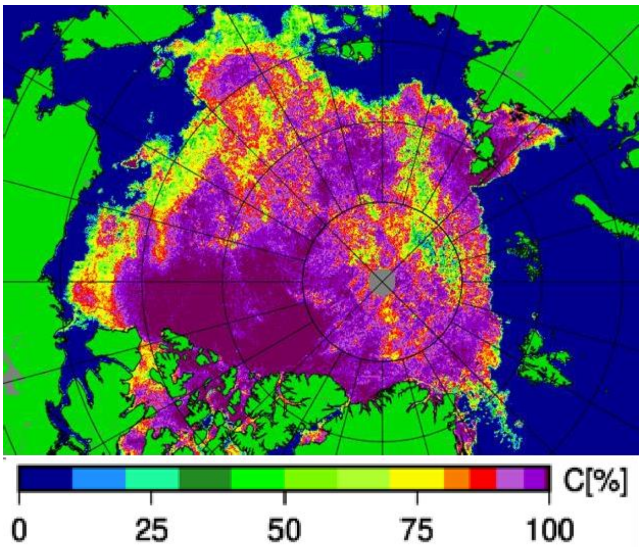


Routes

Namn	Punkter	Distans	
A Shelf route	14	2500,6 nm	
B Economic zone...	8	2303,5 nm	
C Arctic ocean	5	1889,5 nm	

To get an idea about the ice situation on the three suggested routes, ice concentration data have been compiled data from 2013 to 2023 with 15 days in between each image. The dates are chosen after the operational timeslot for offshore work in the Arctic, 1st of August to 31st of October. Note that this is only ice concentration nothing about thickness and ice types. Find the conclusion on the last page.

This is how to interpret the images.



The scale of sea ice concentration

Dark purple = 95-100 % ice coverage

Purple = 90-95 % ice coverage

Red = 80-90 % Ice coverage

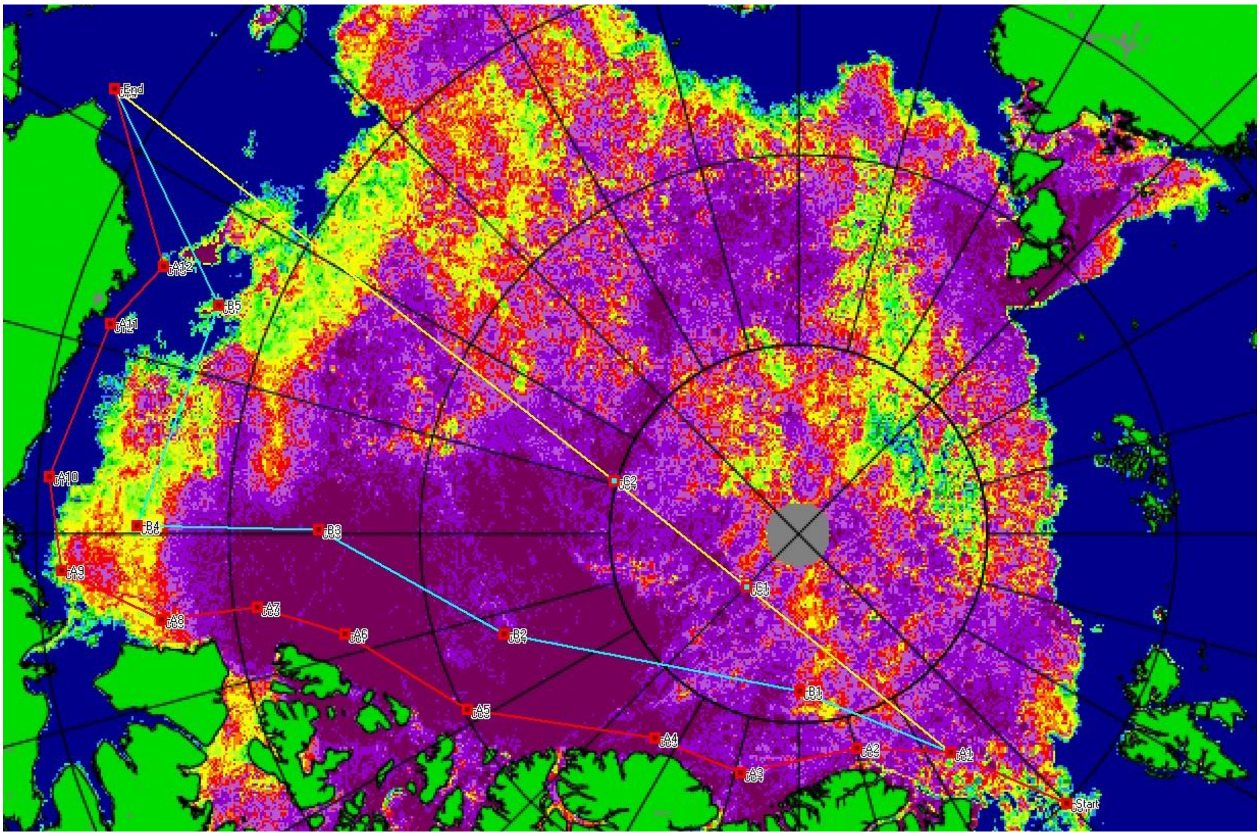
Yellow = 70-80 % ice coverage

Green = 30-70 % ice coverage

Light blue = 10-30 % ice coverage

Dark blue = 0-10 % ice coverage

1st of August 2013-2023



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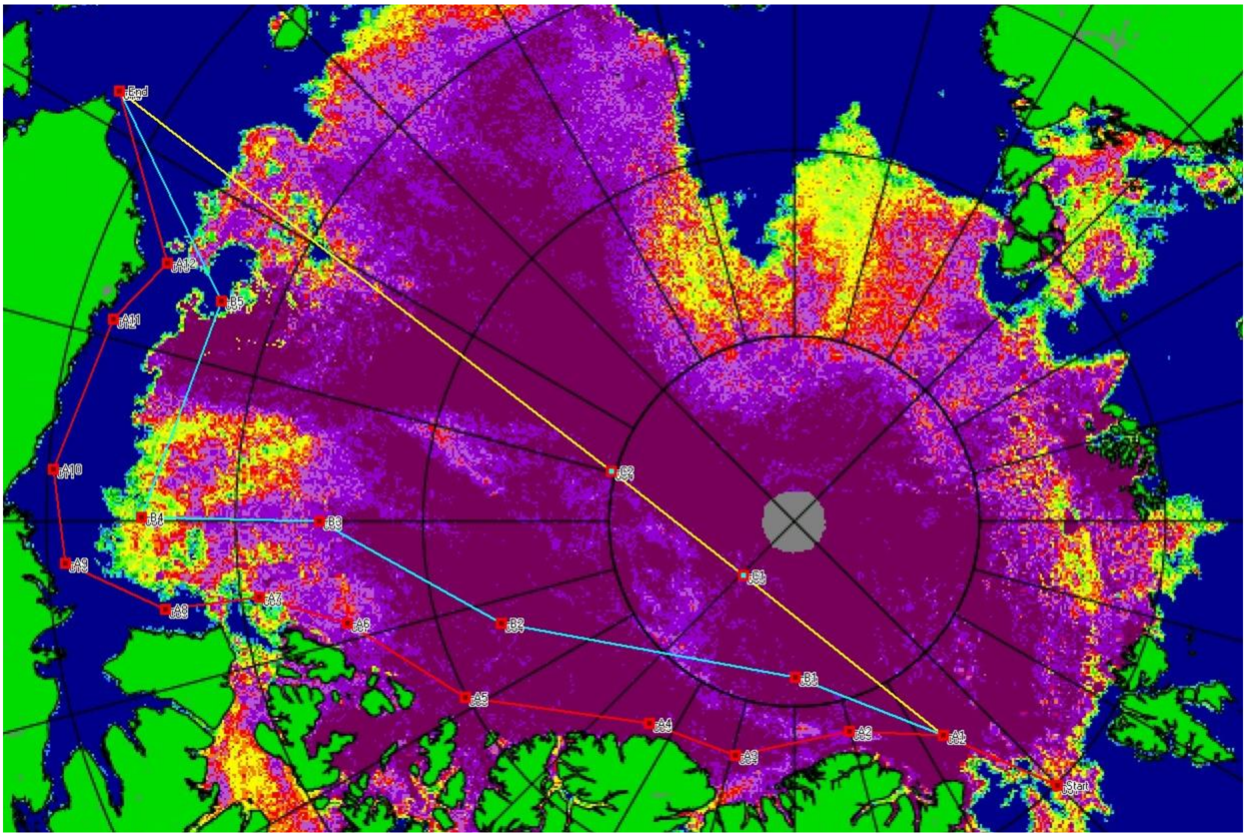

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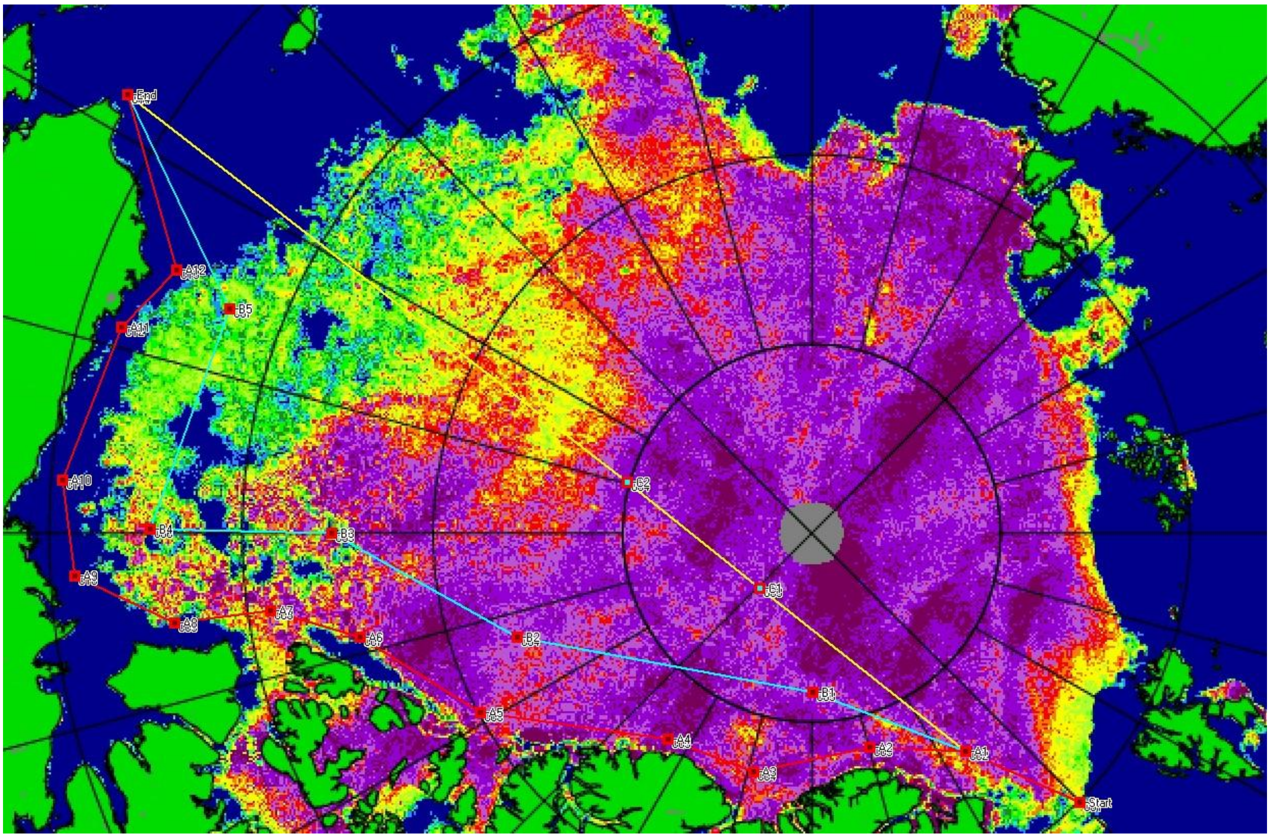

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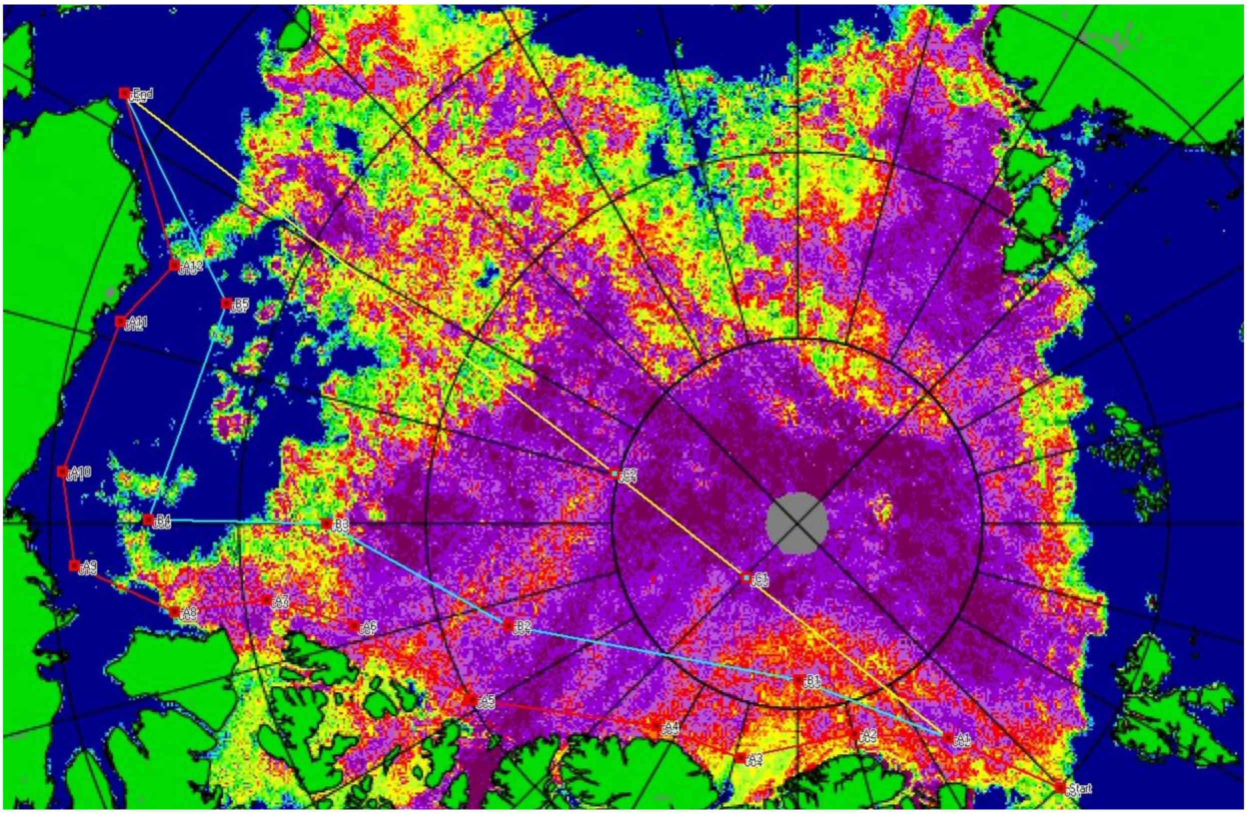

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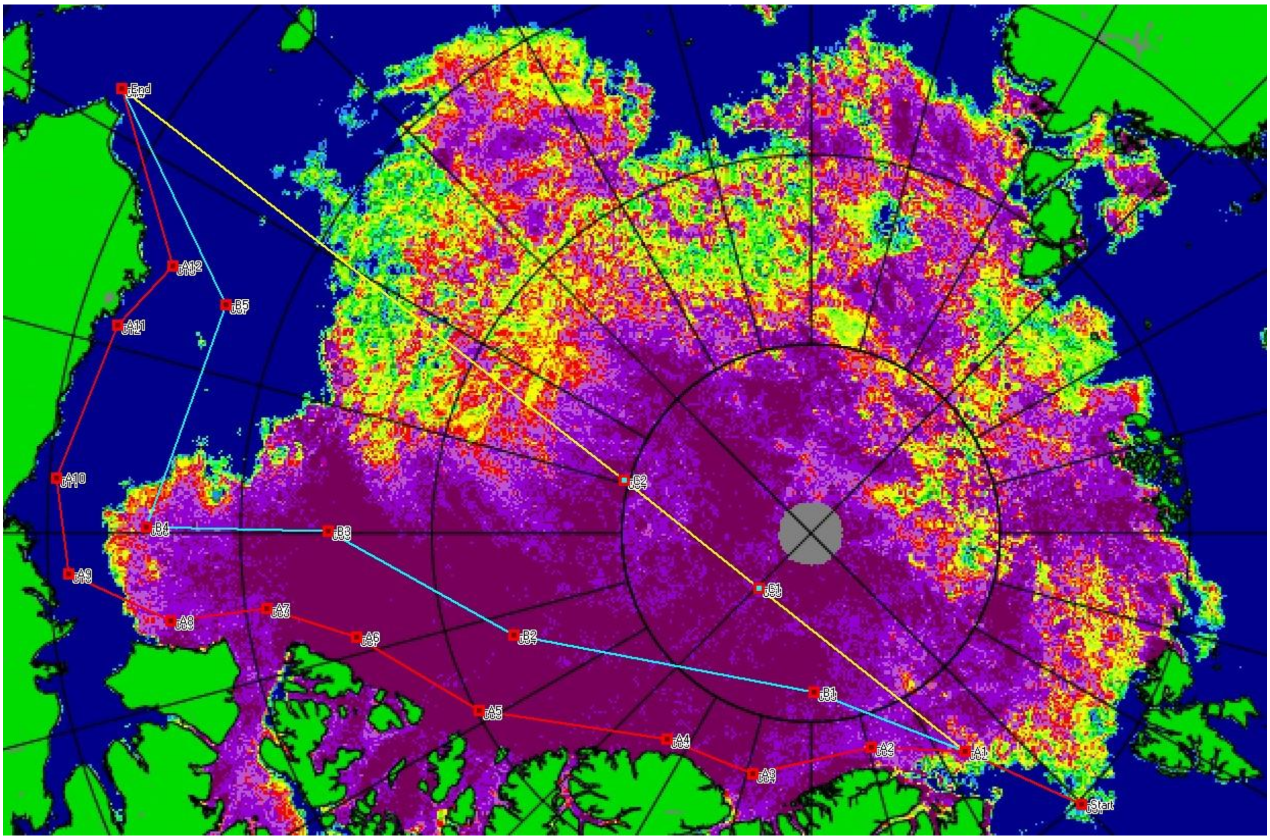

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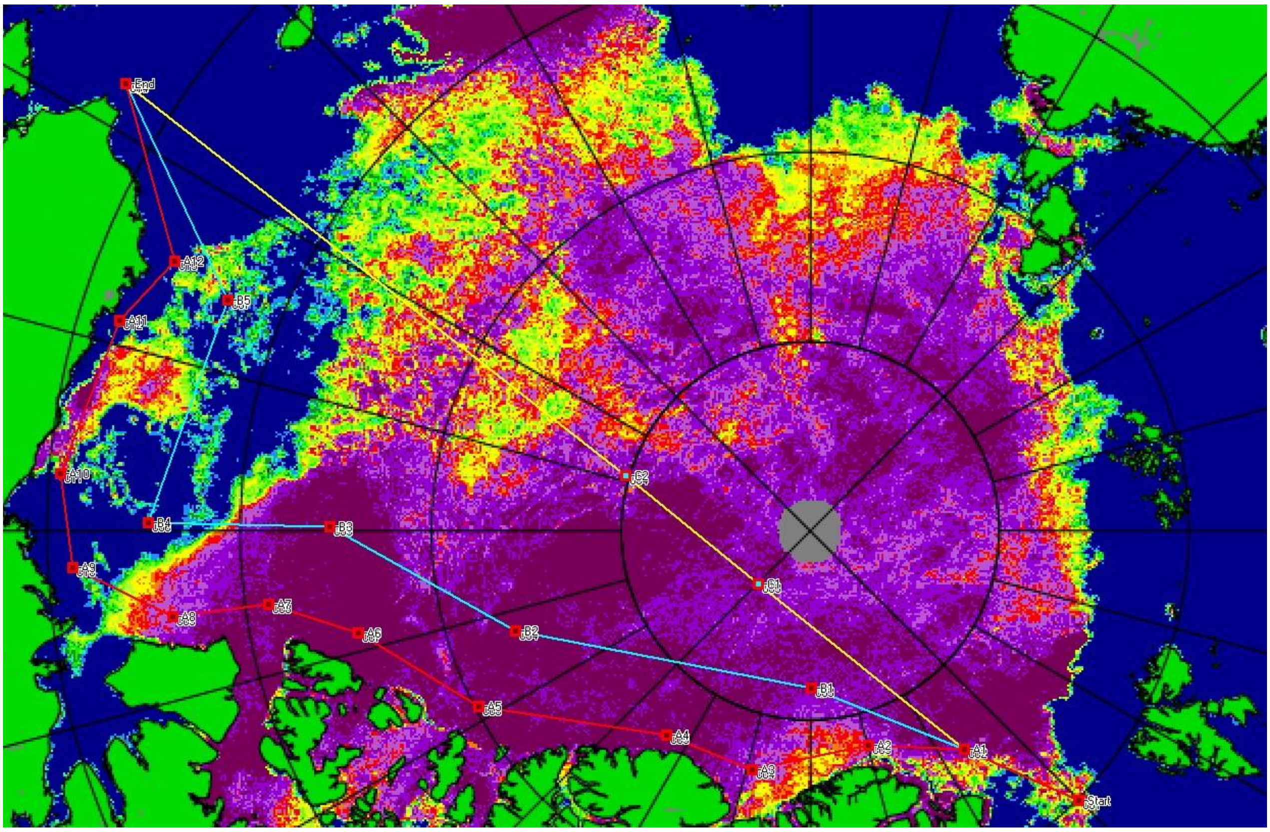

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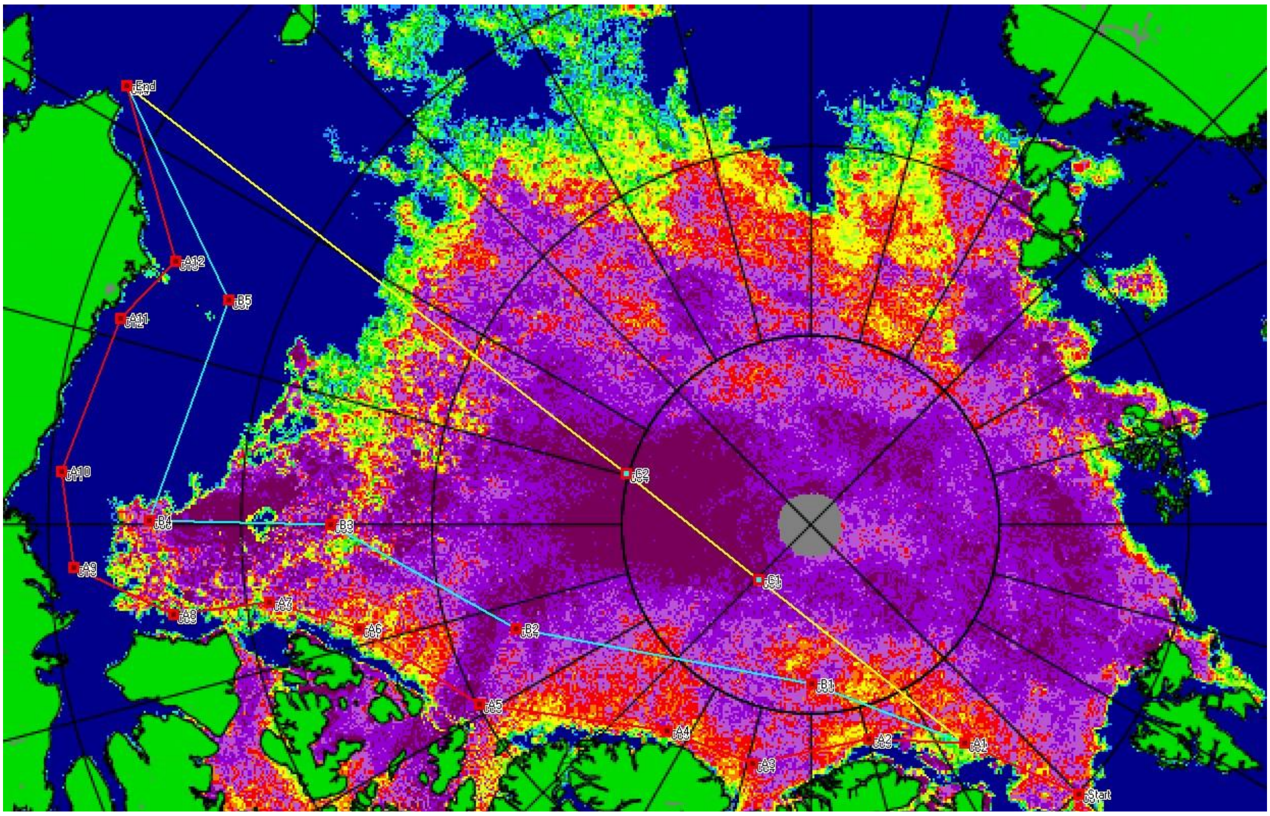

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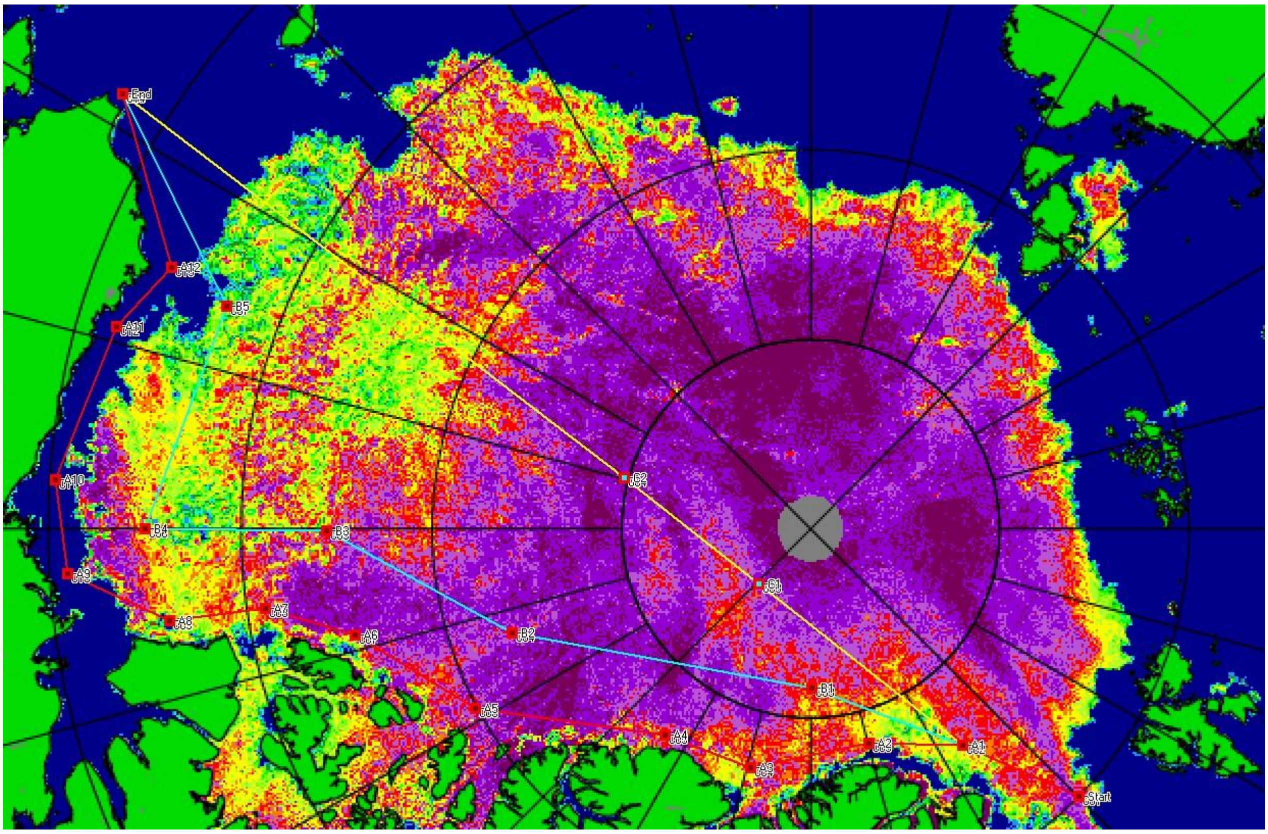

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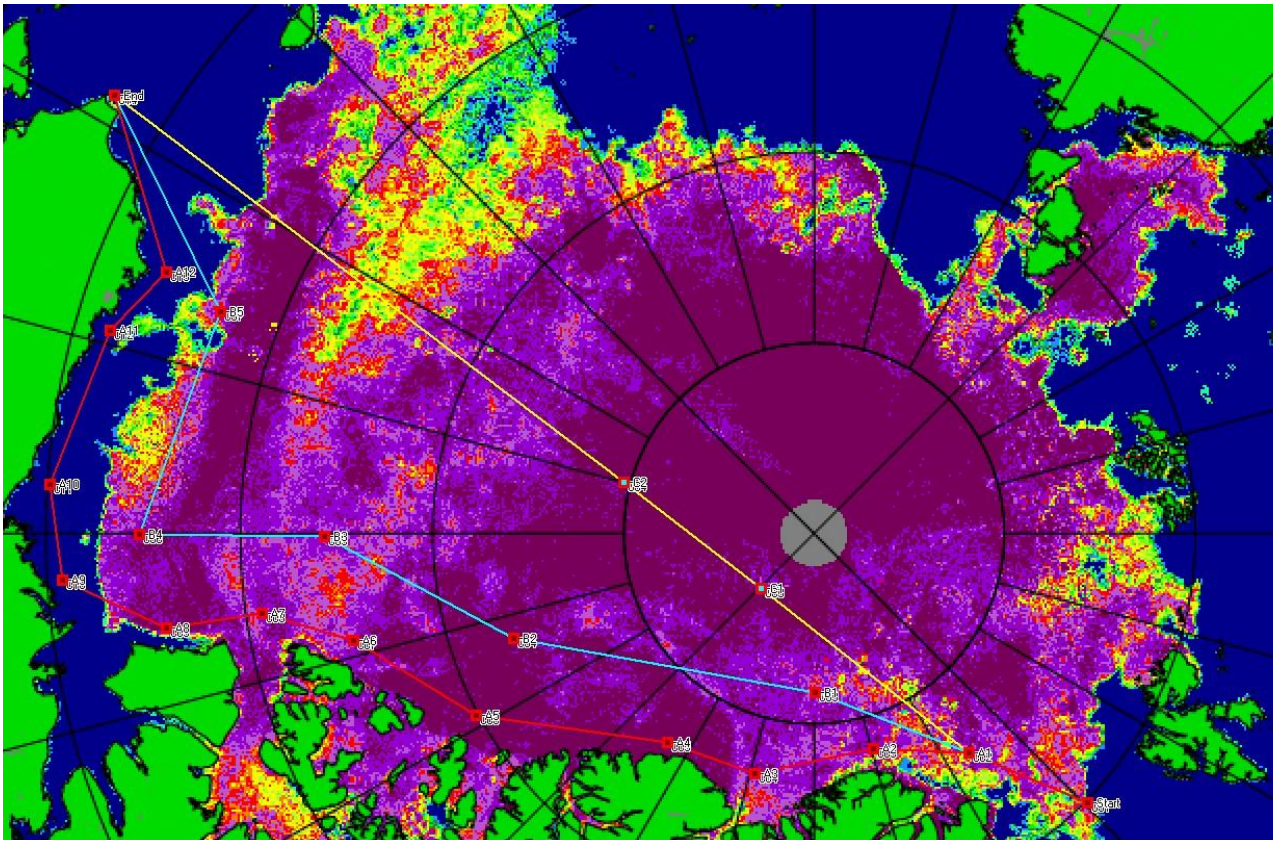

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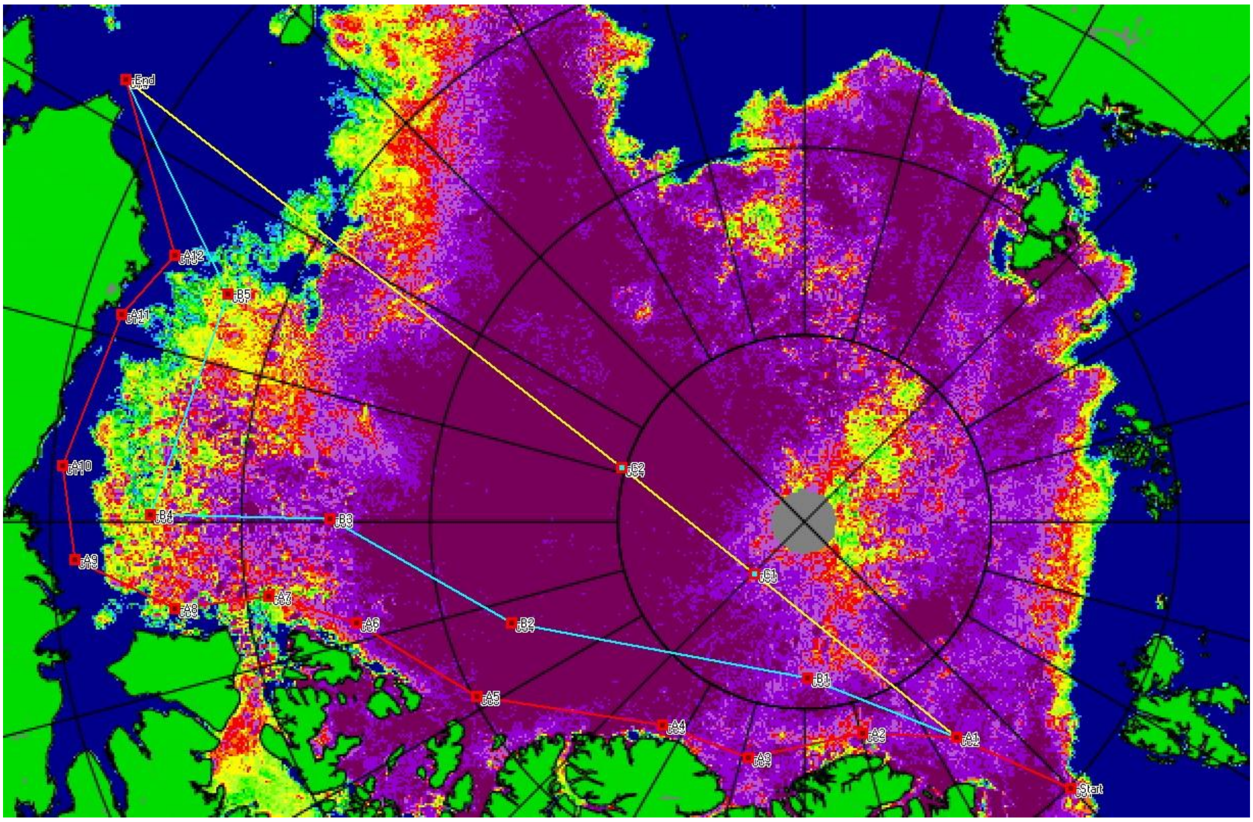

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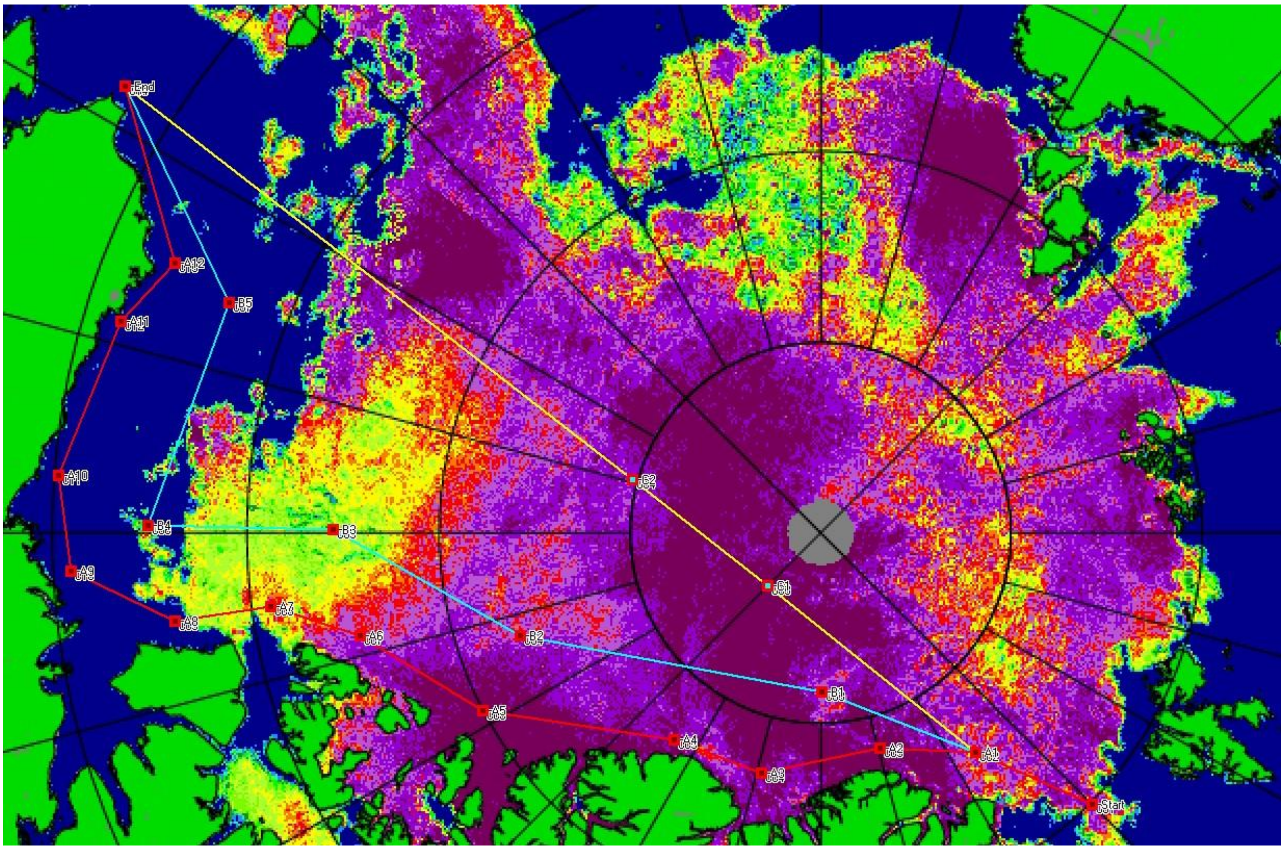

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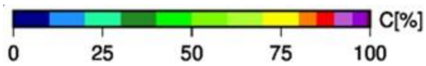
A1
Start

2023-08-01



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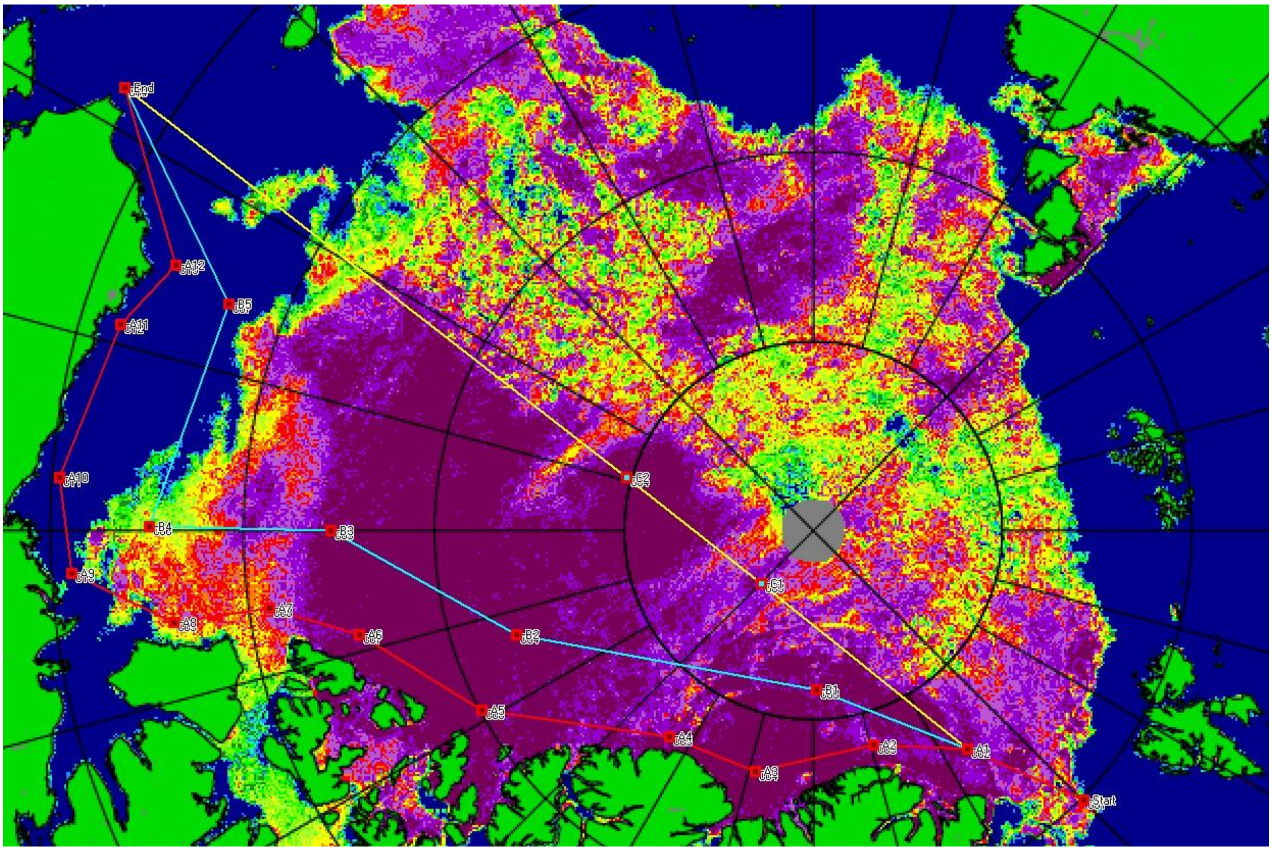
15th of August 2013-2023



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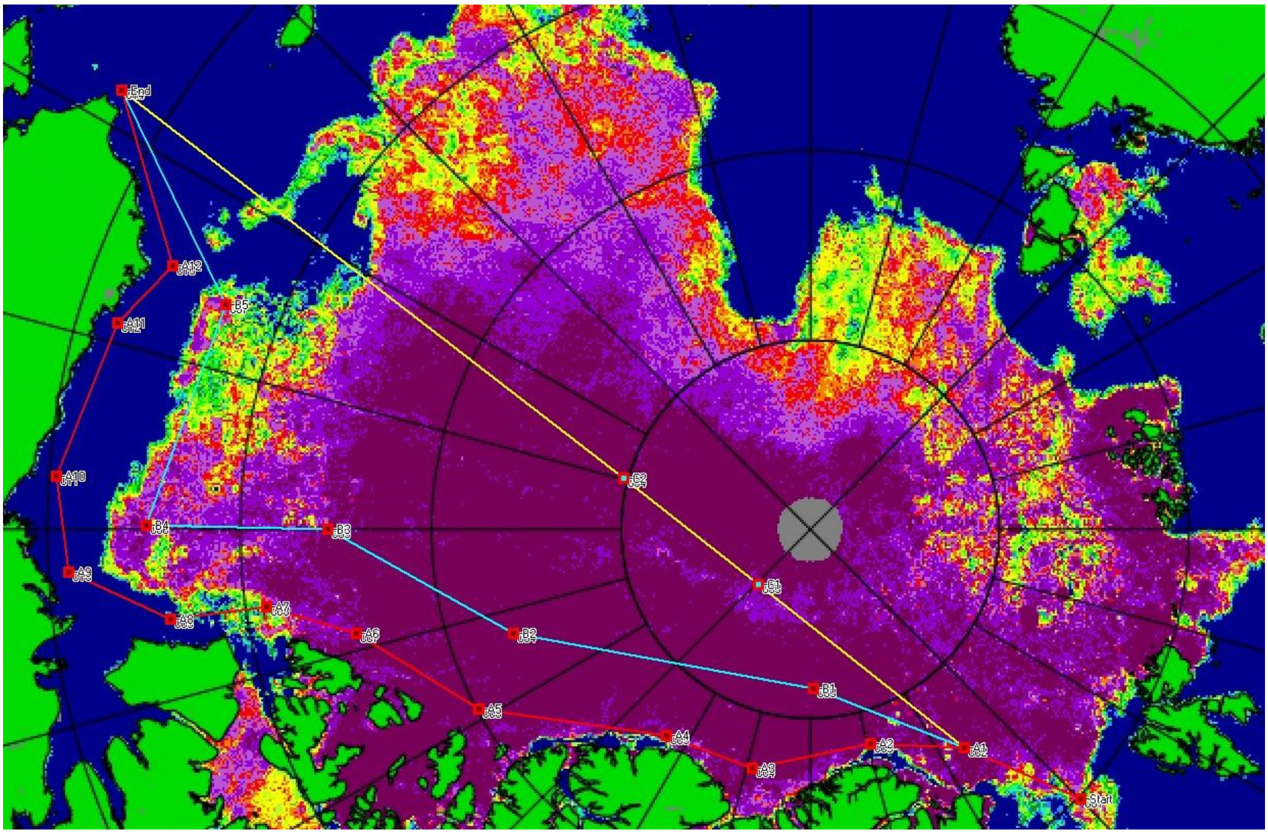

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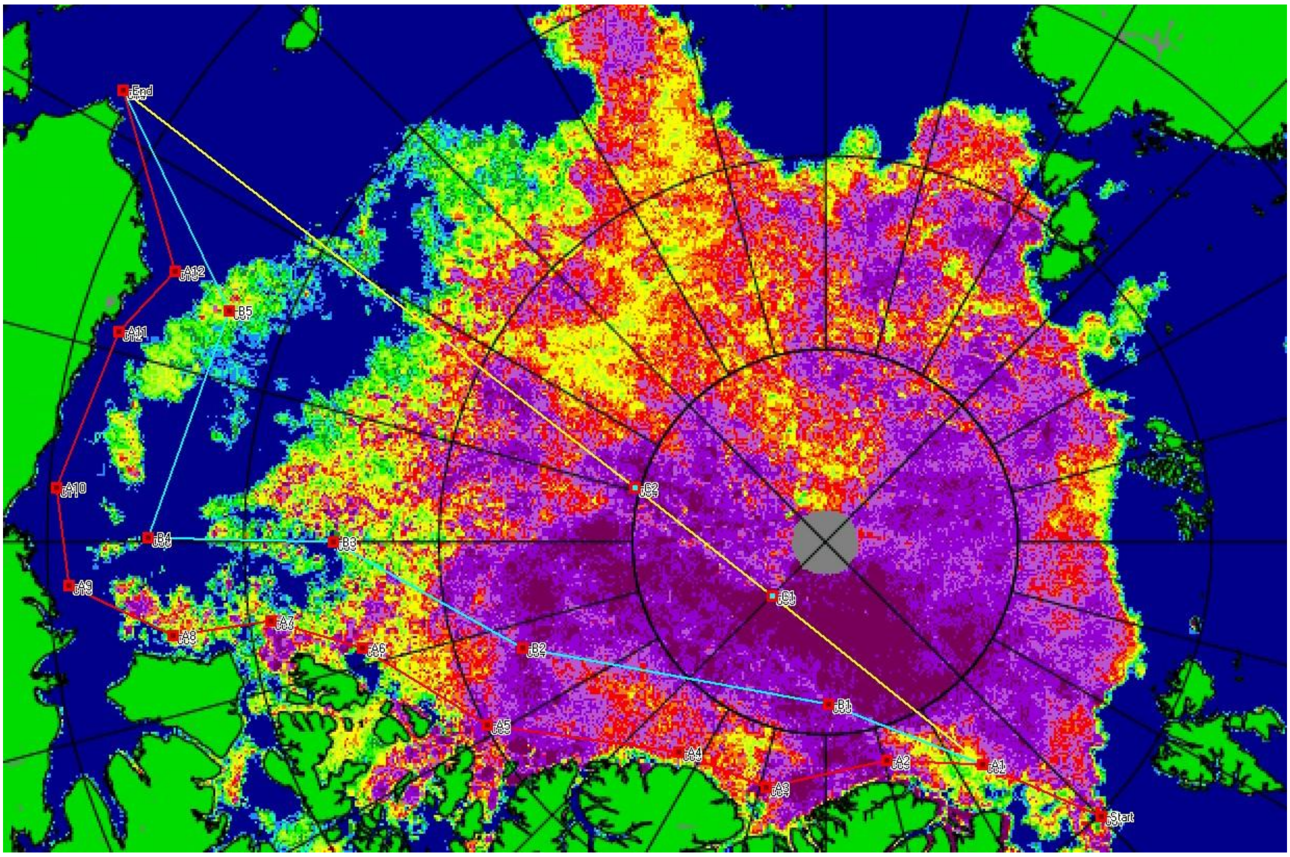

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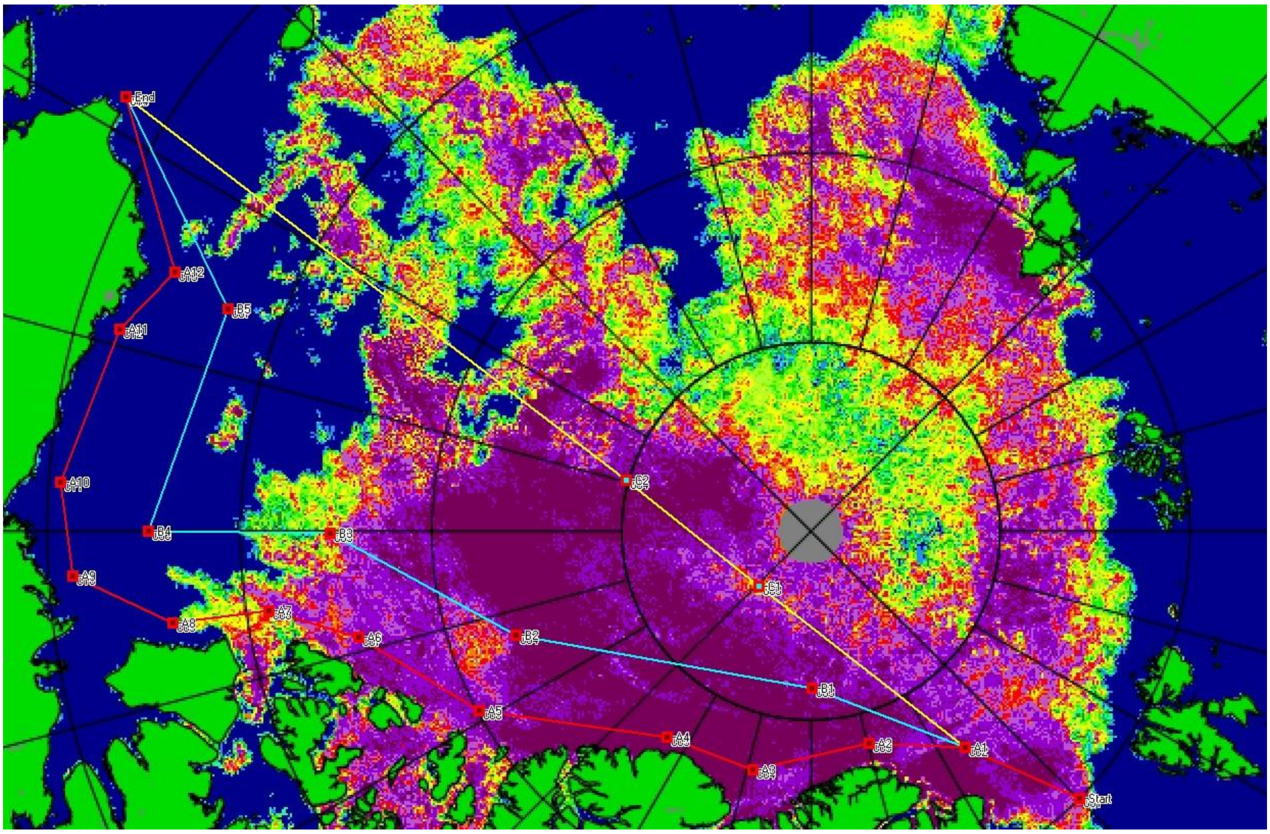

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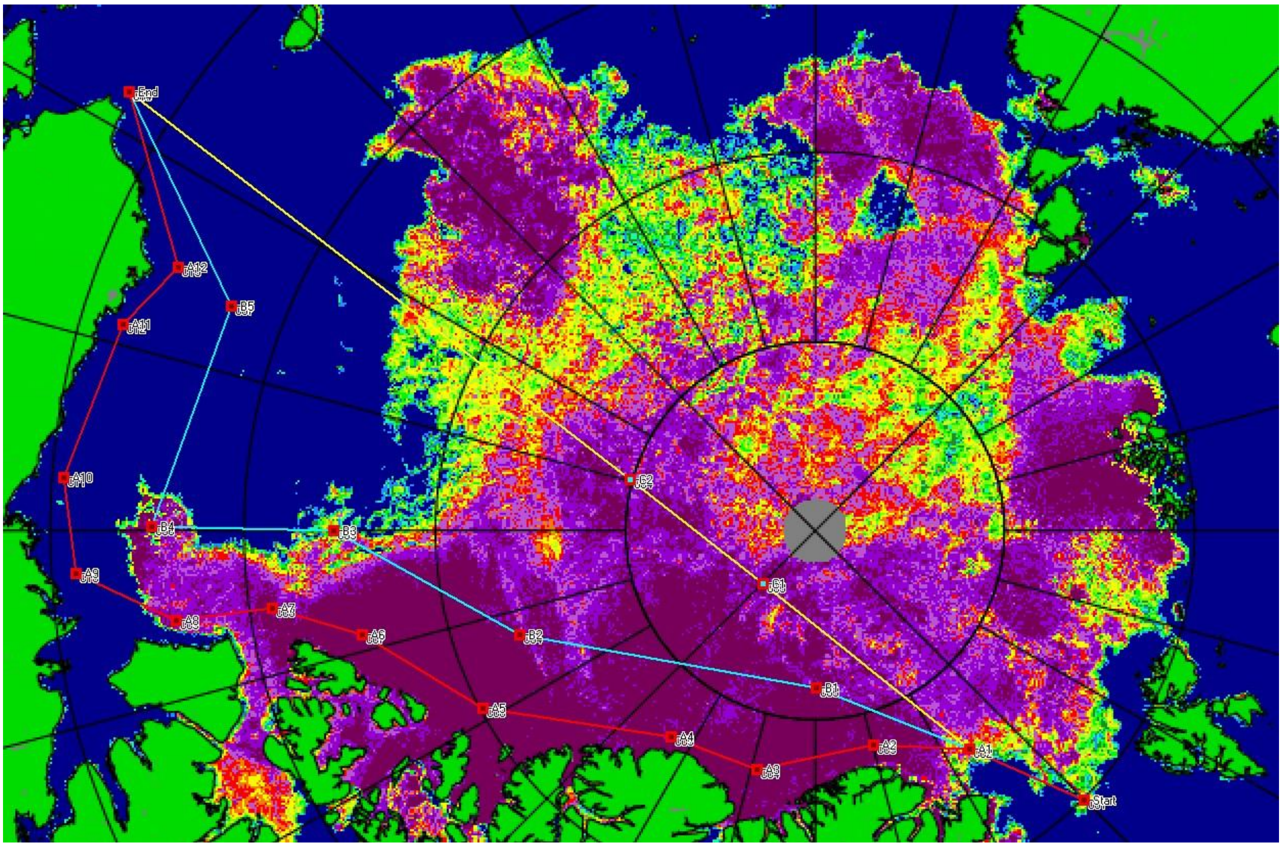

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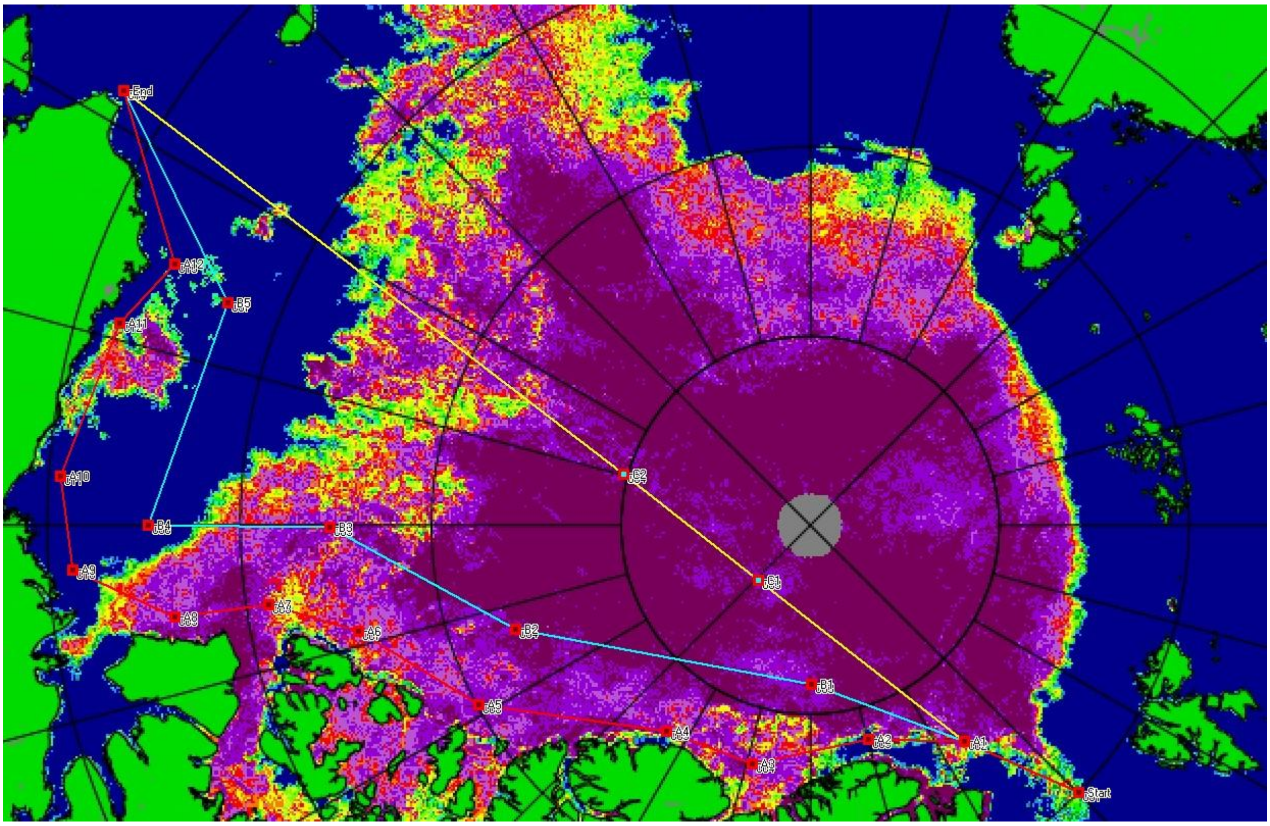

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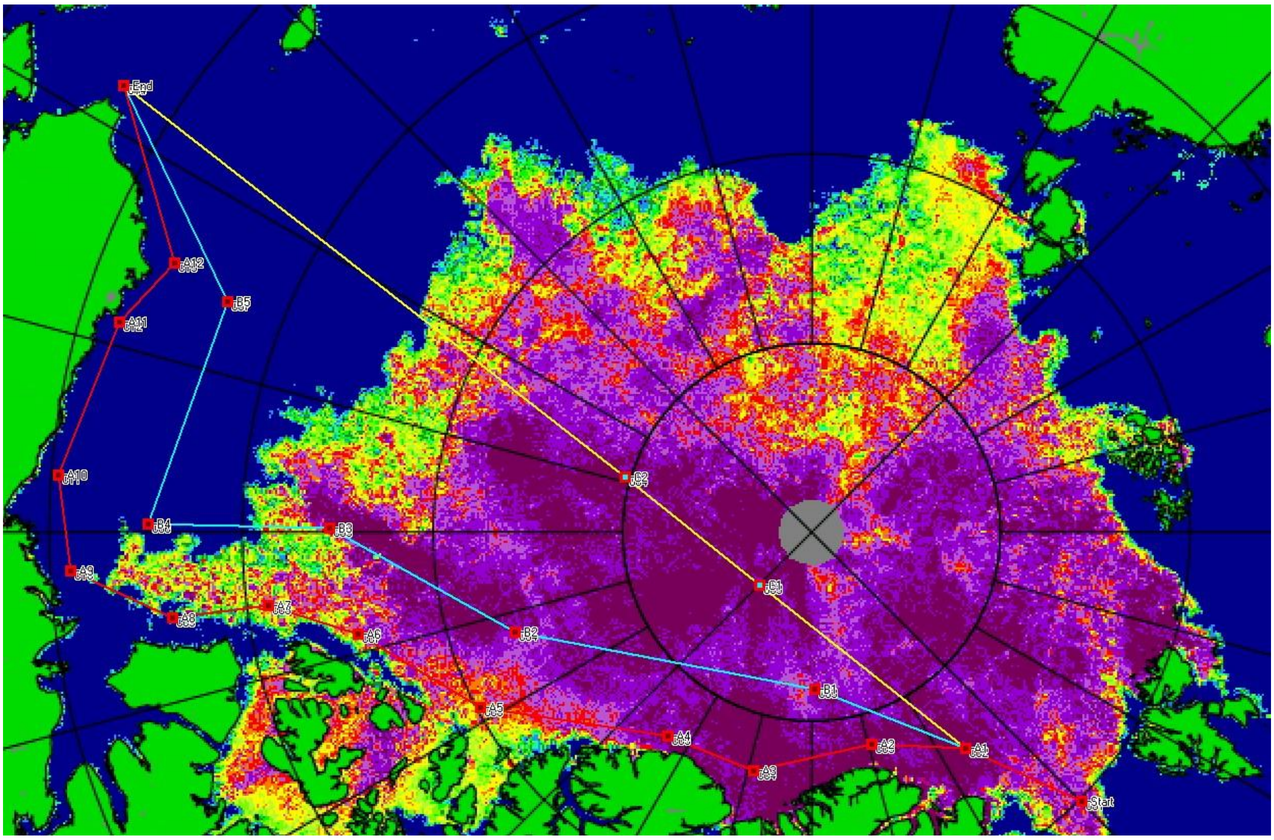

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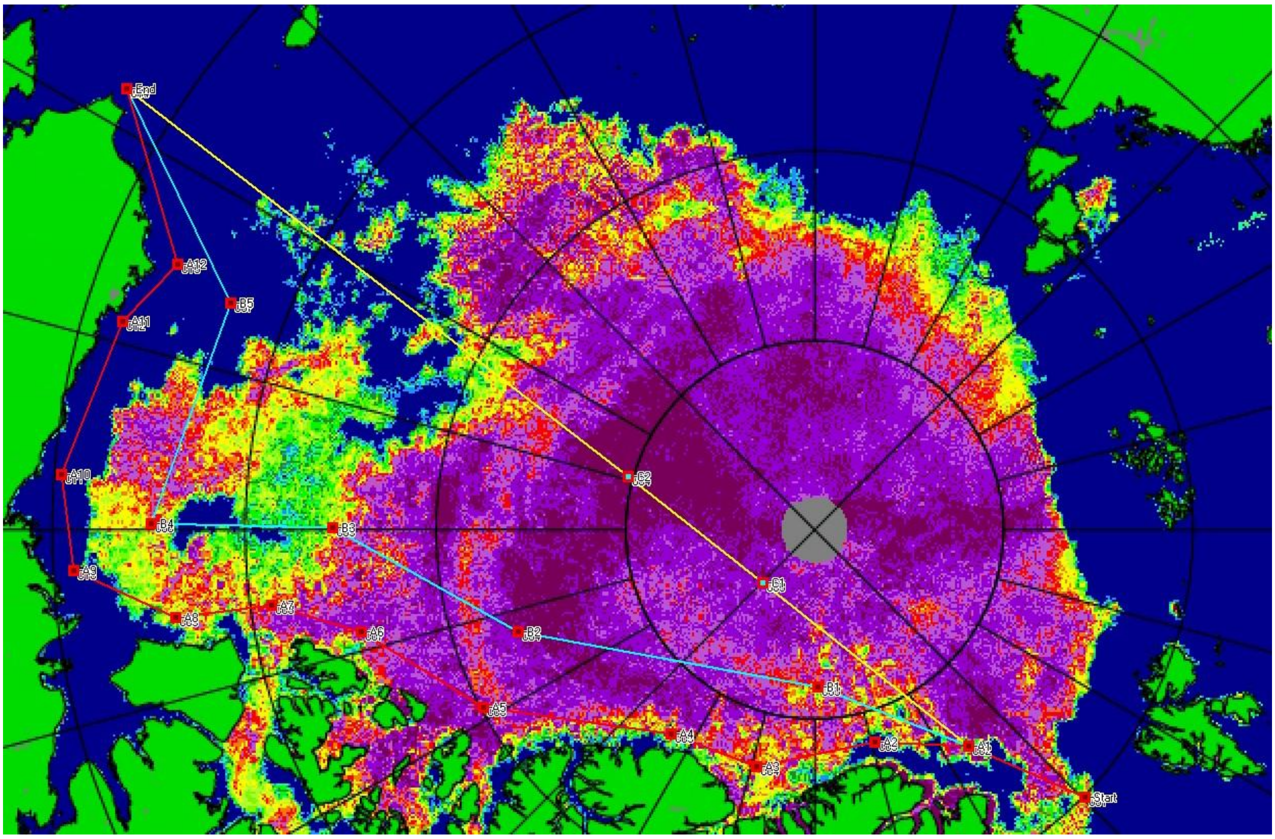

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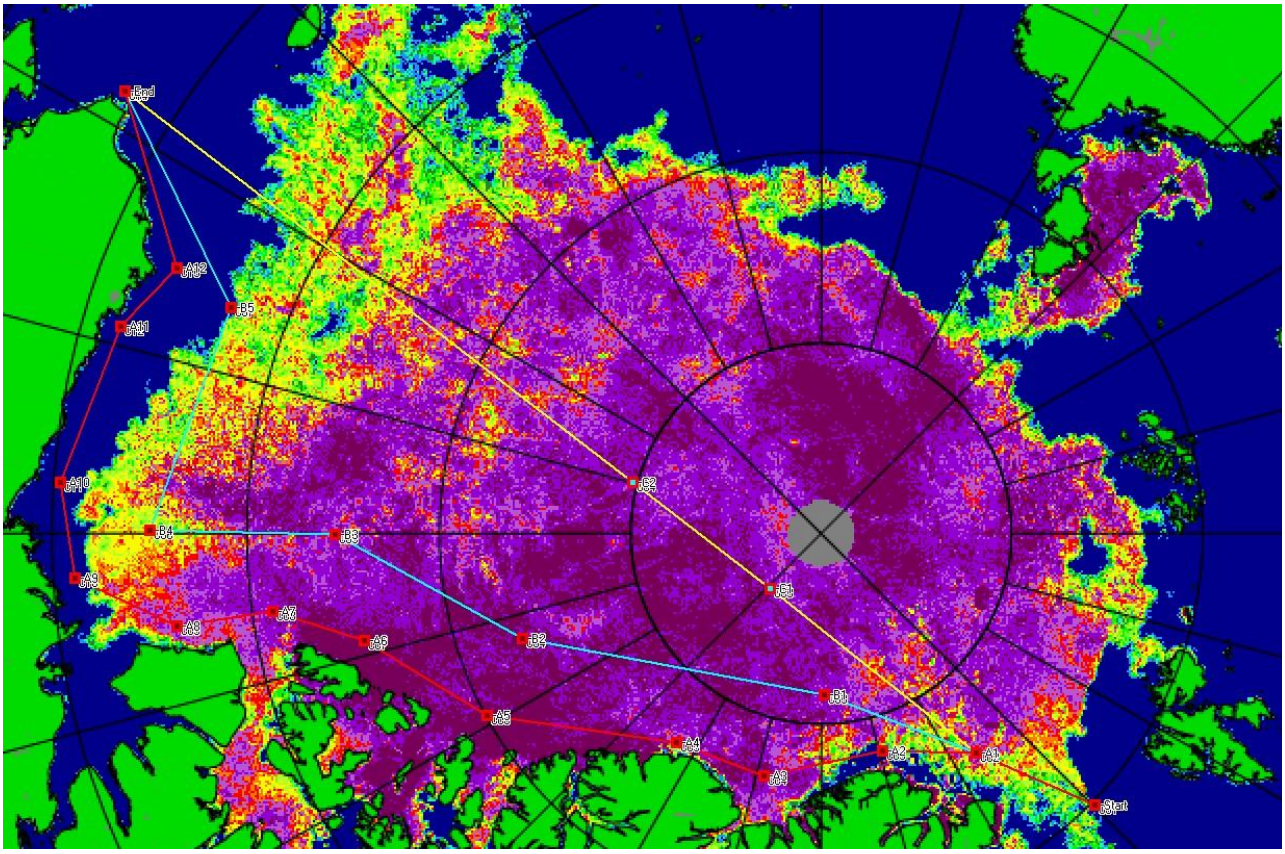

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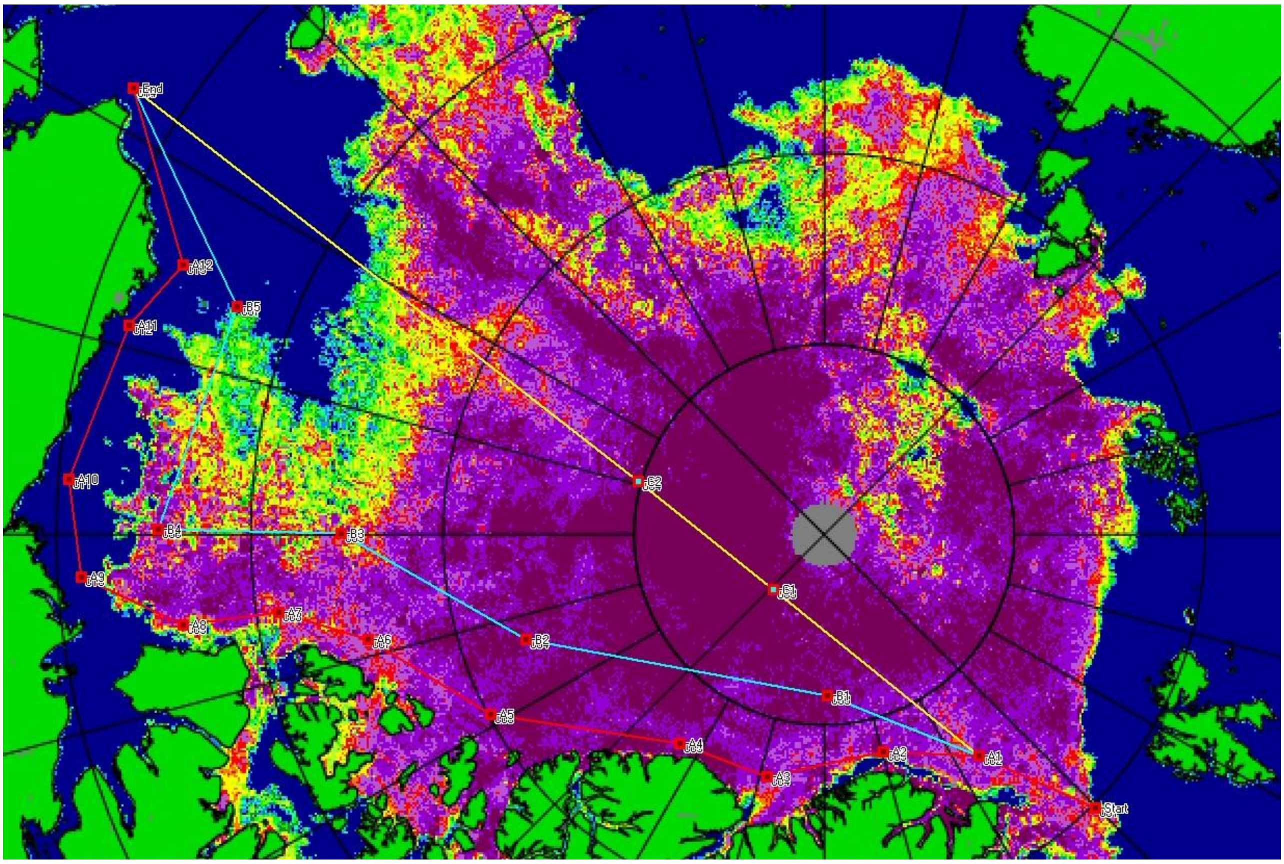

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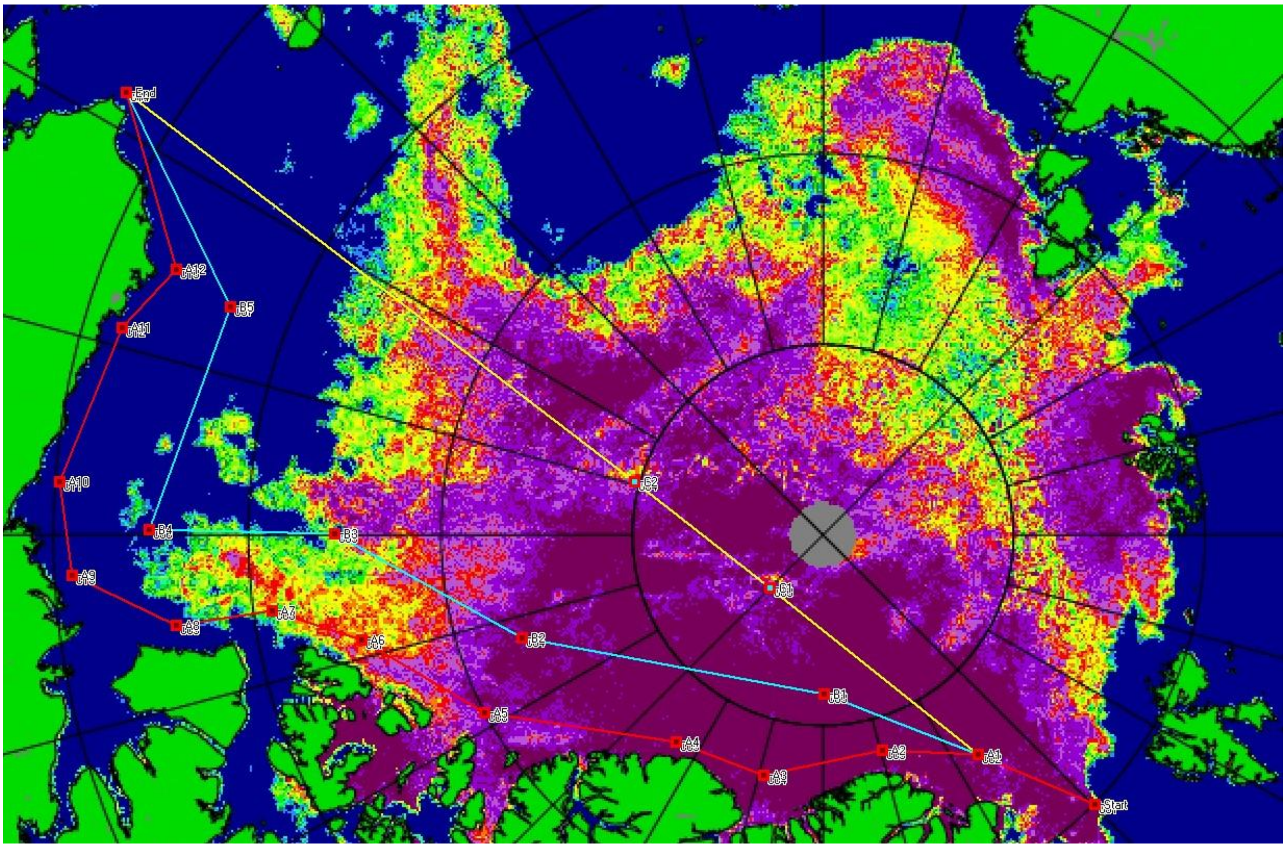

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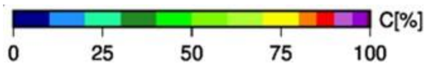
Start

2023-08-15



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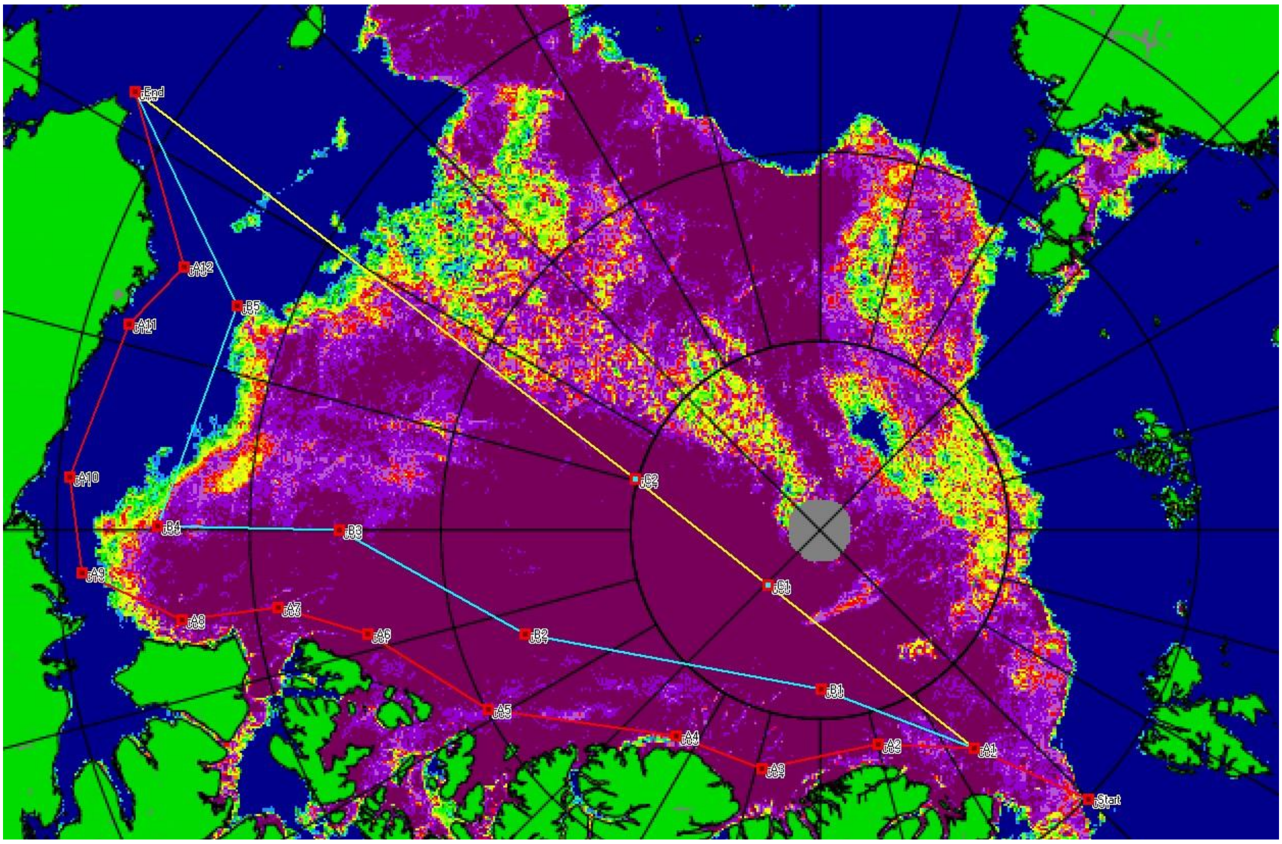
31st of August 2013-2023



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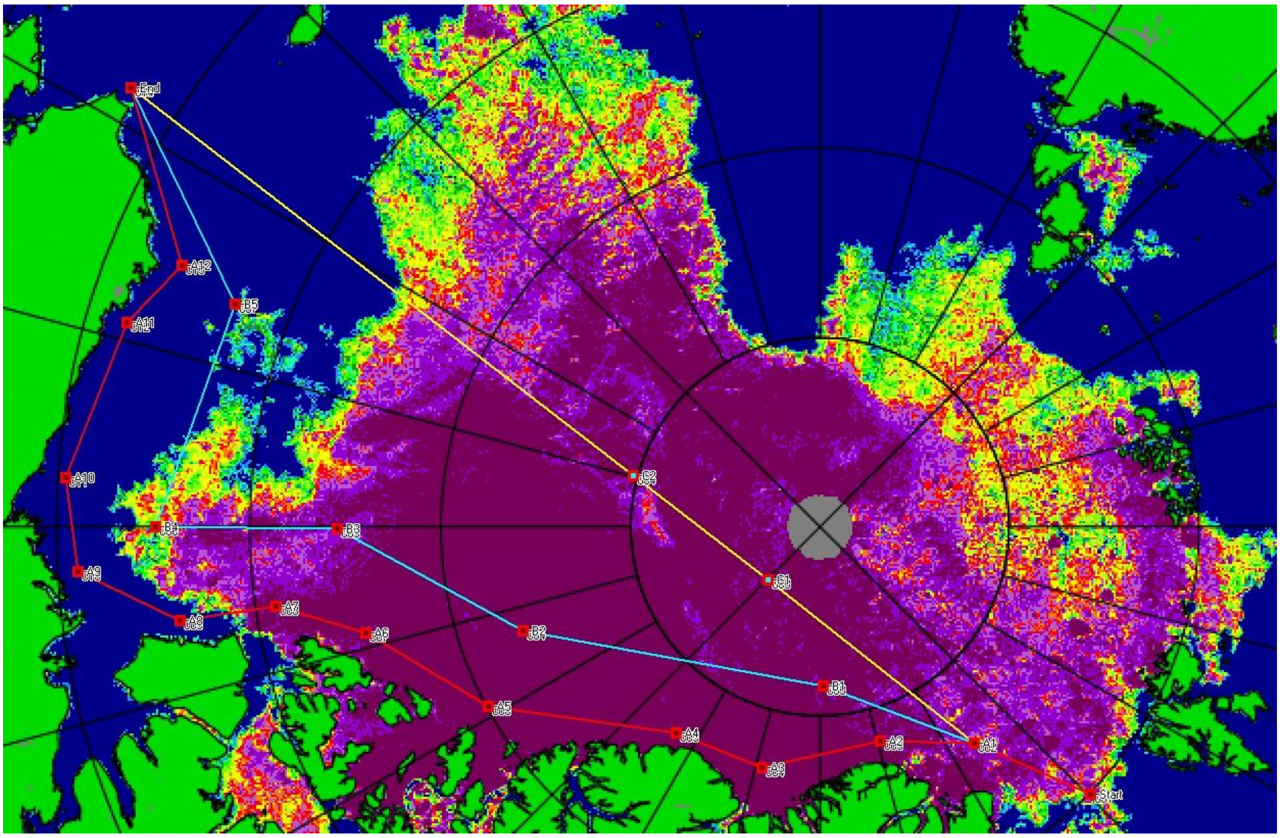

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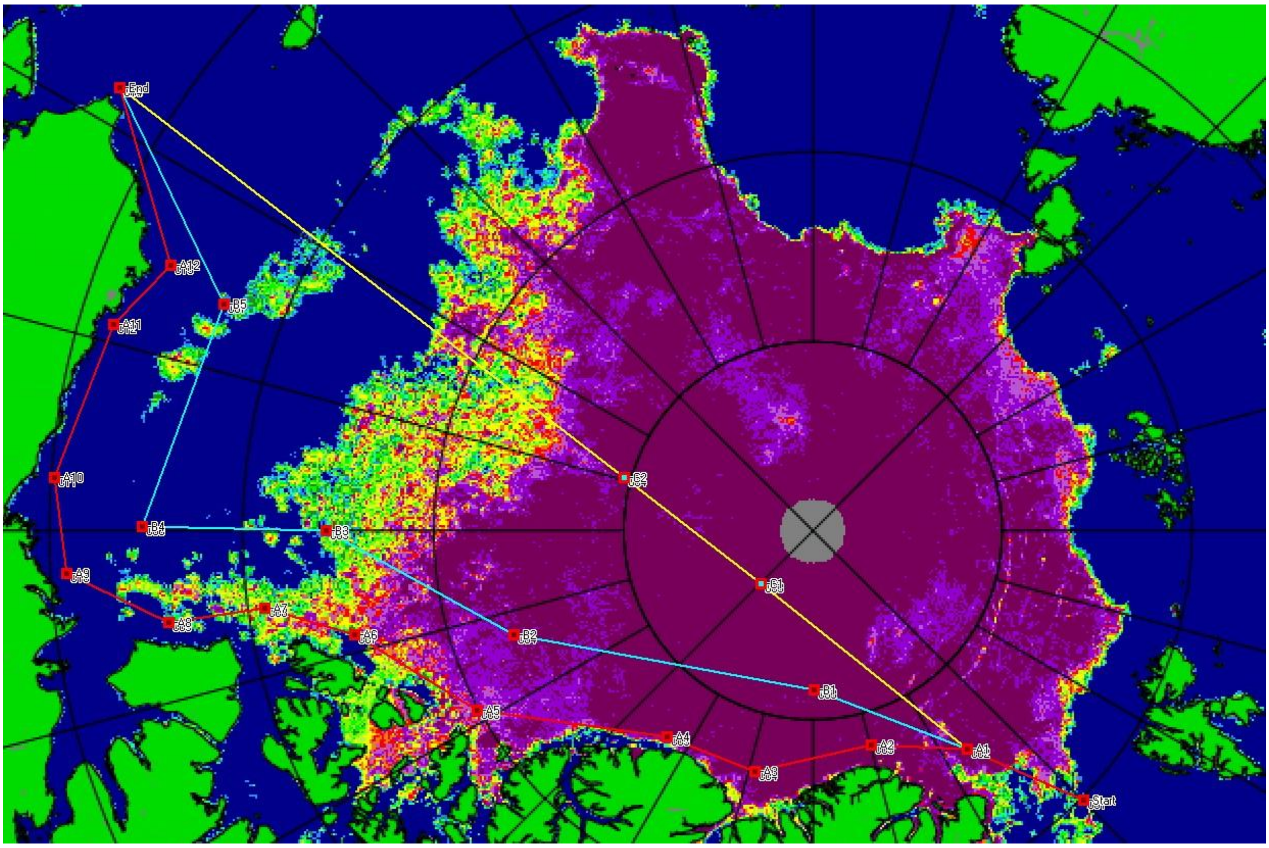

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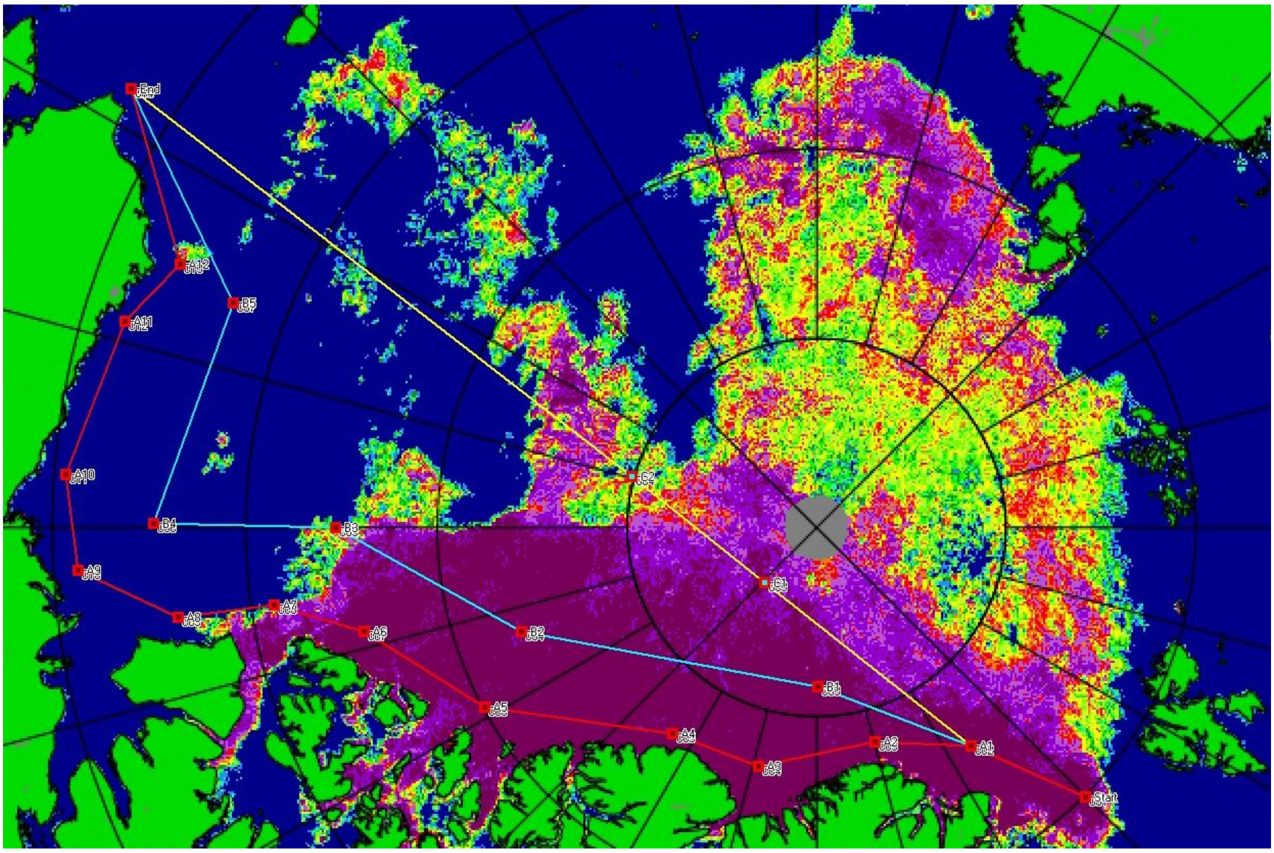

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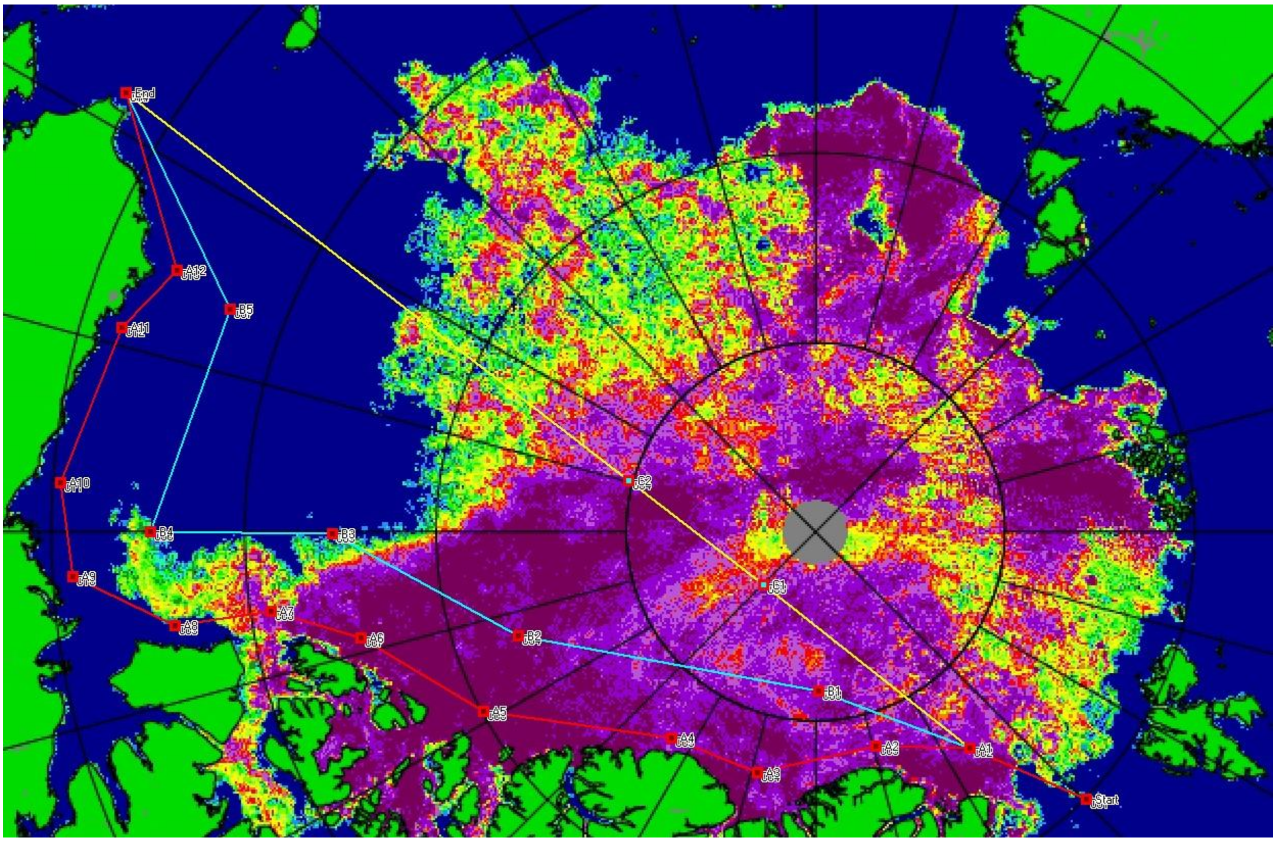

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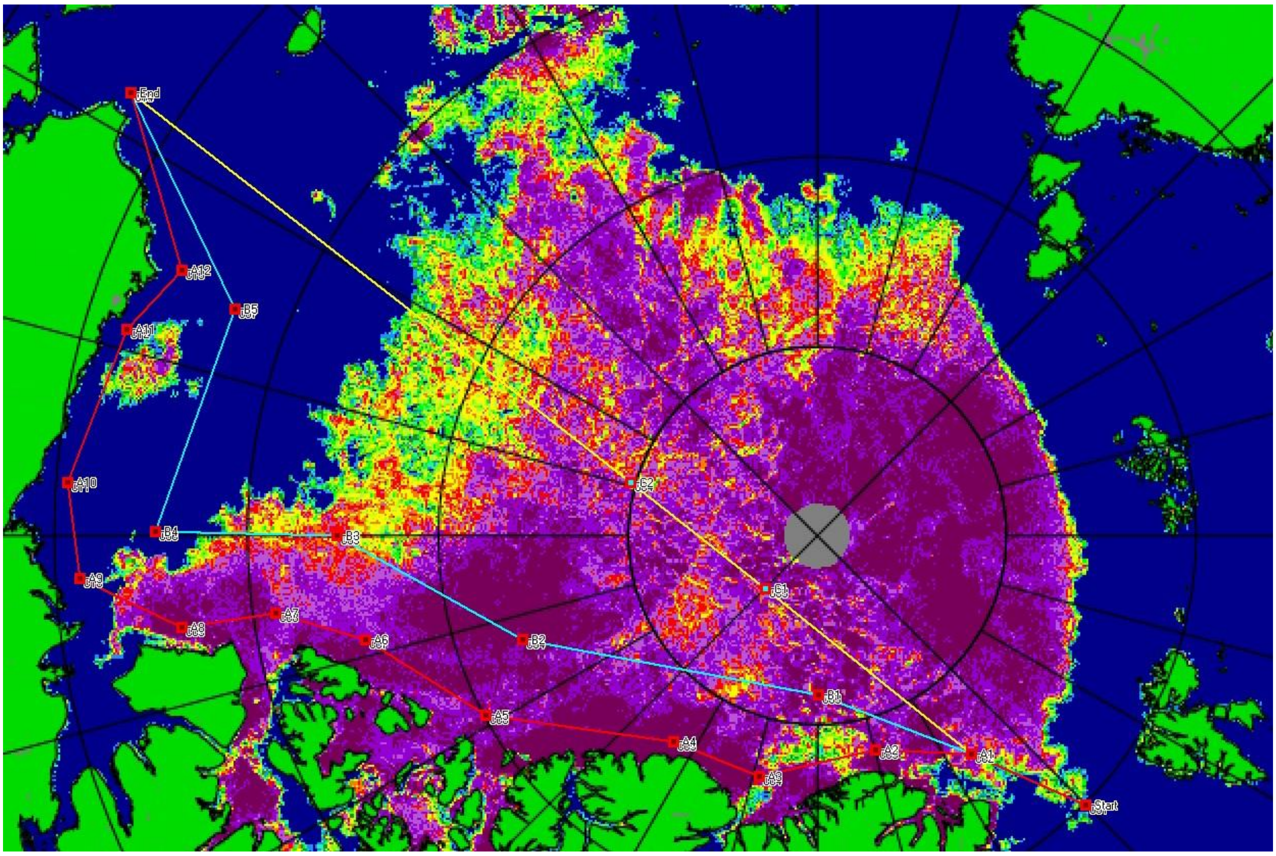

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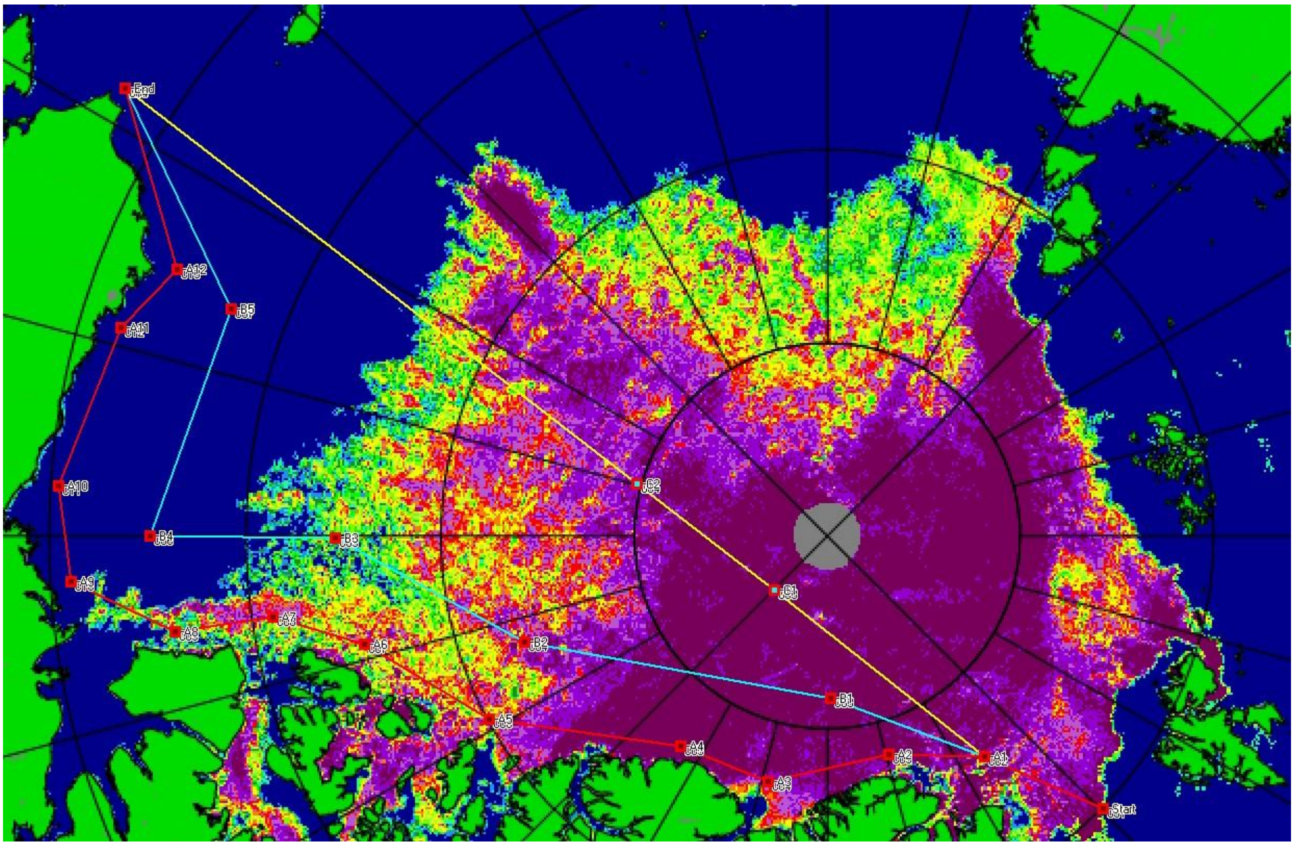

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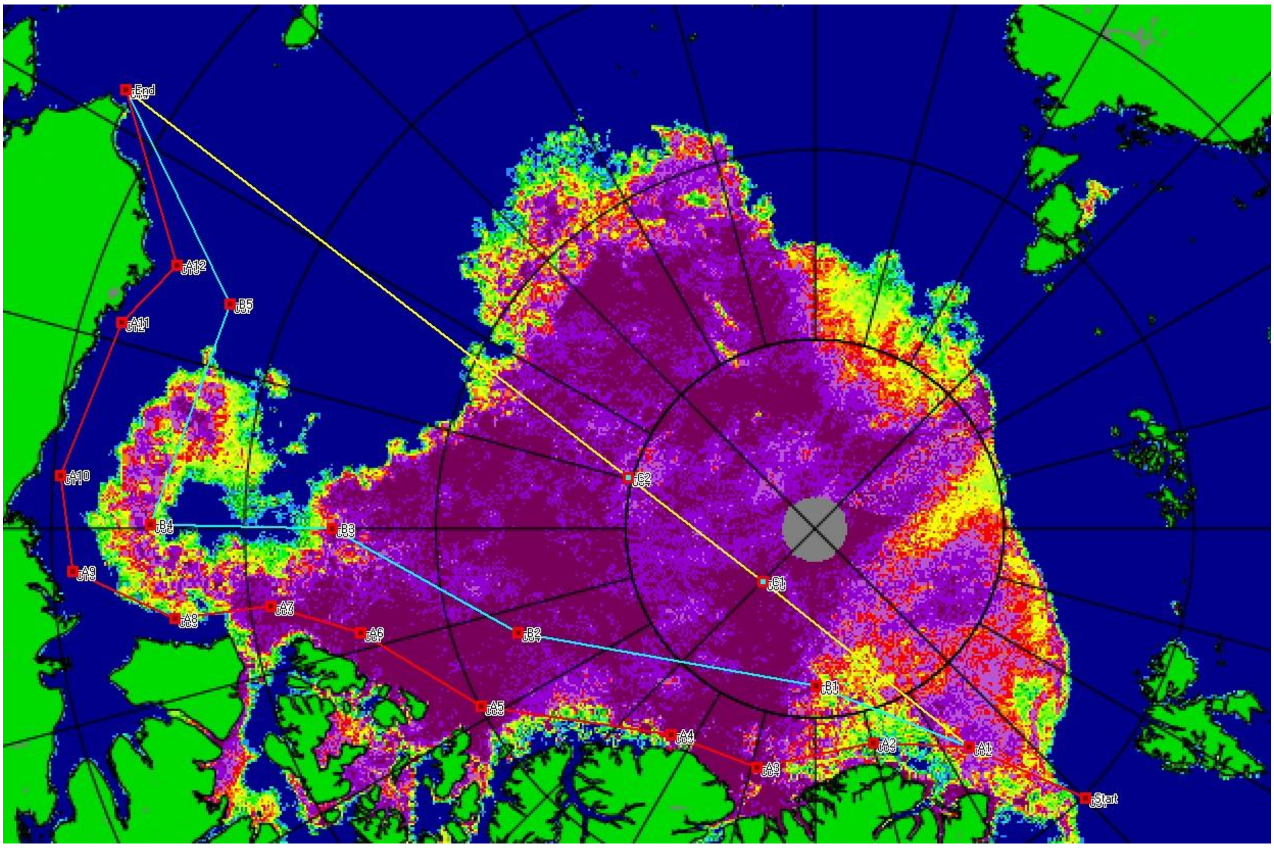

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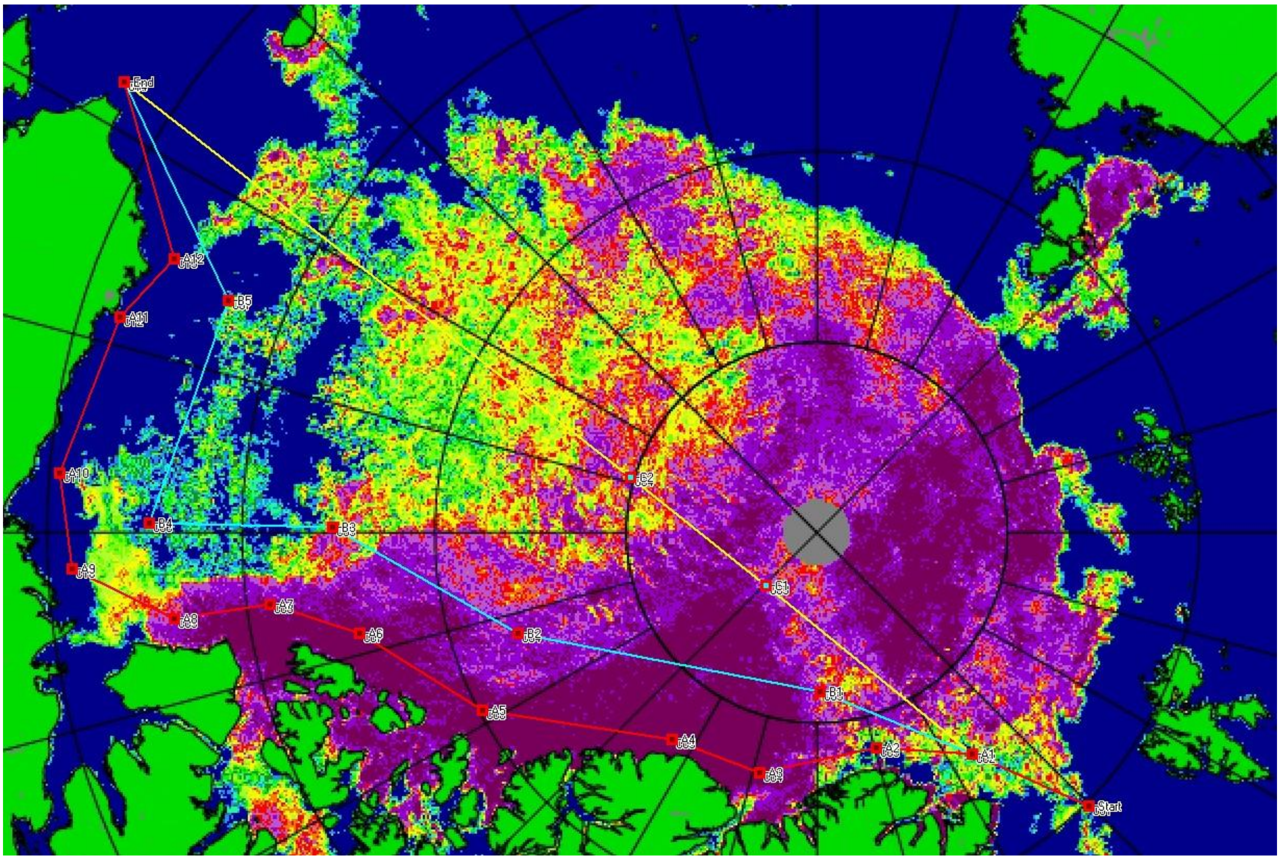

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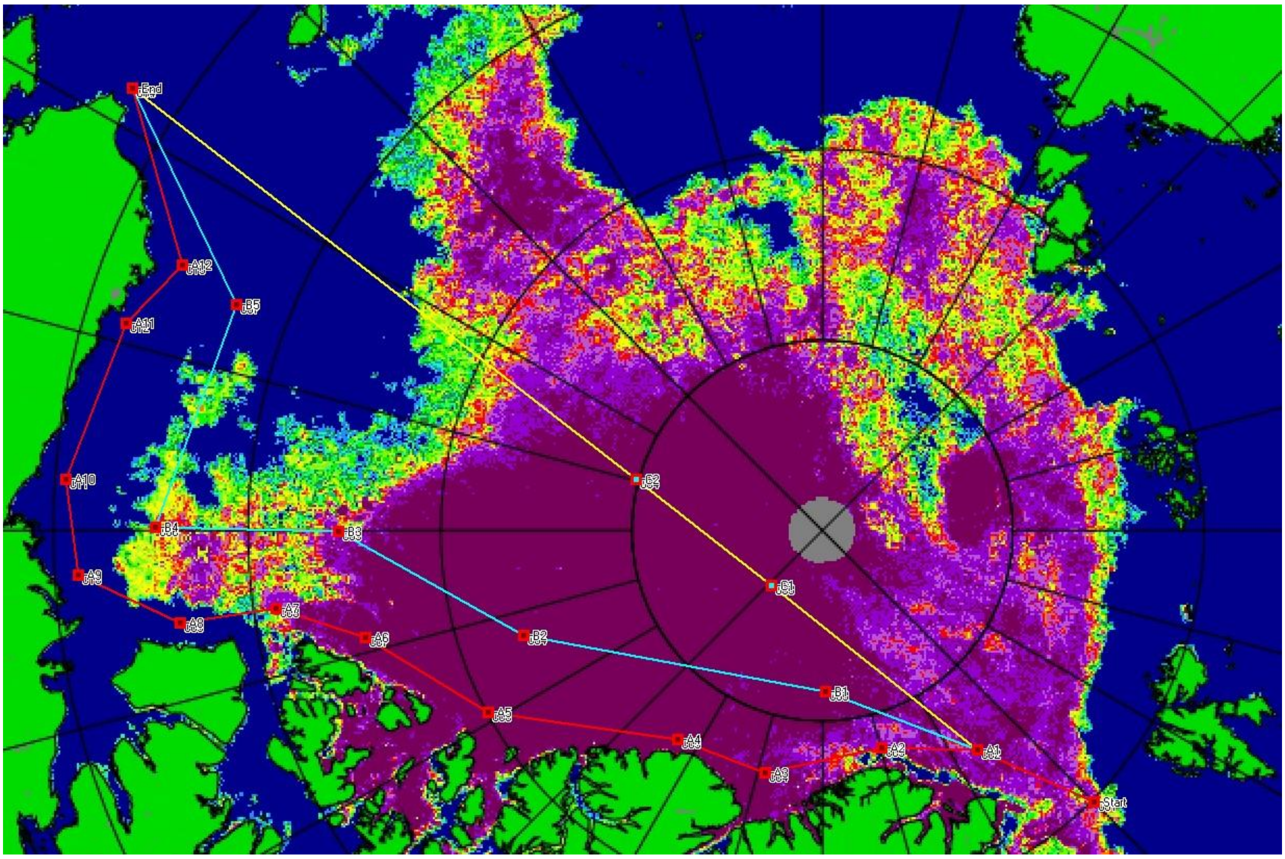

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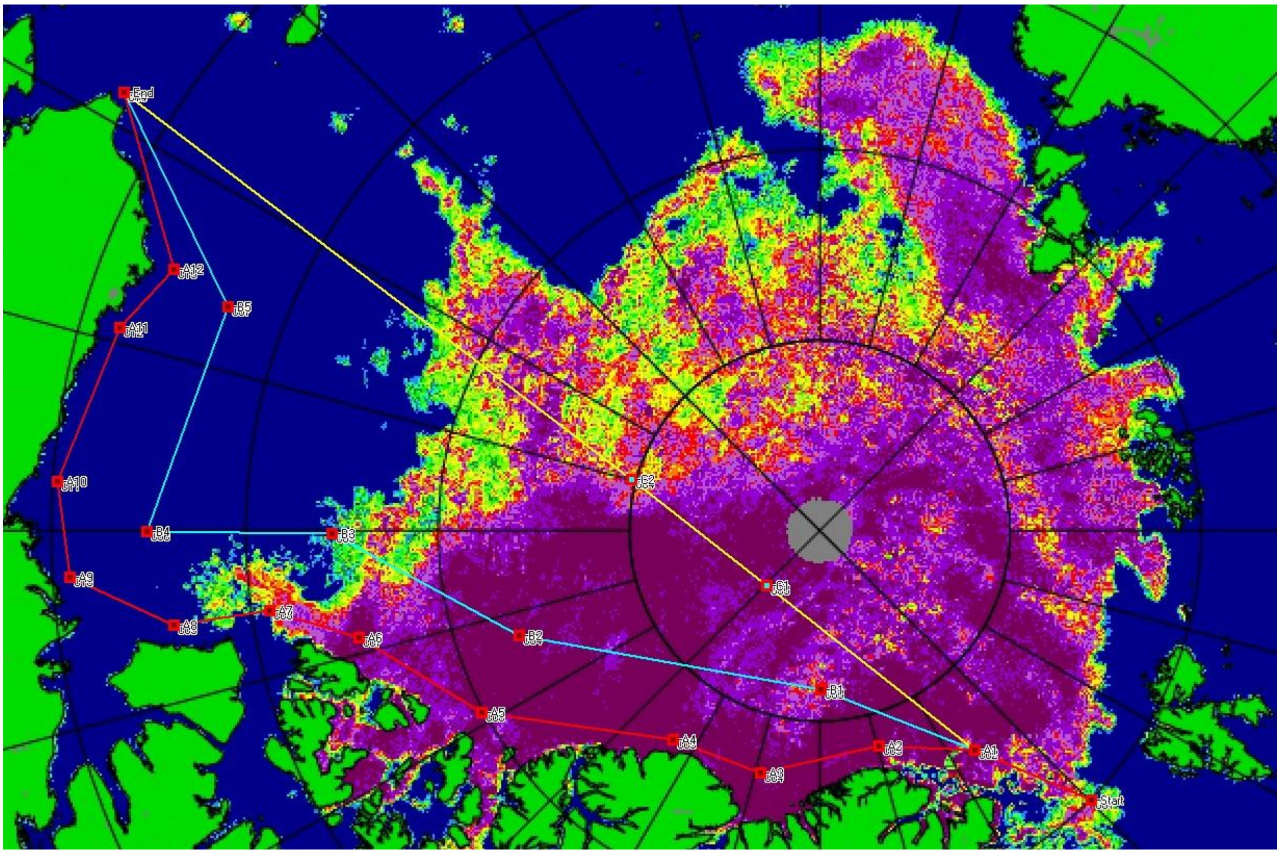
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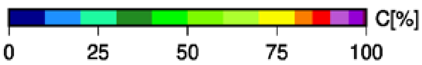
Start

2023-08-31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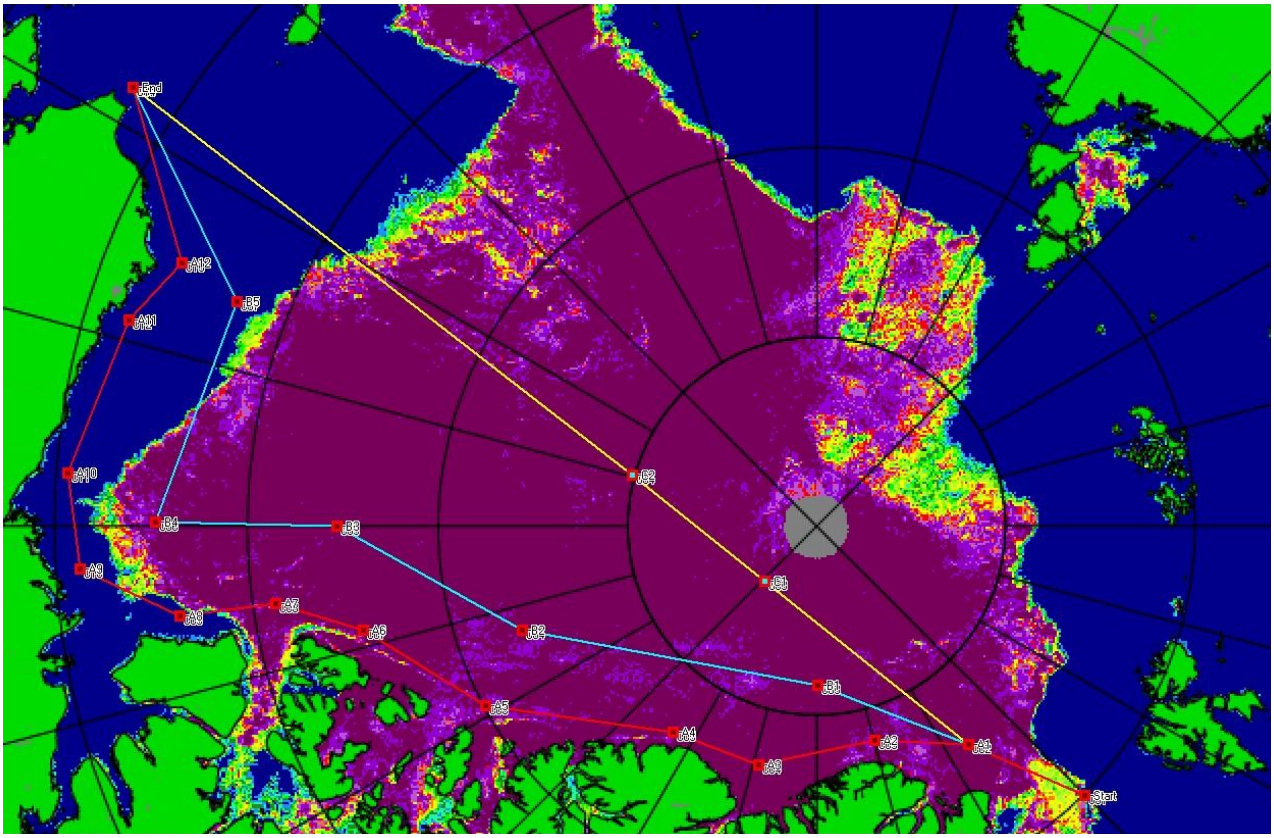
15th of September 2013-2023



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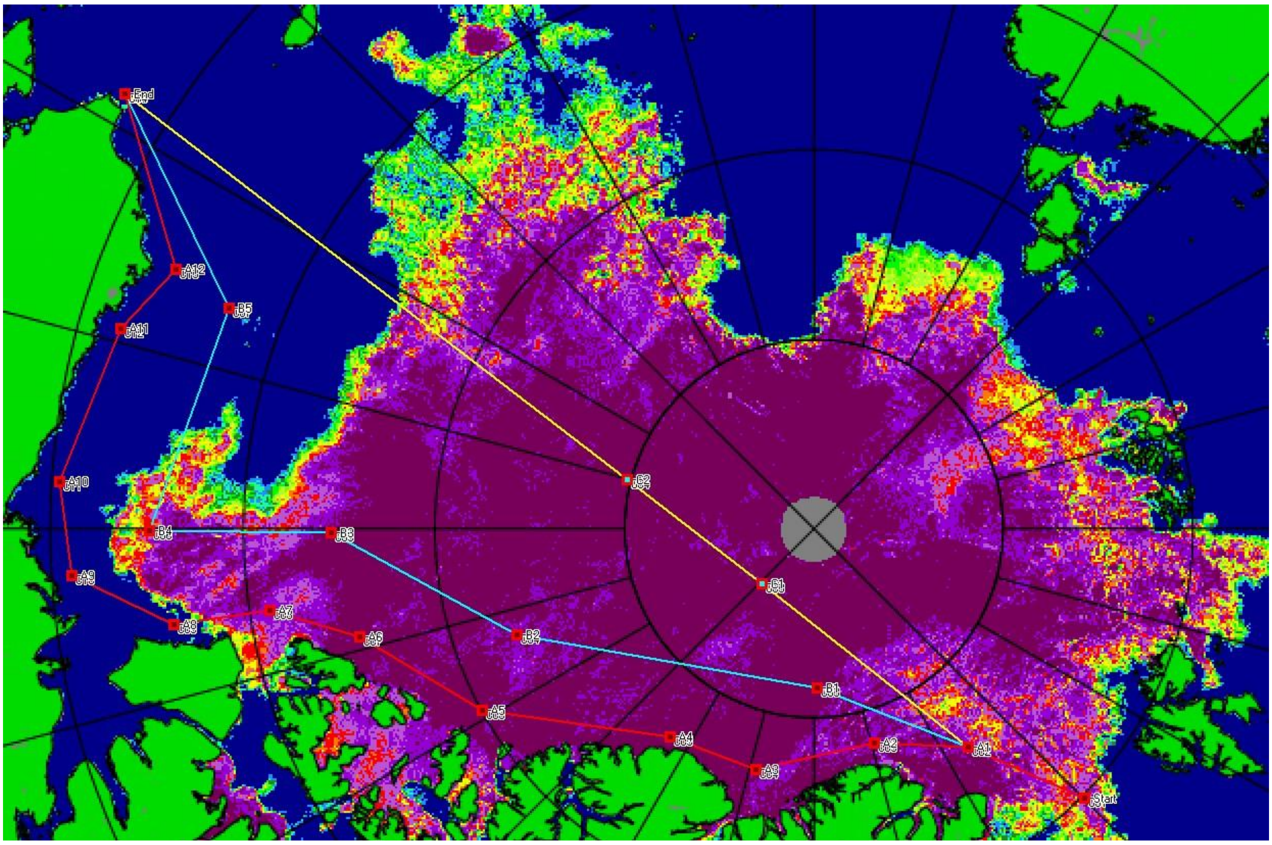

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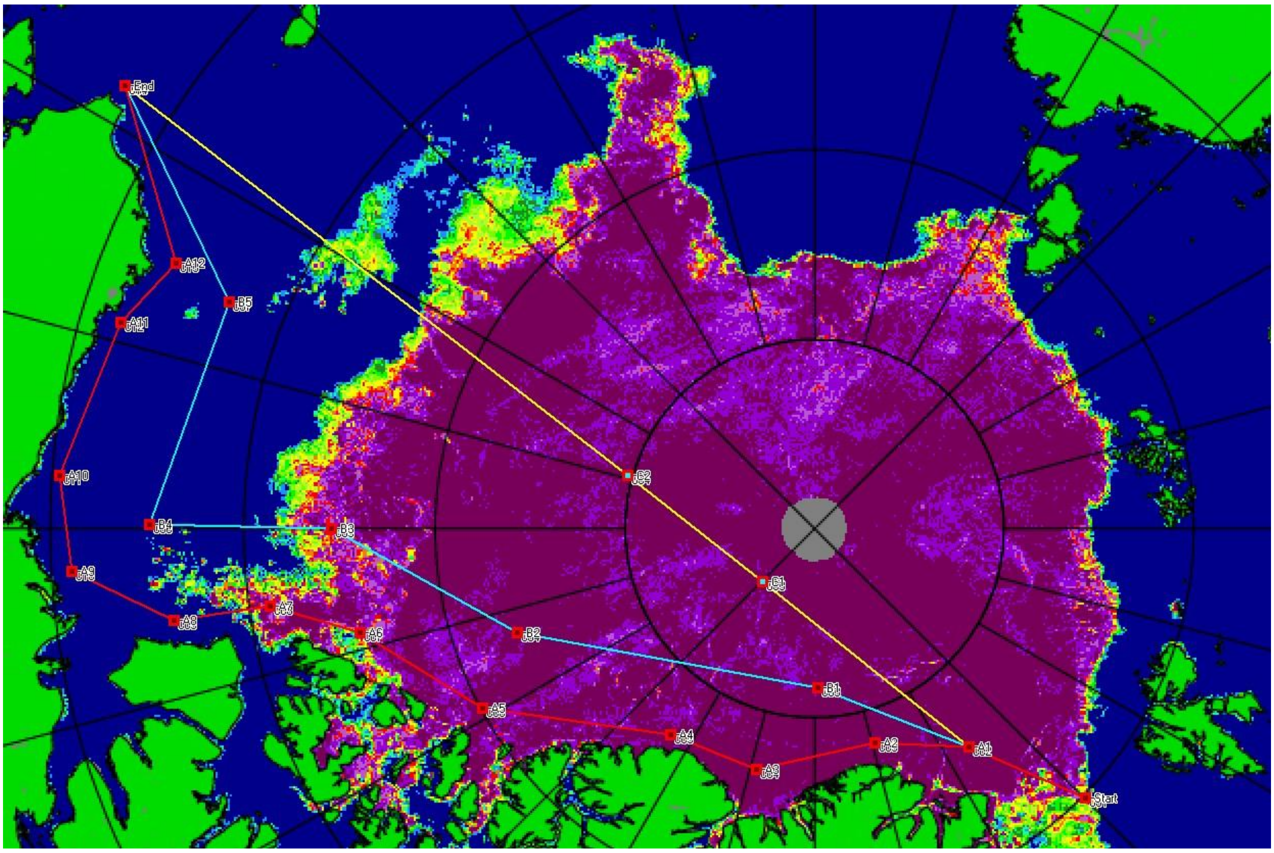

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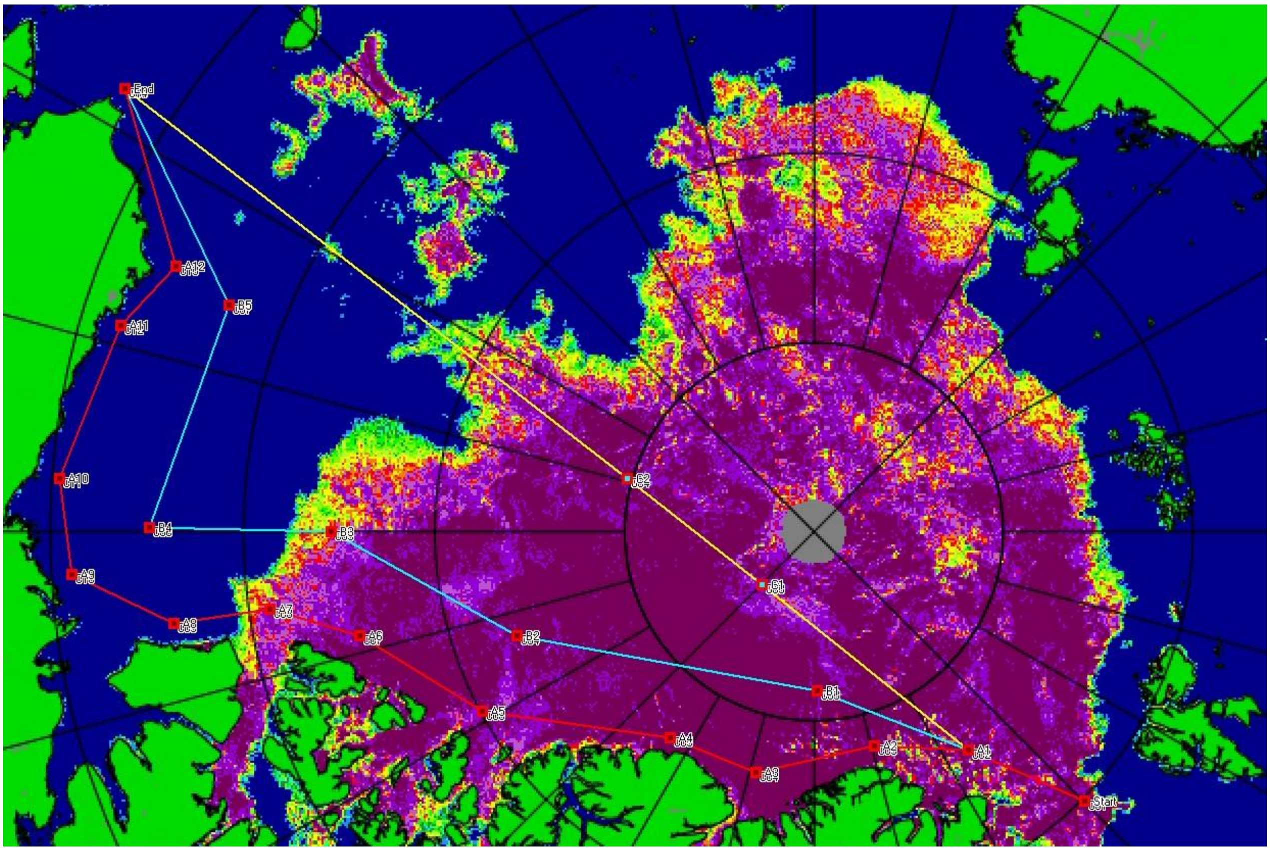

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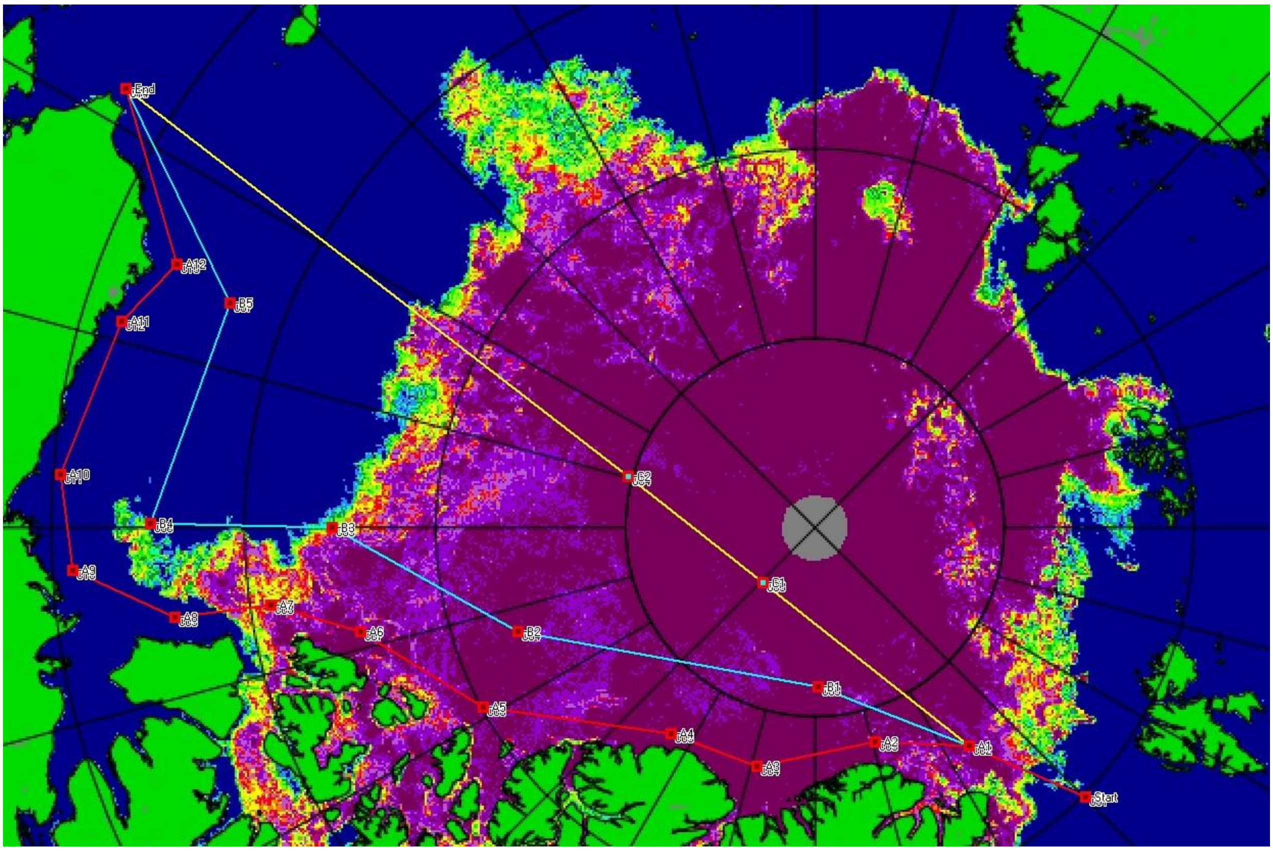

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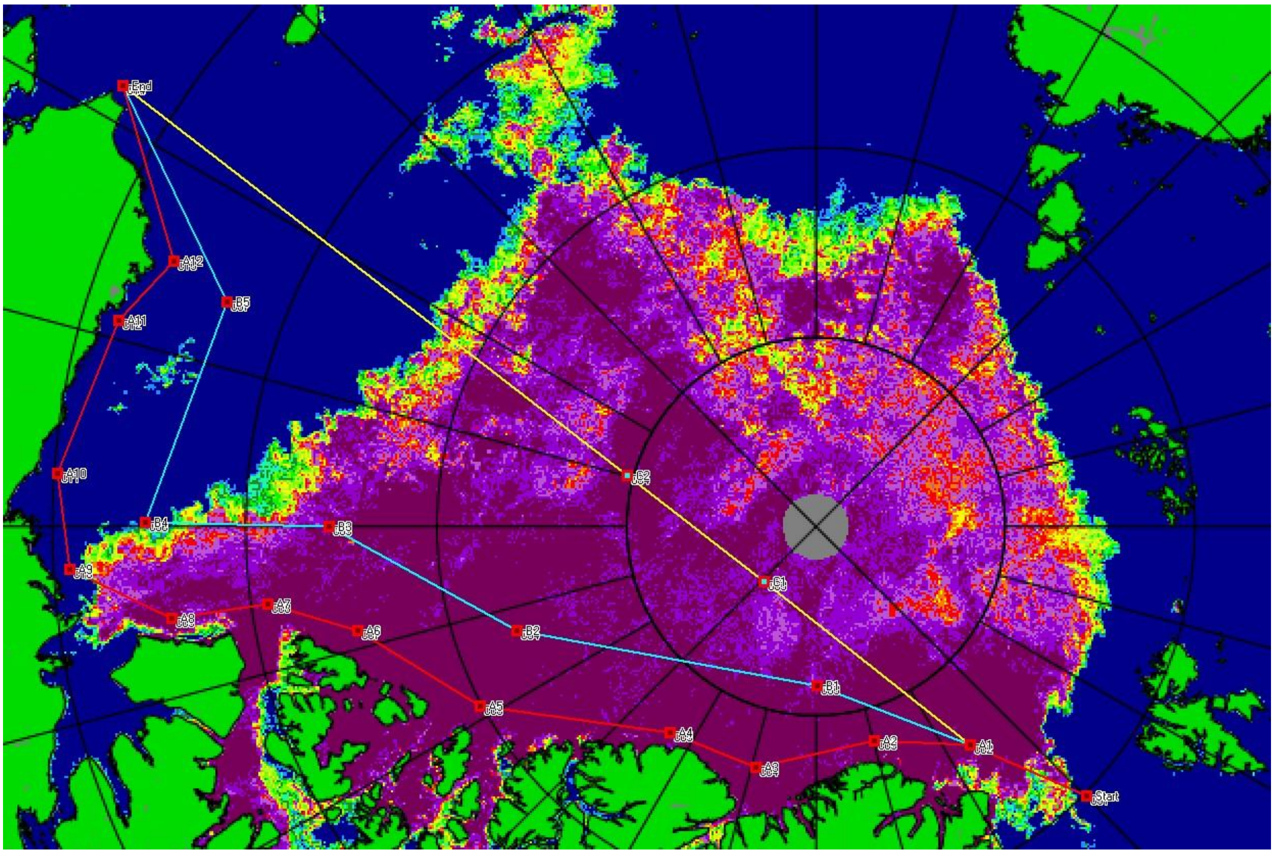

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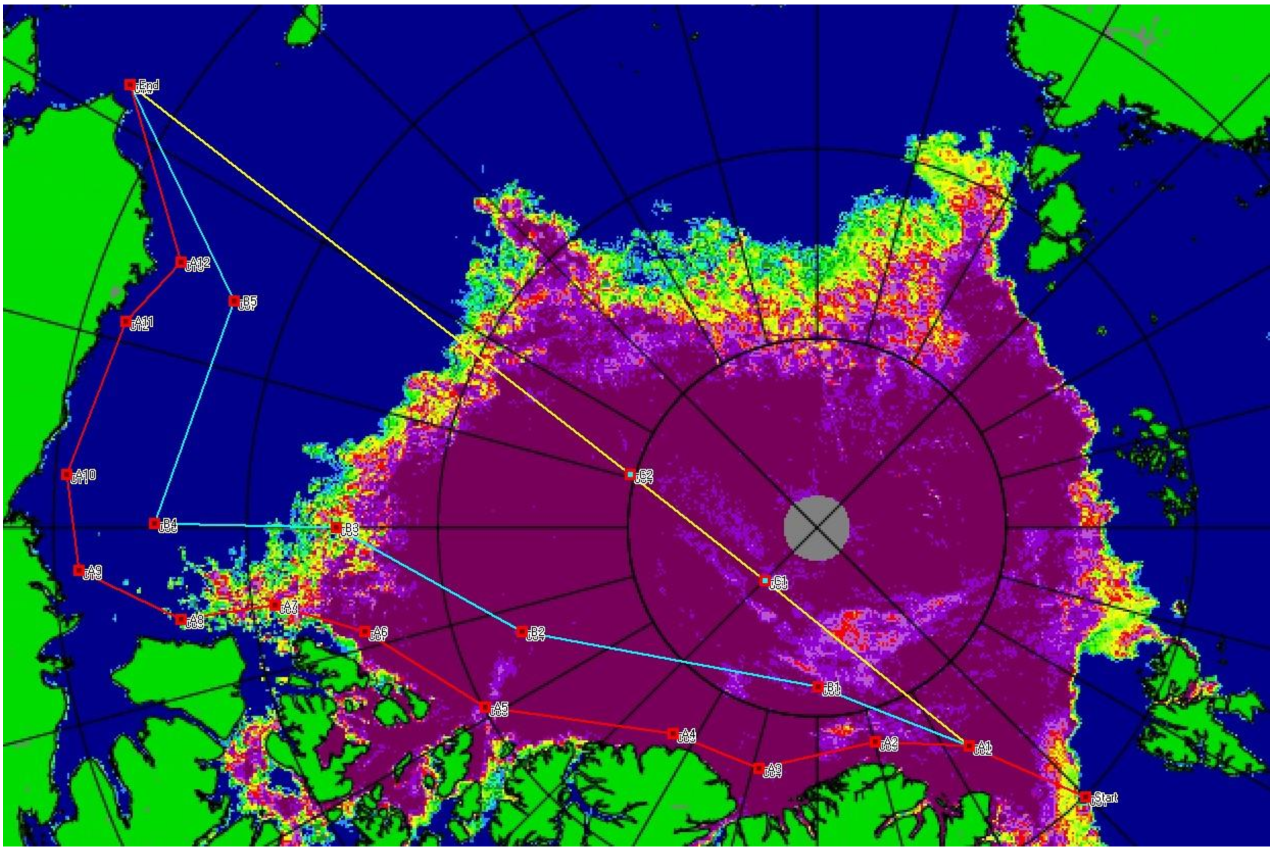

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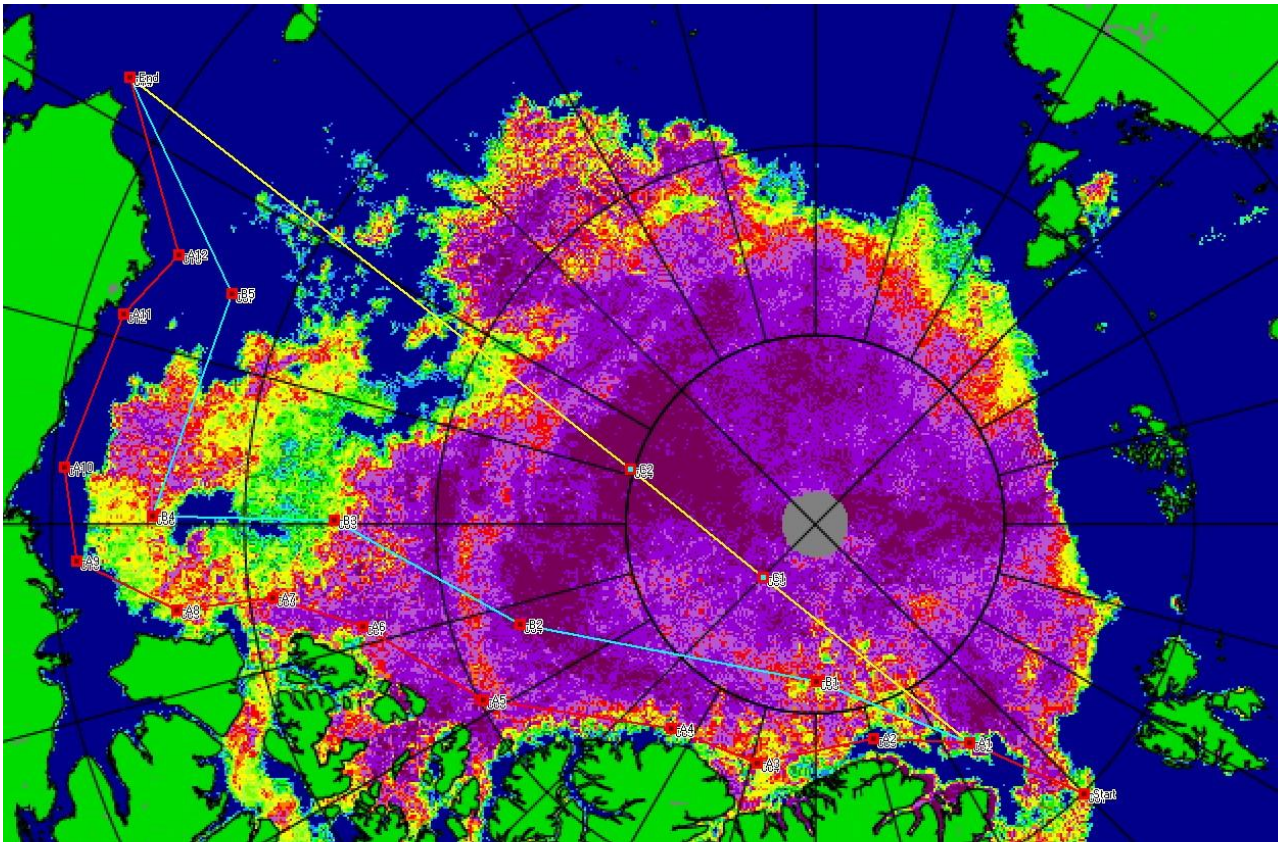

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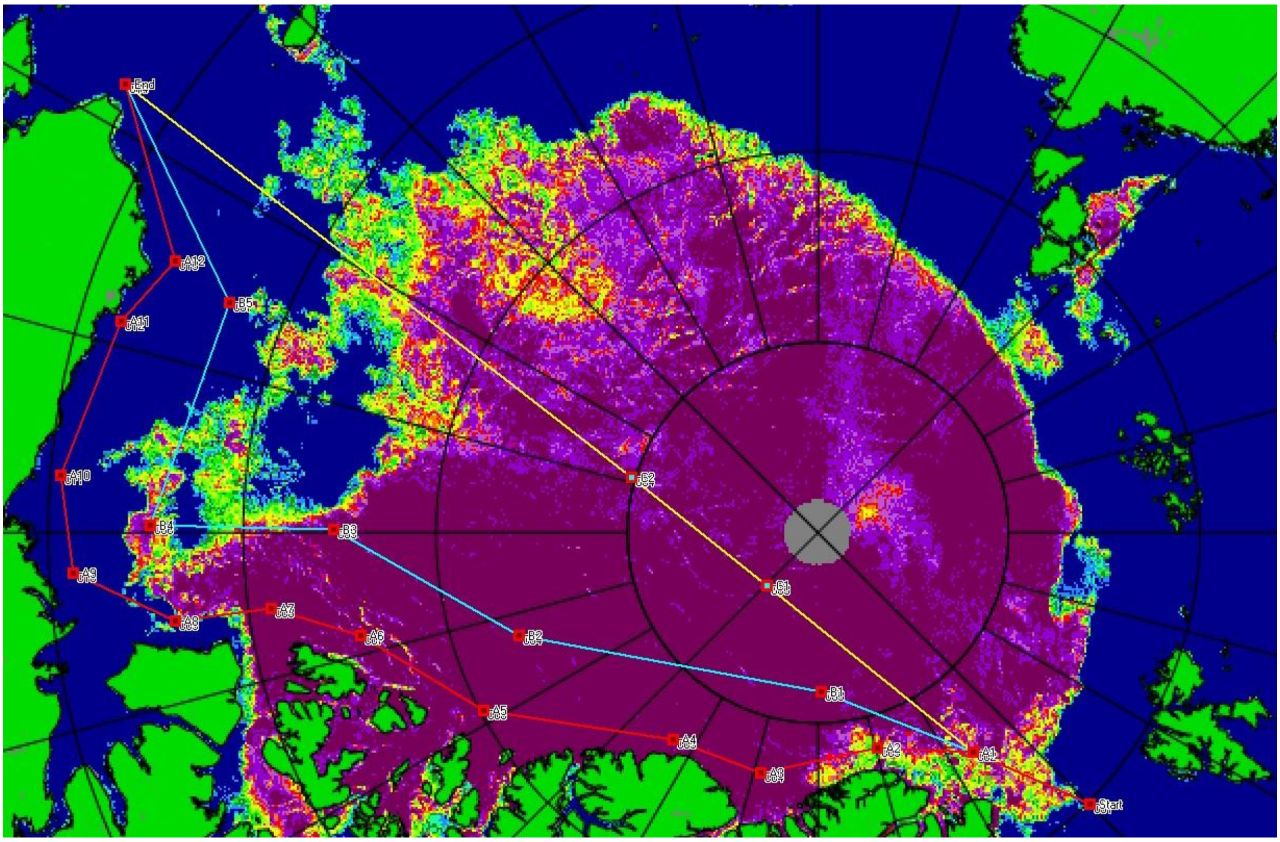

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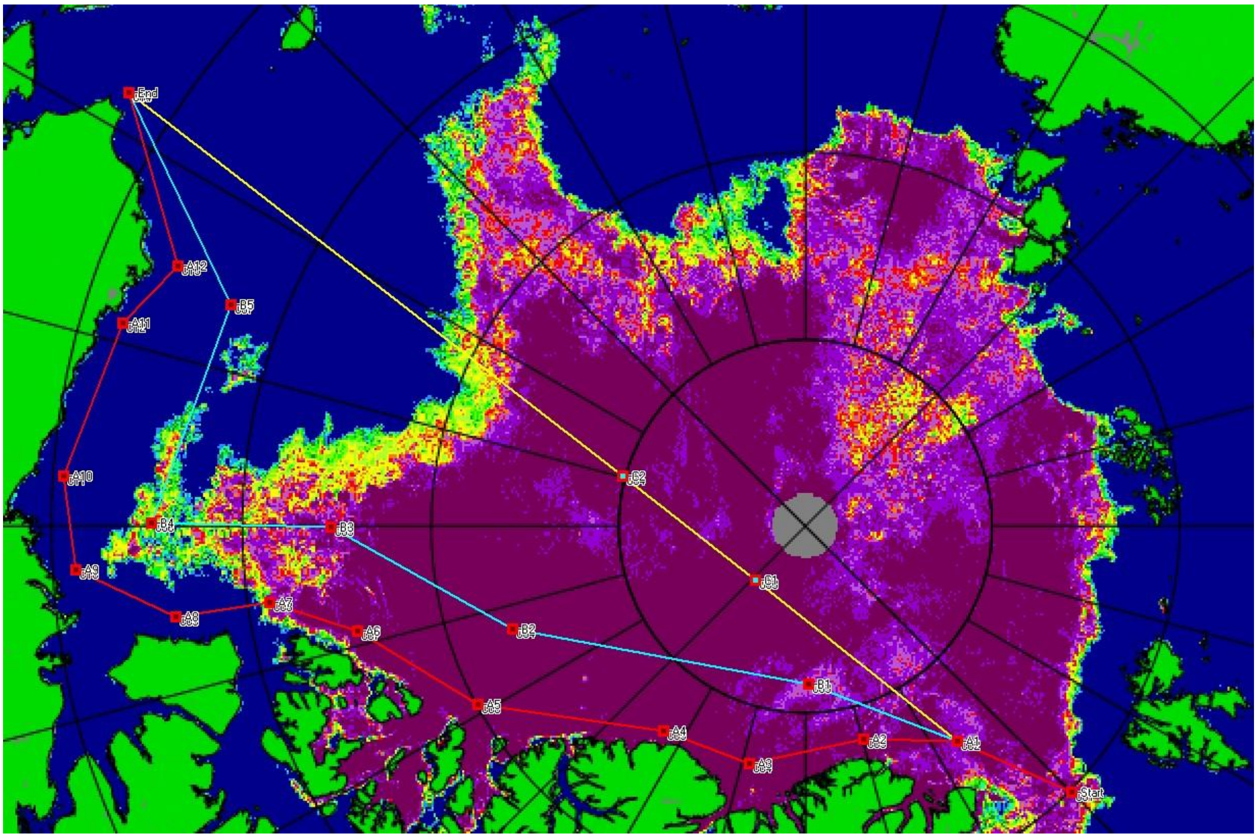

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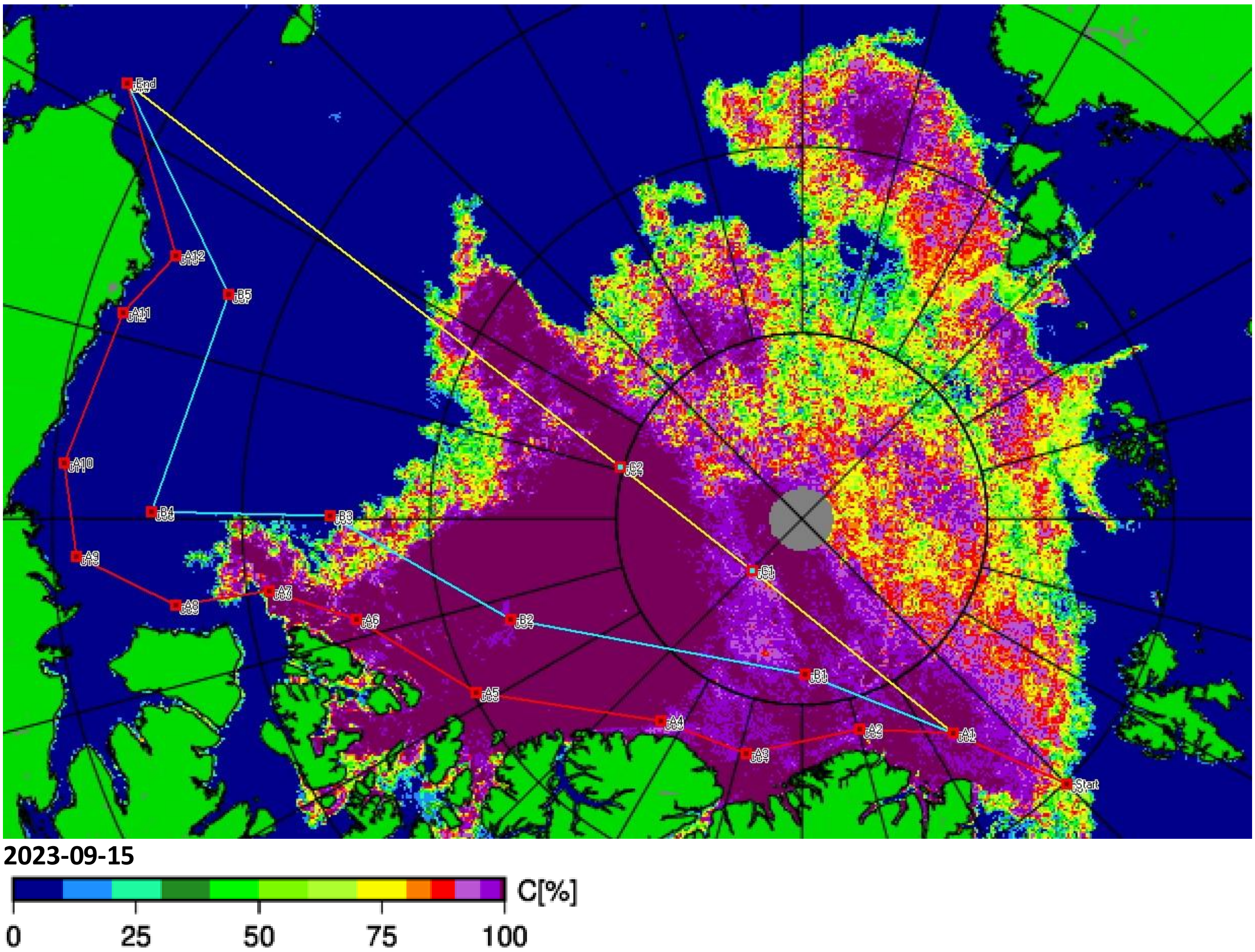

Start
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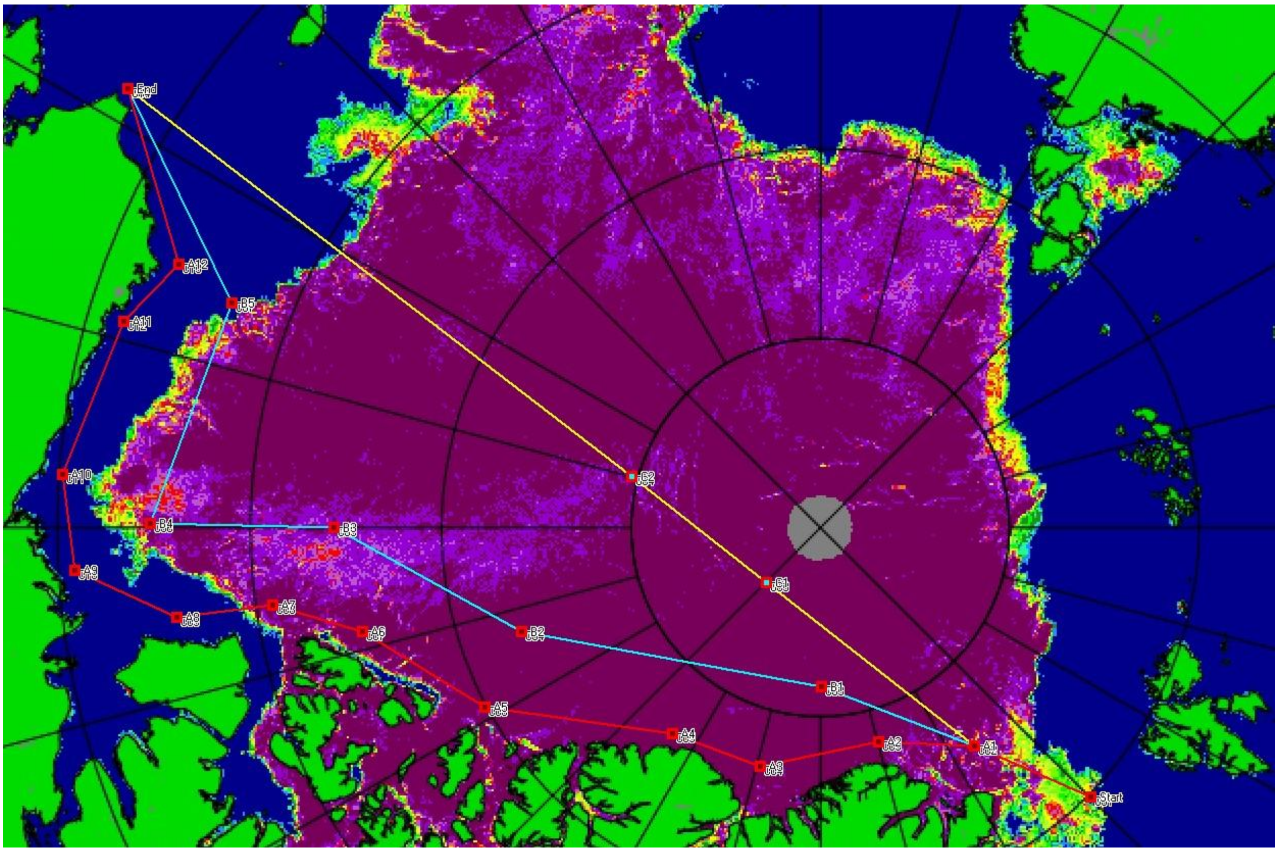
30th of September 2013-2023



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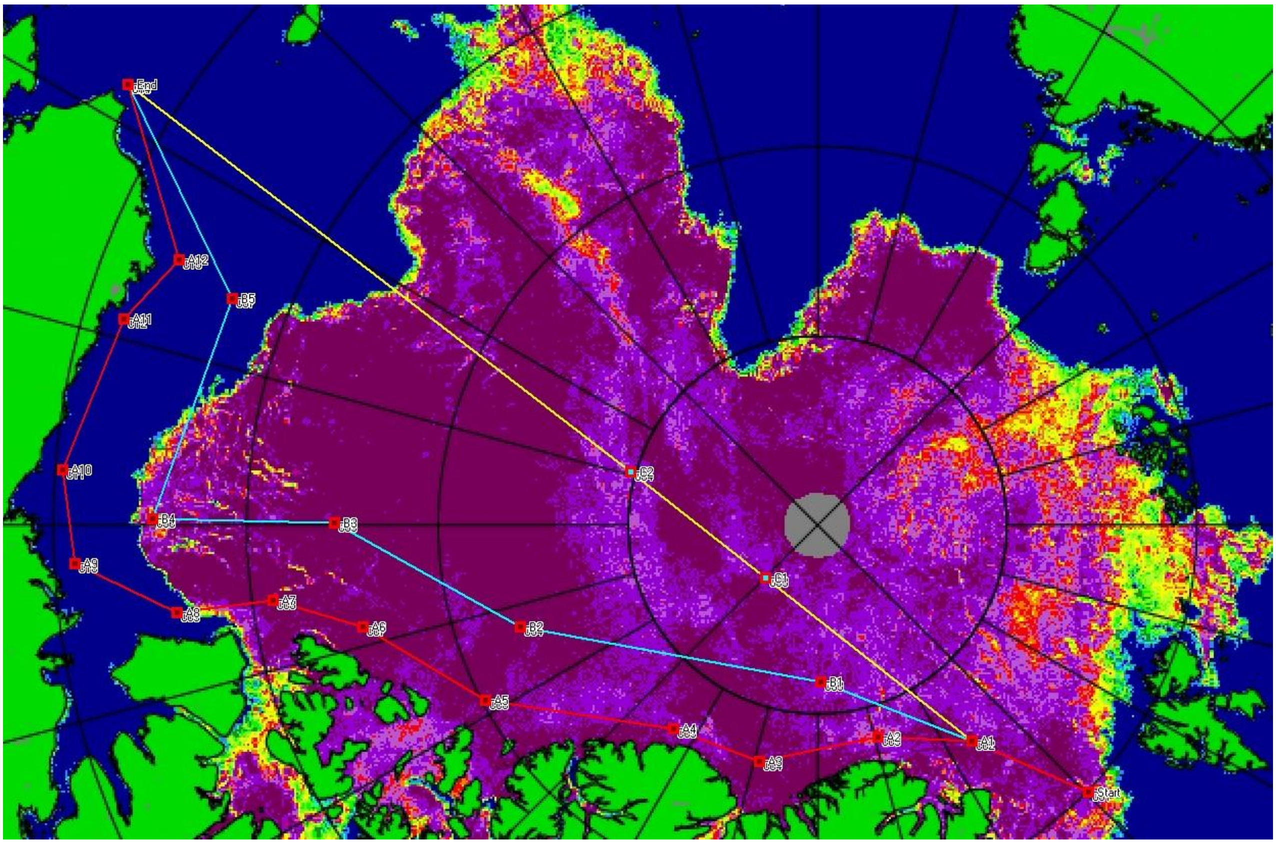

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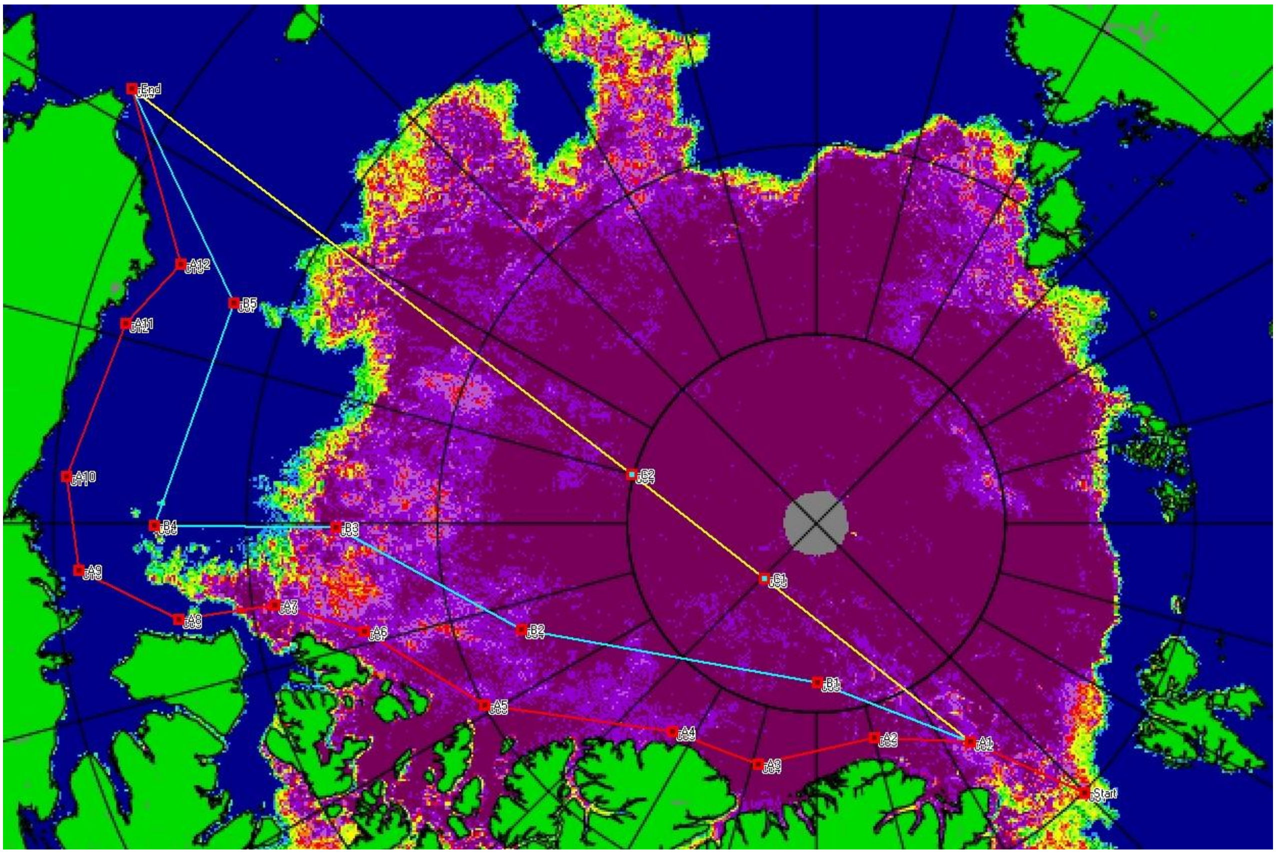

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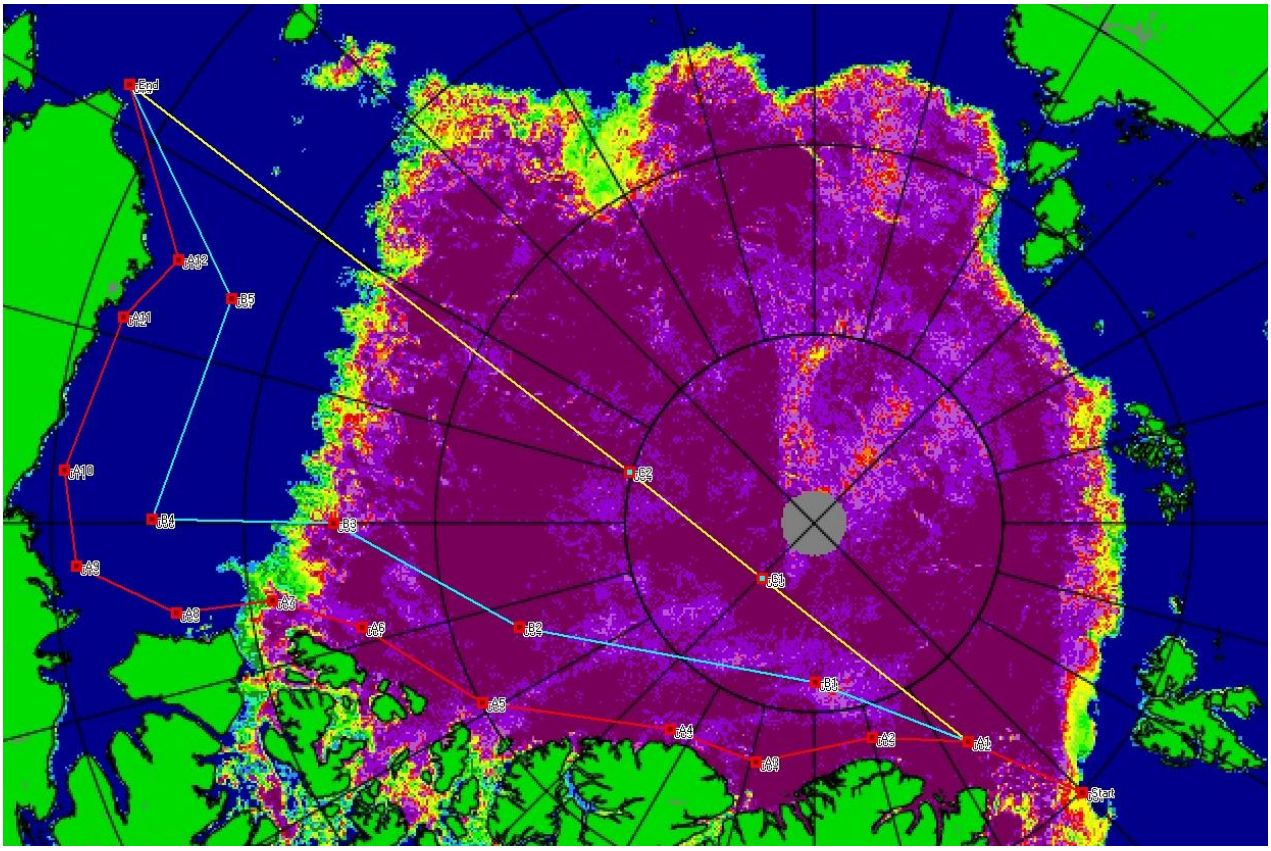

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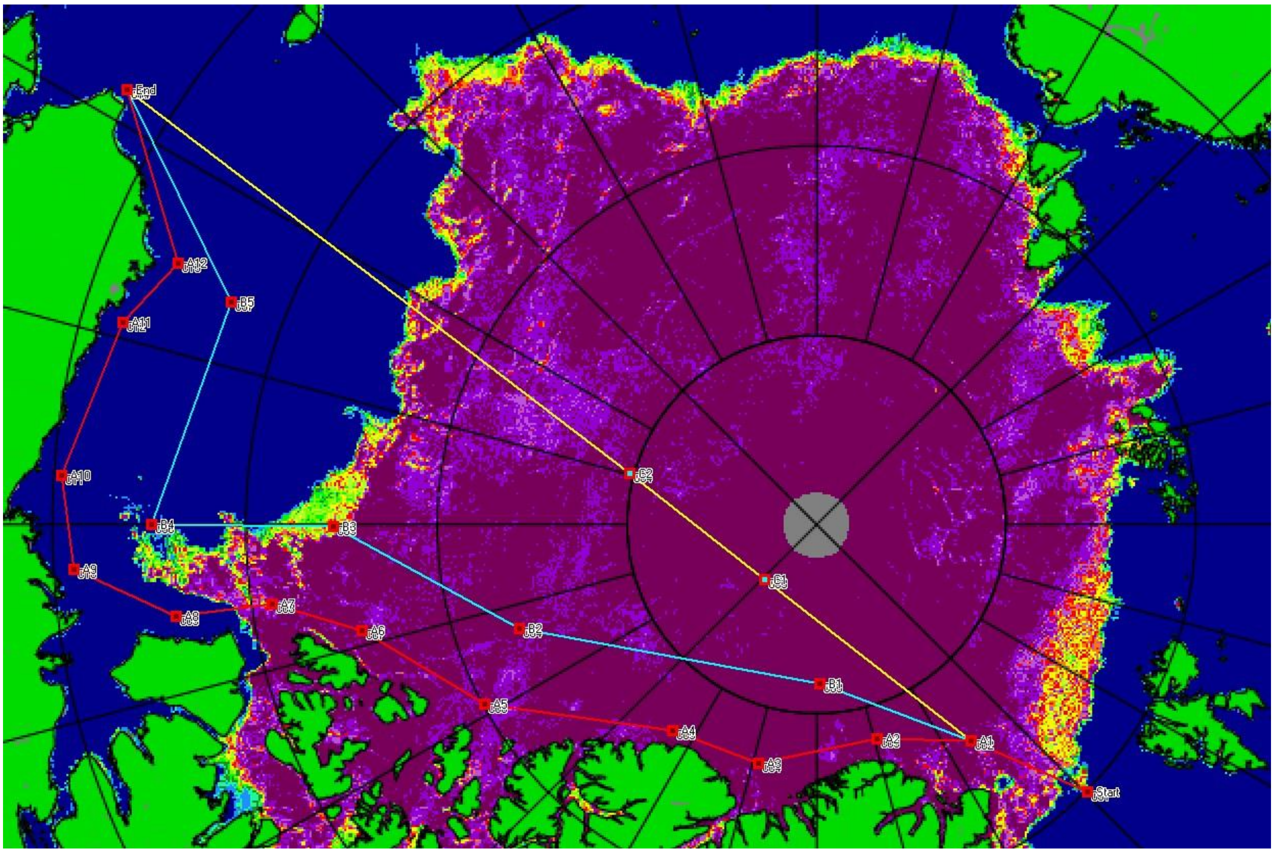

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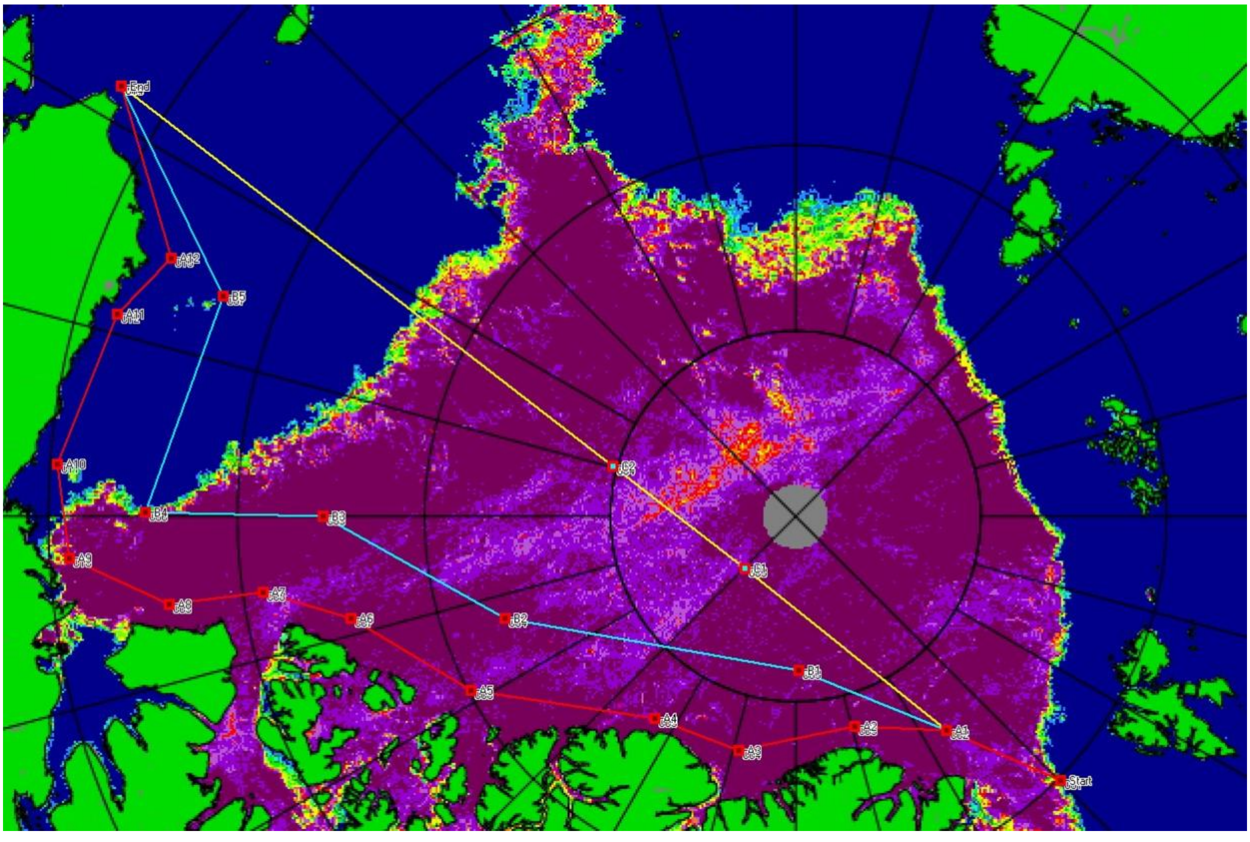

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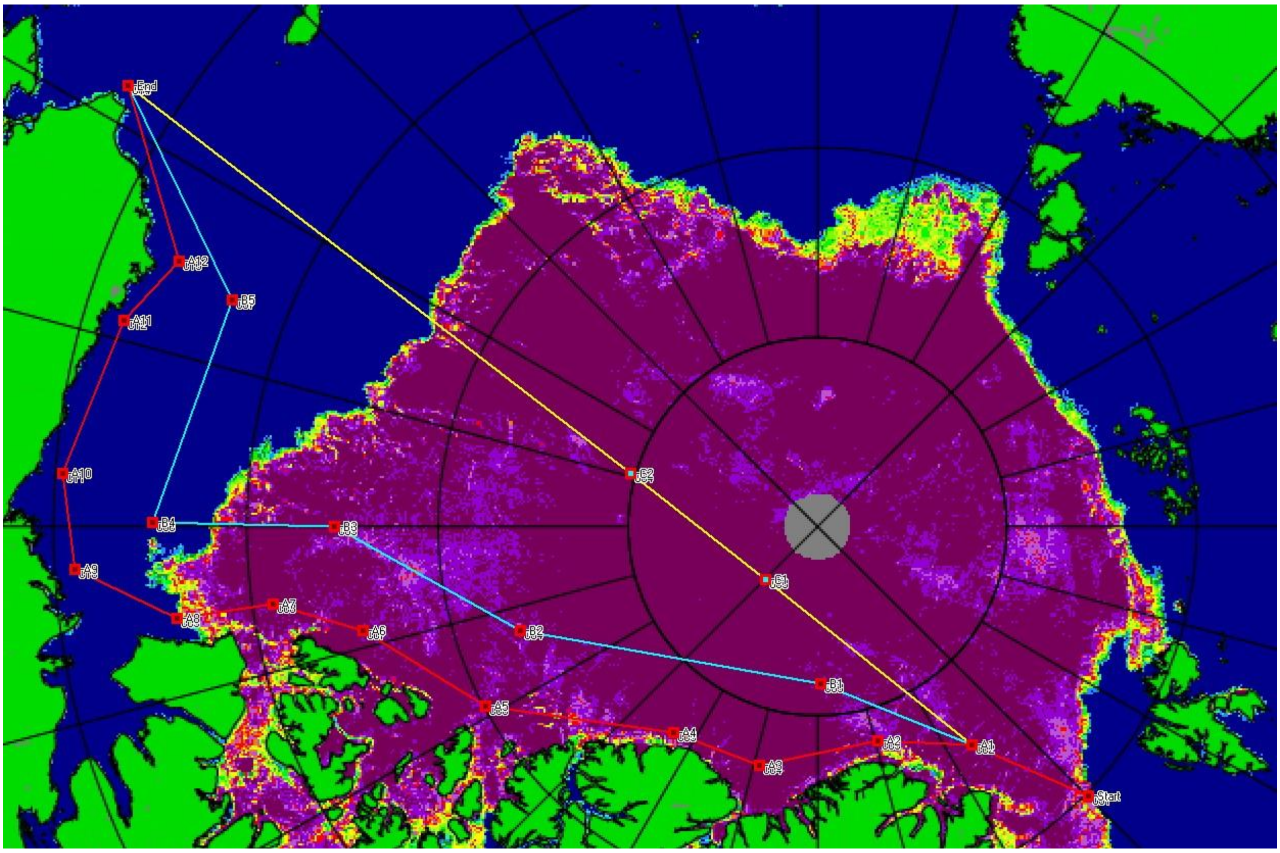

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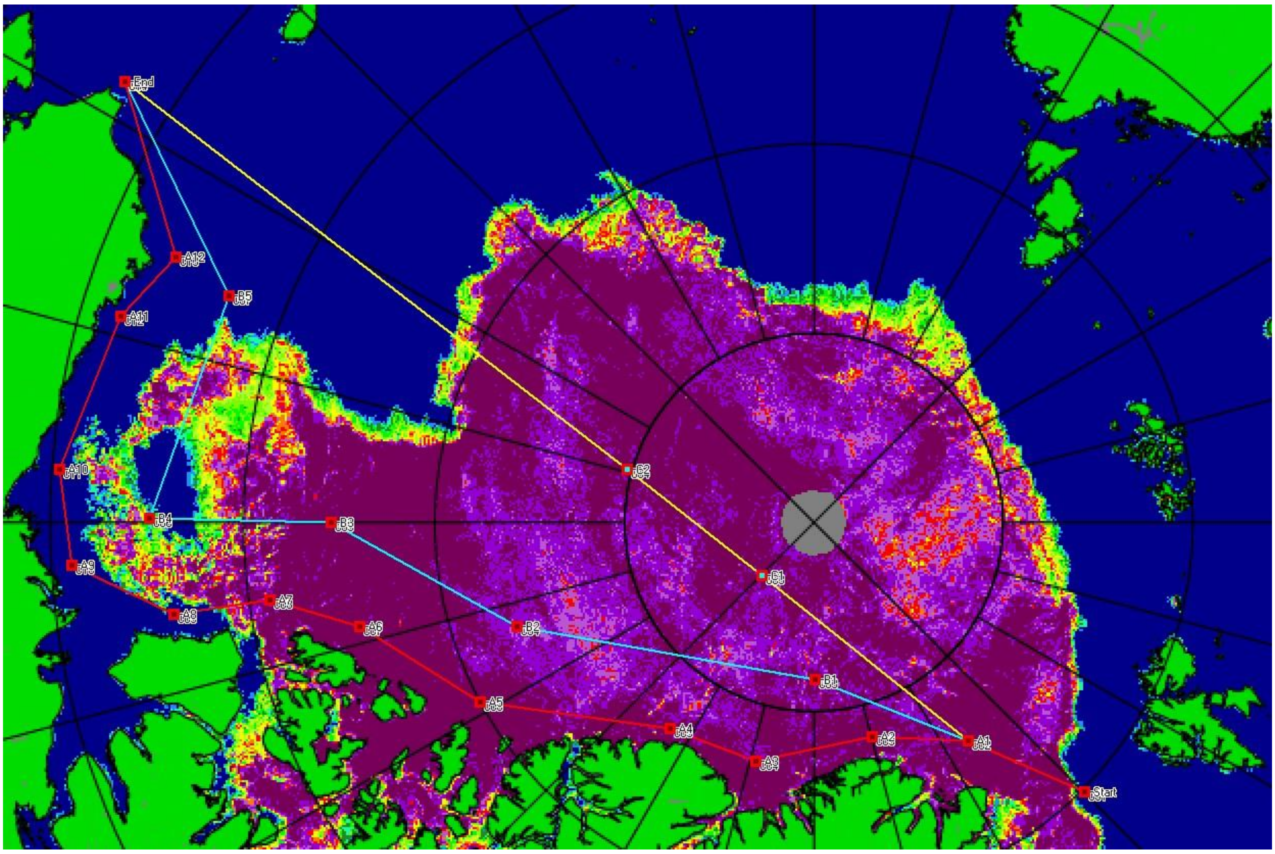

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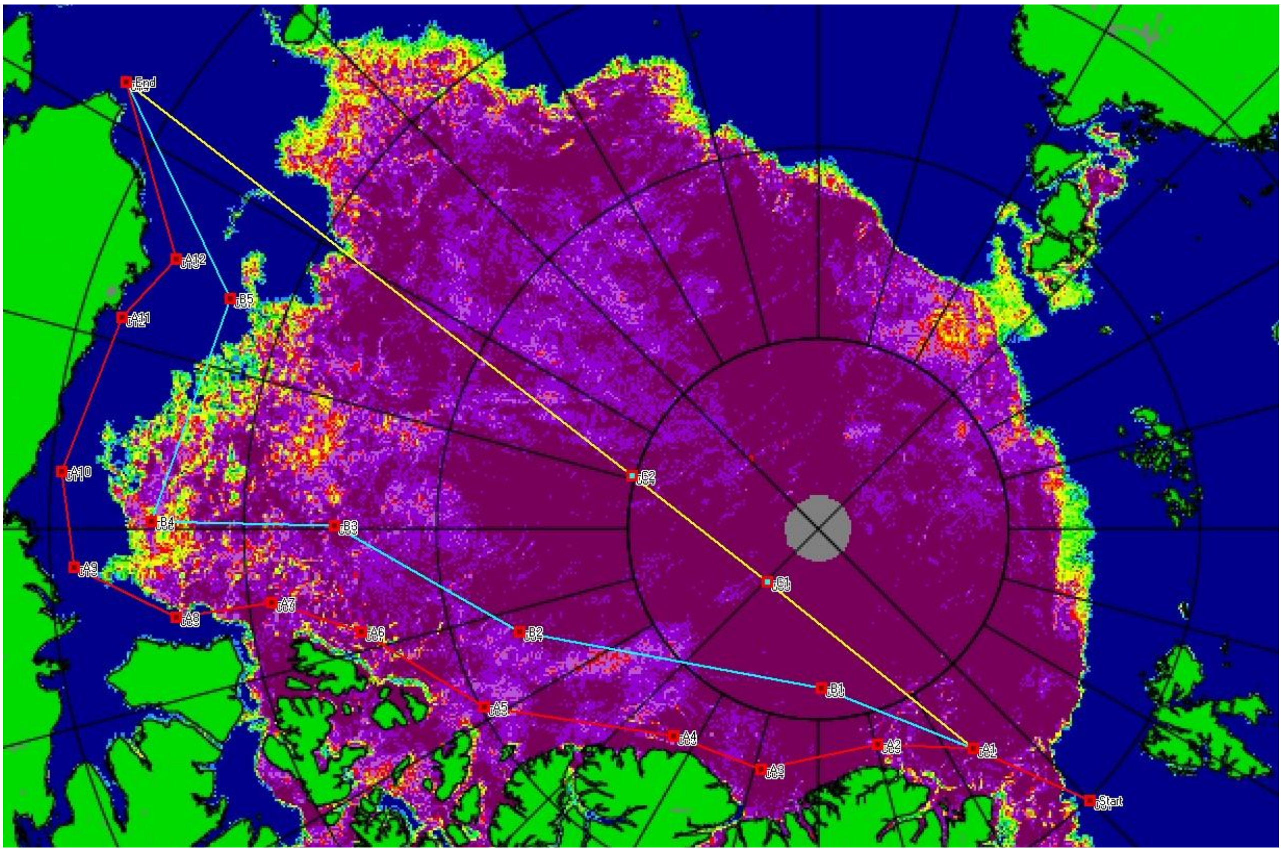

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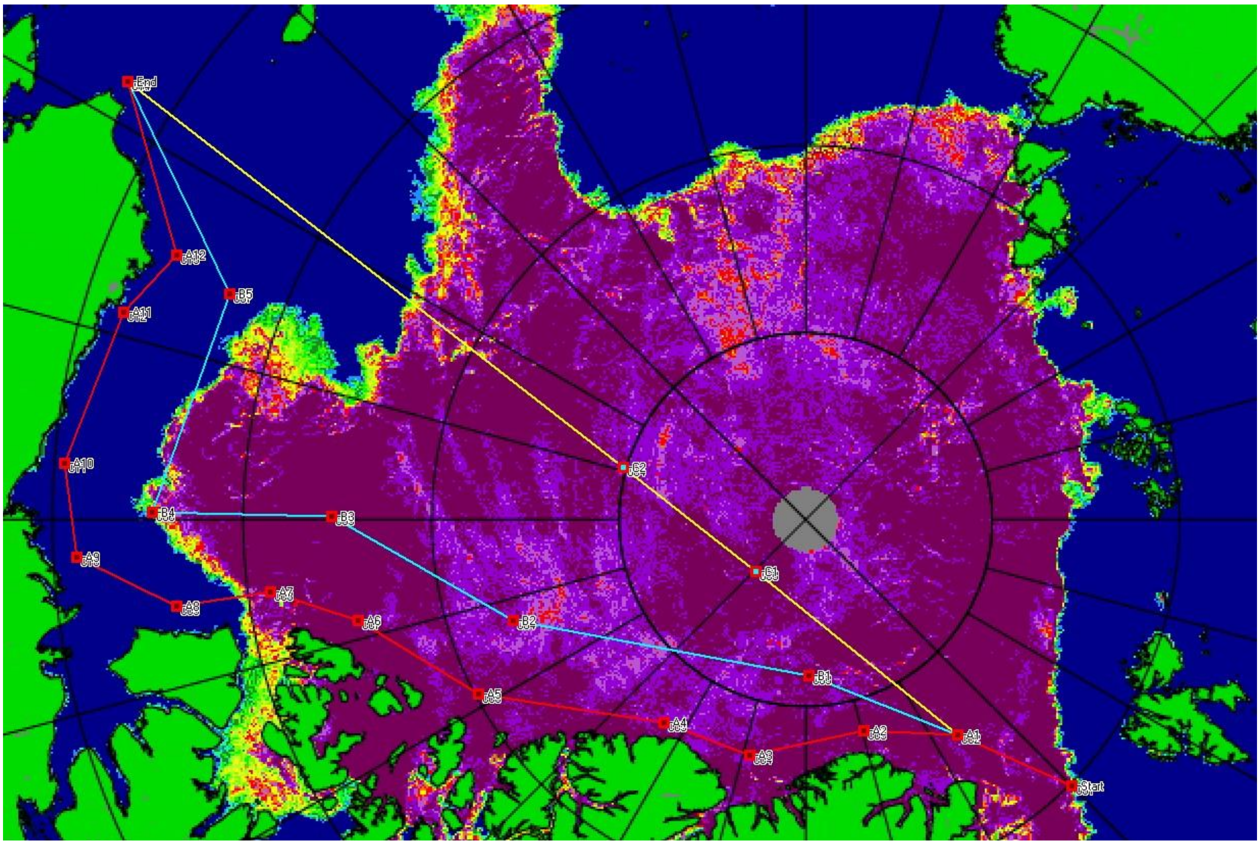

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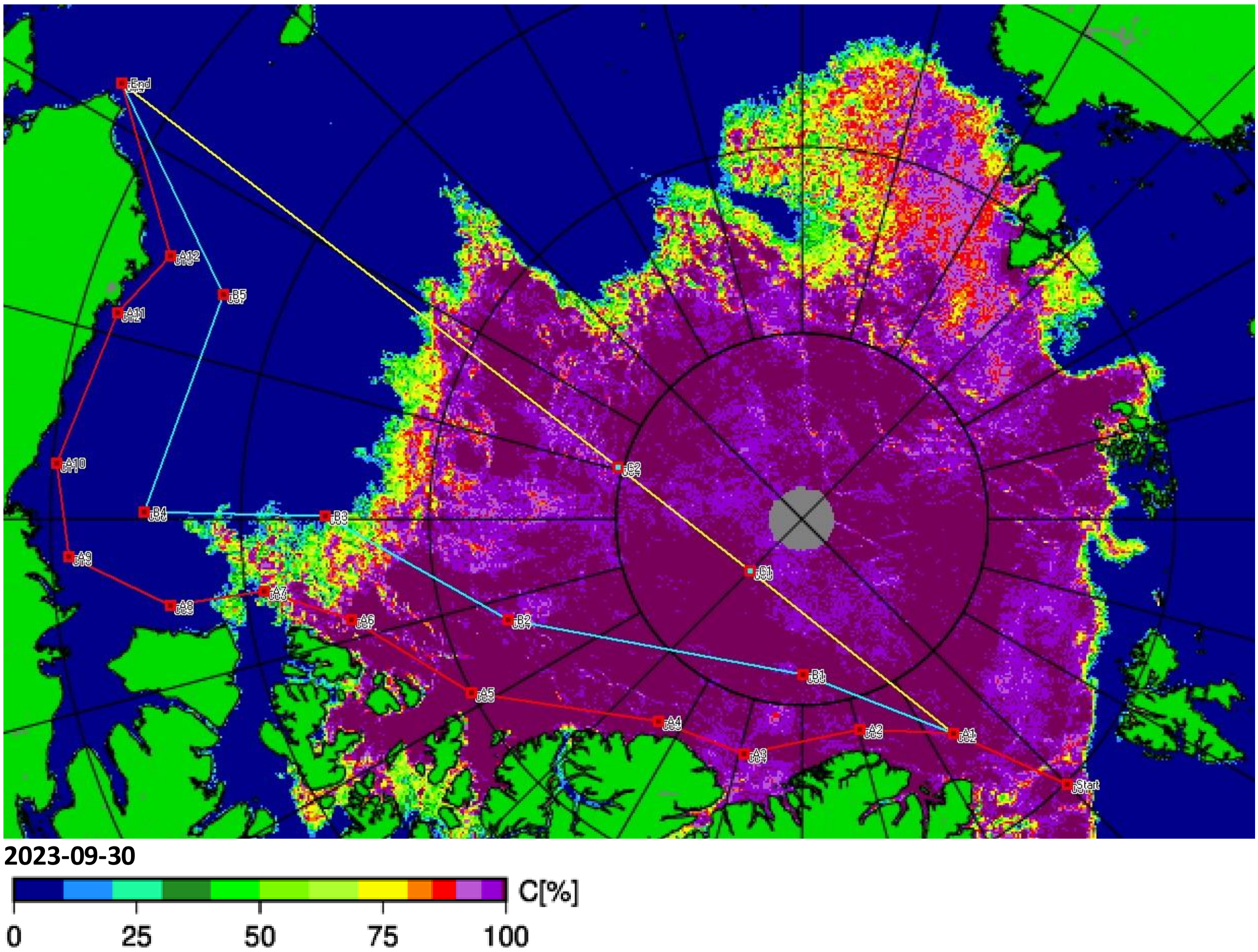
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2023-09-30
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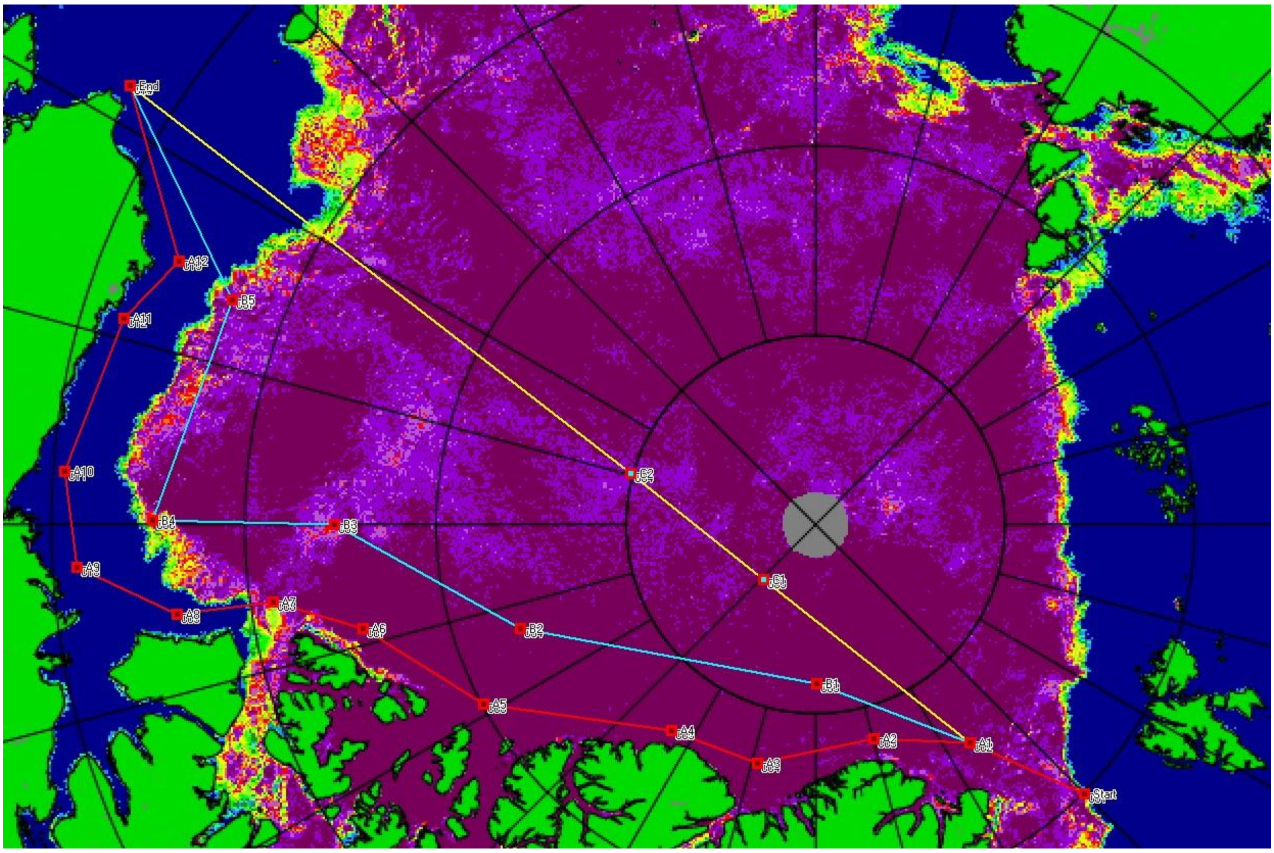
15th of October 2013-2023



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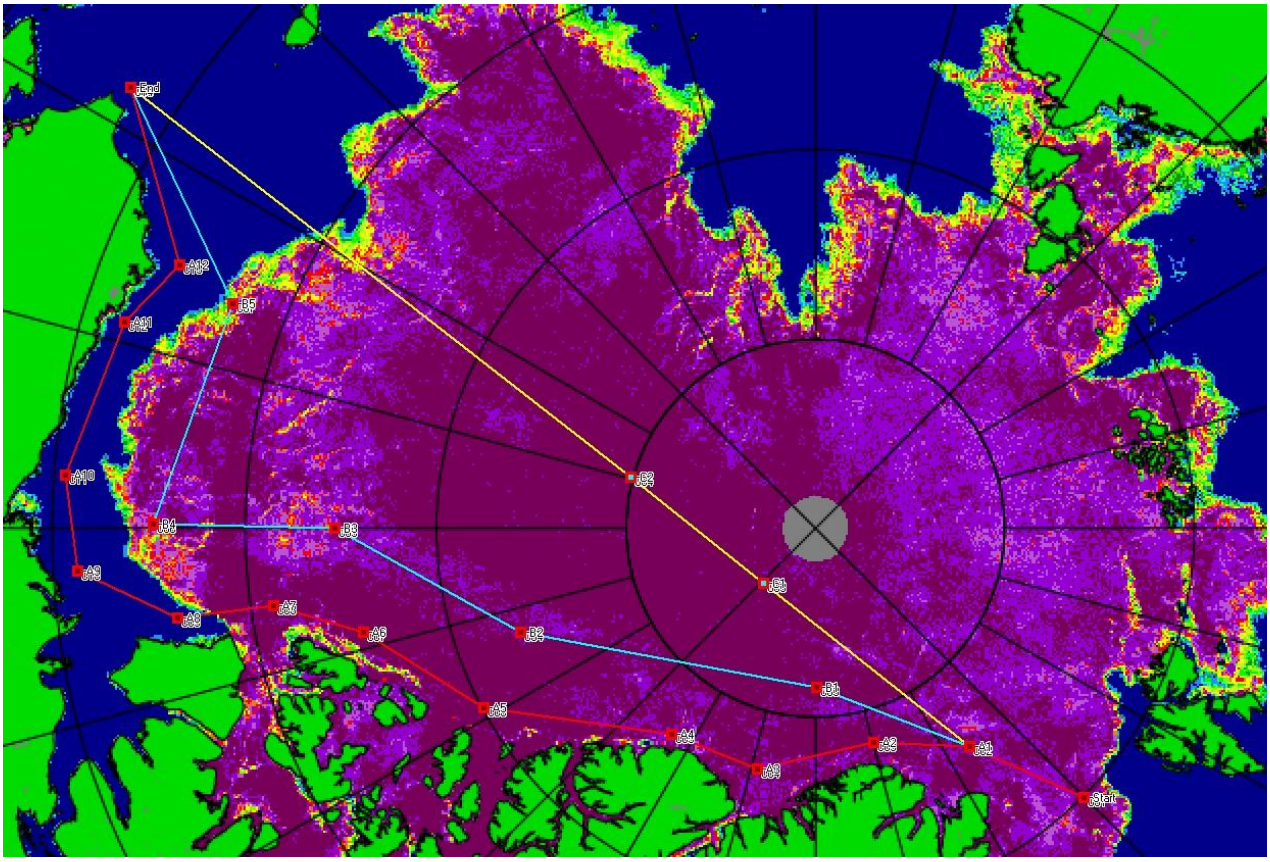

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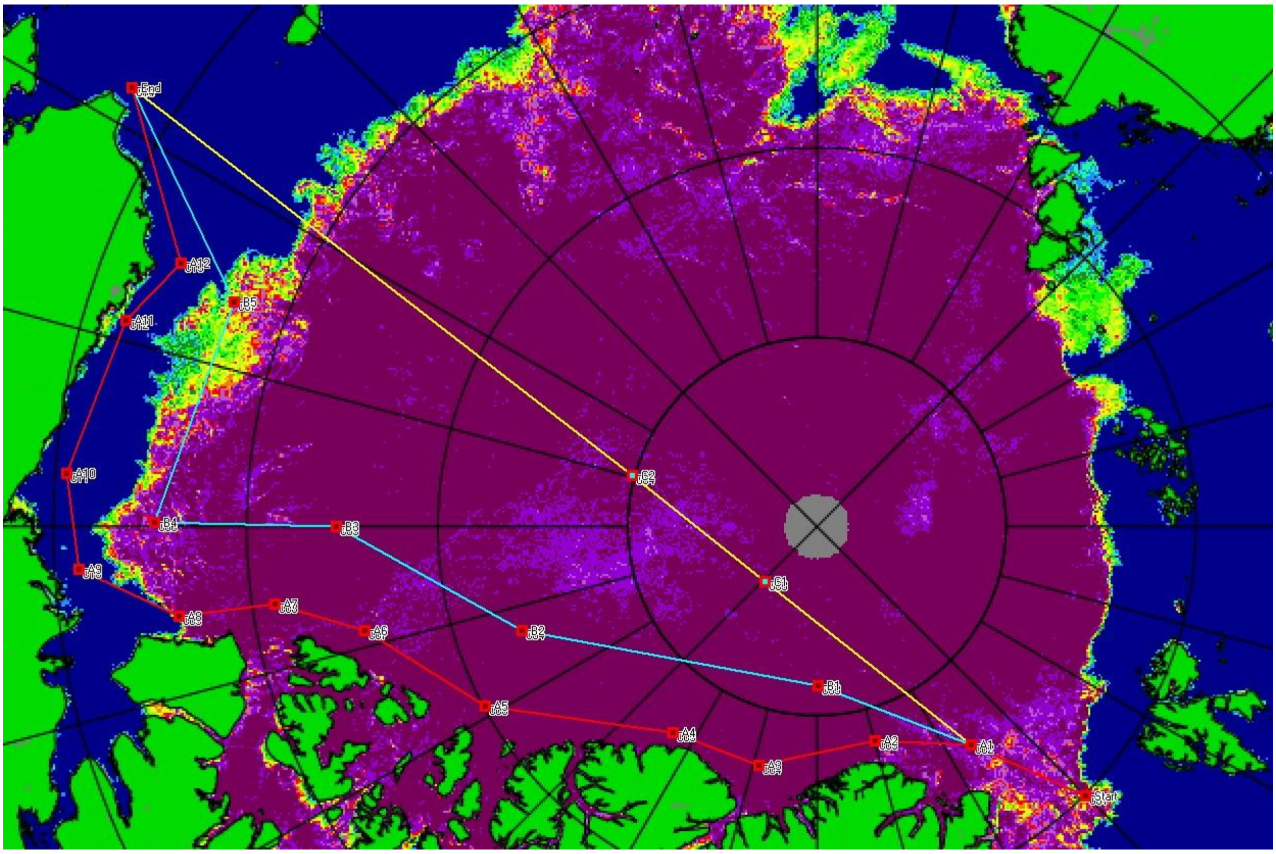

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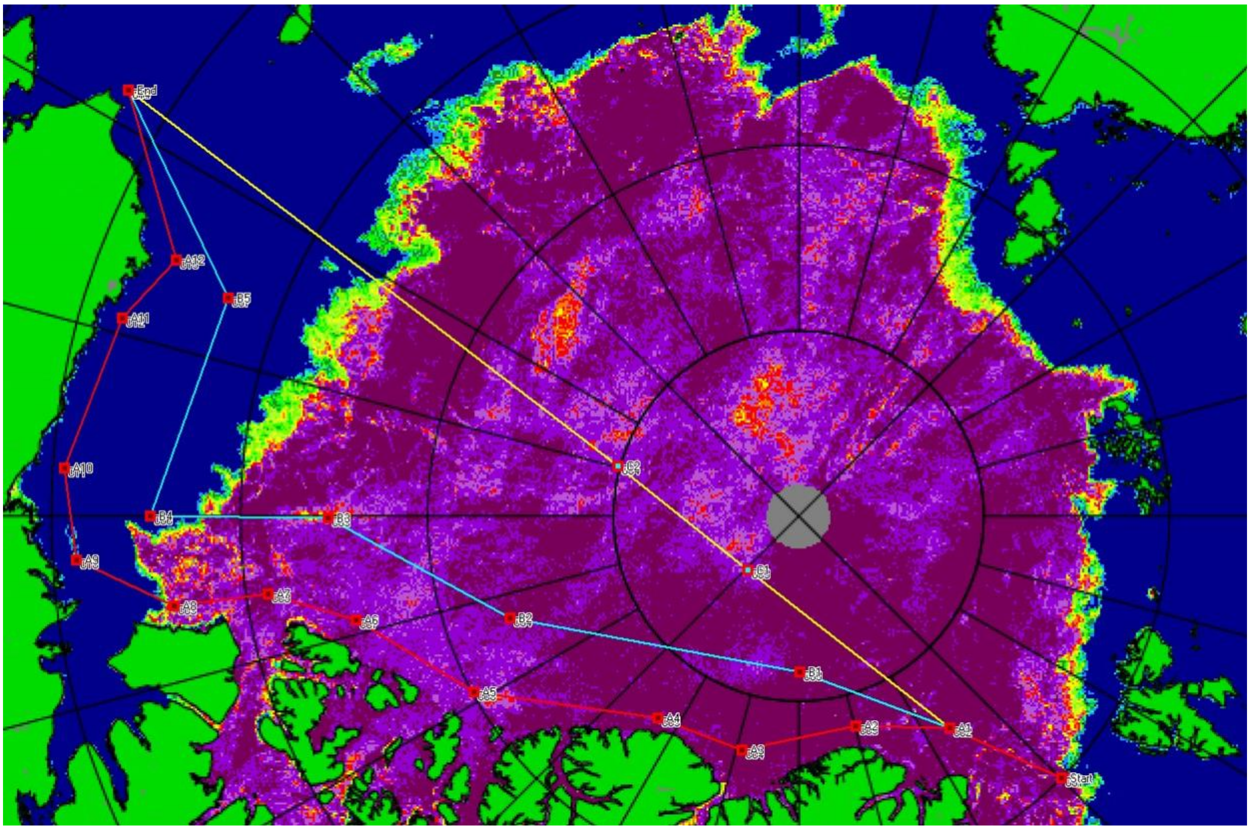

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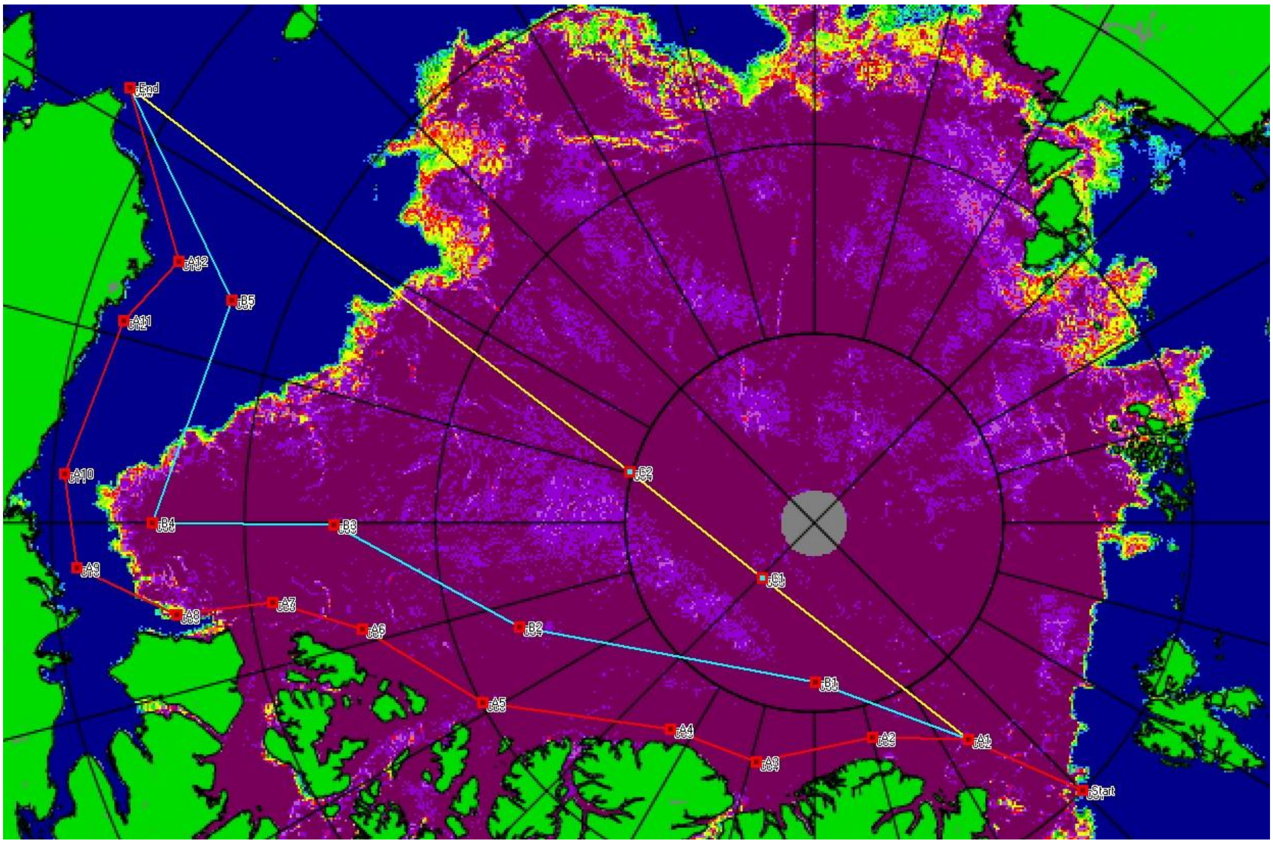

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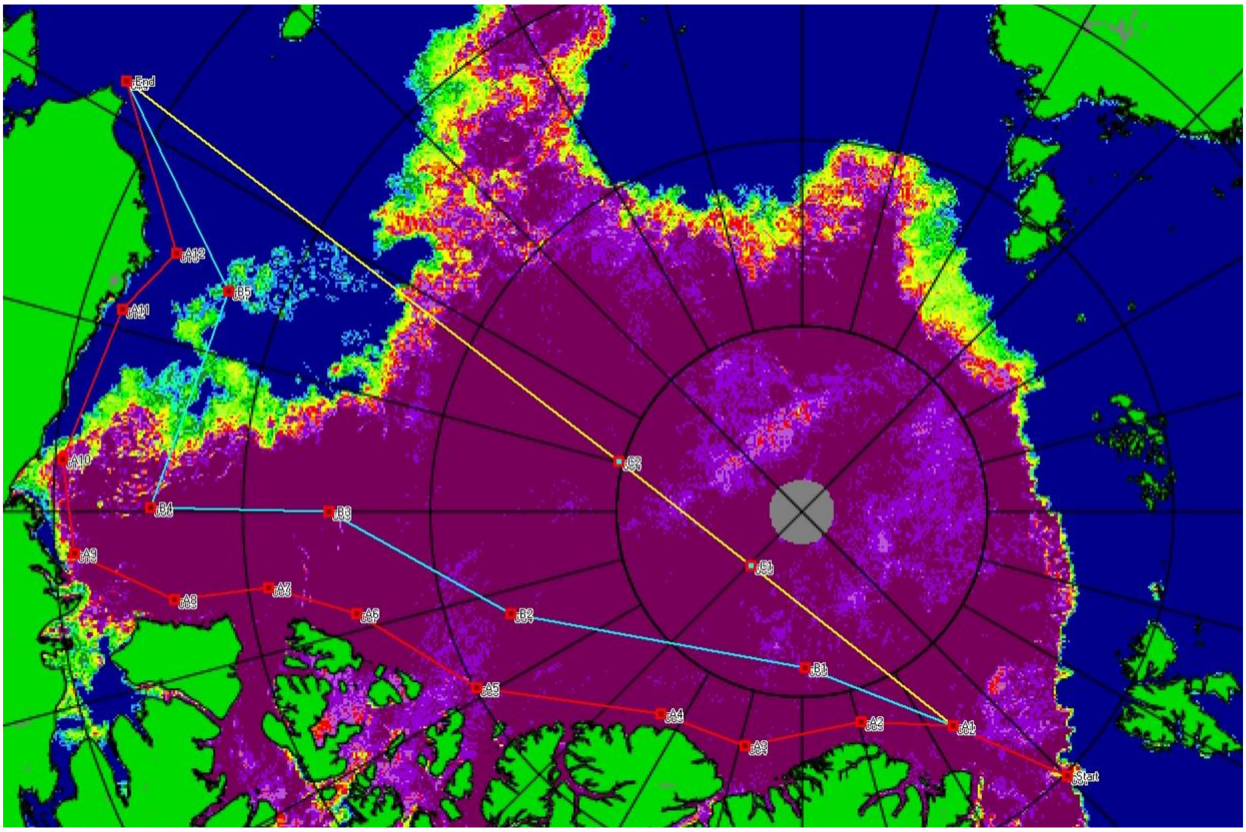

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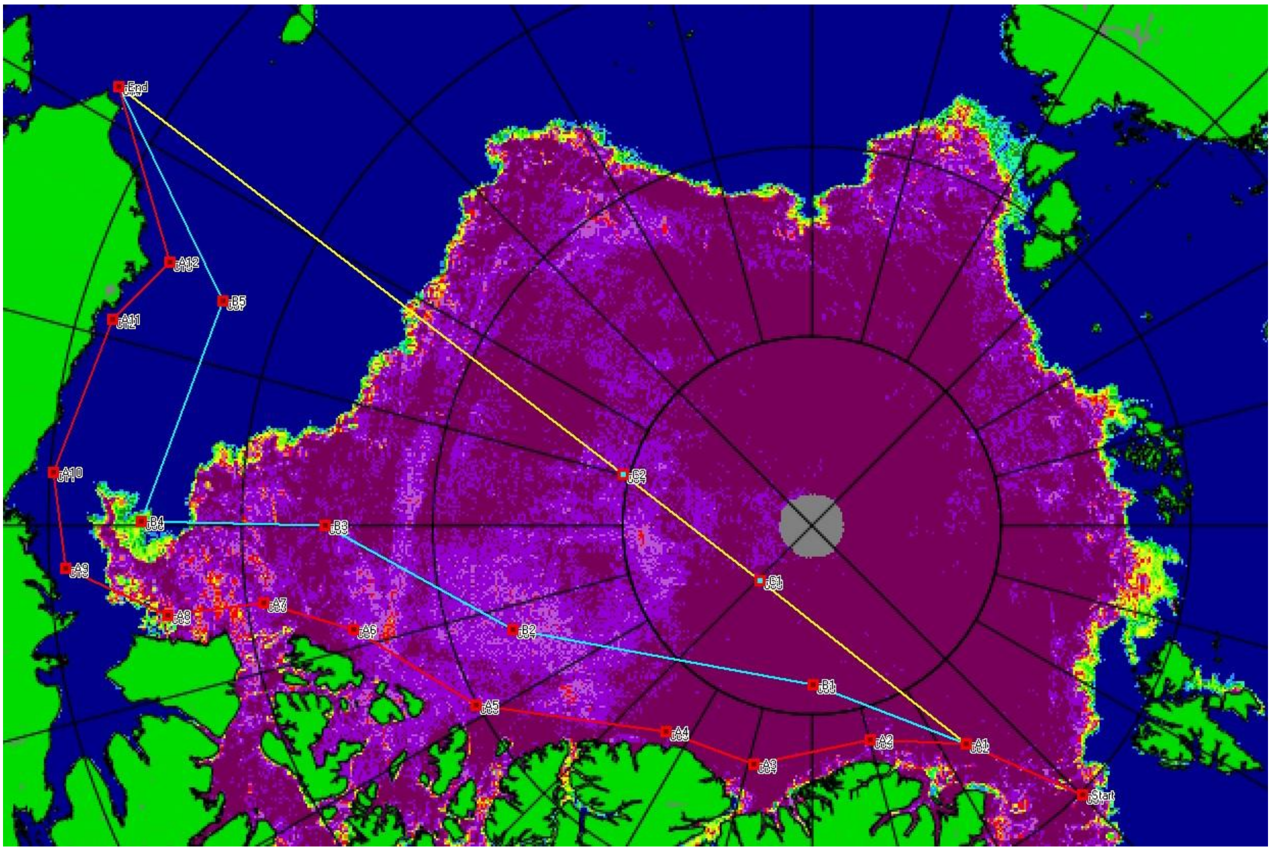

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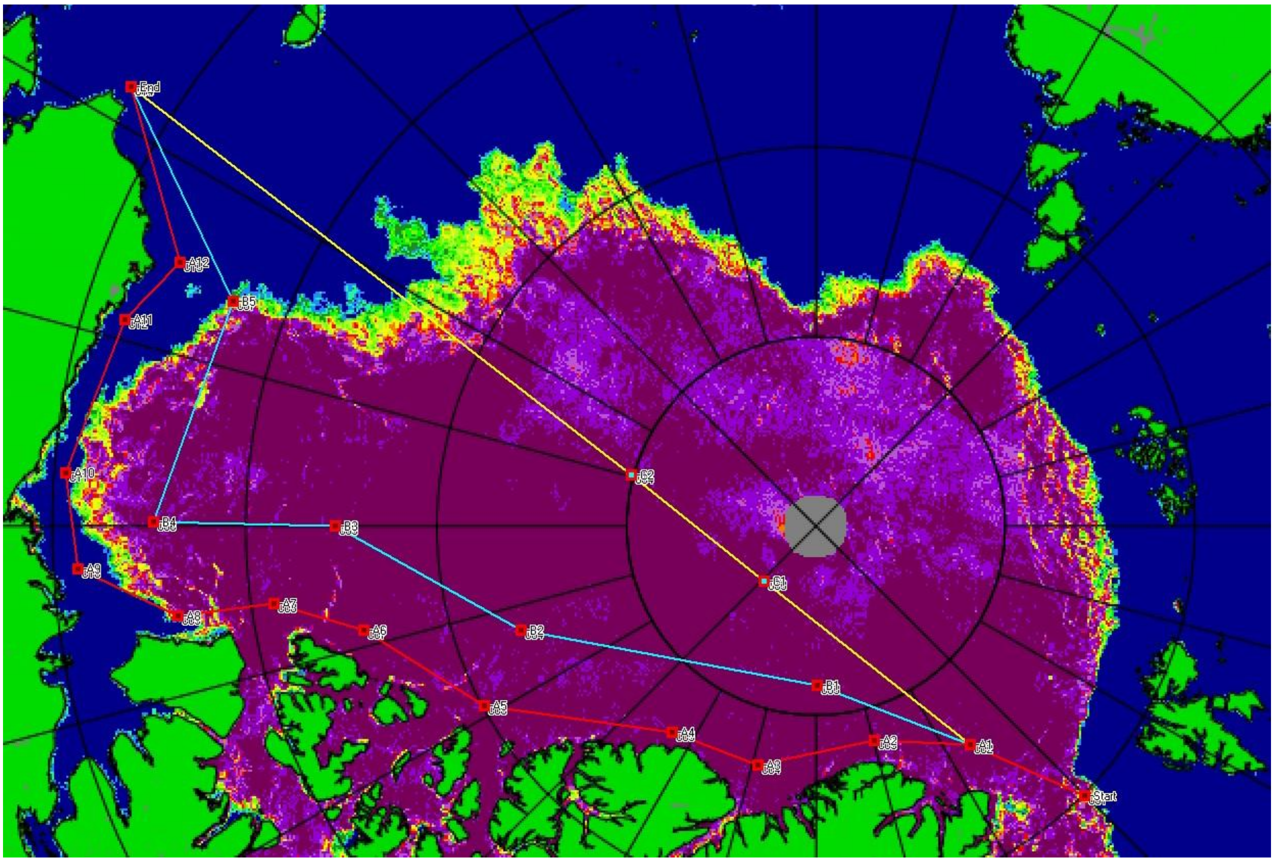

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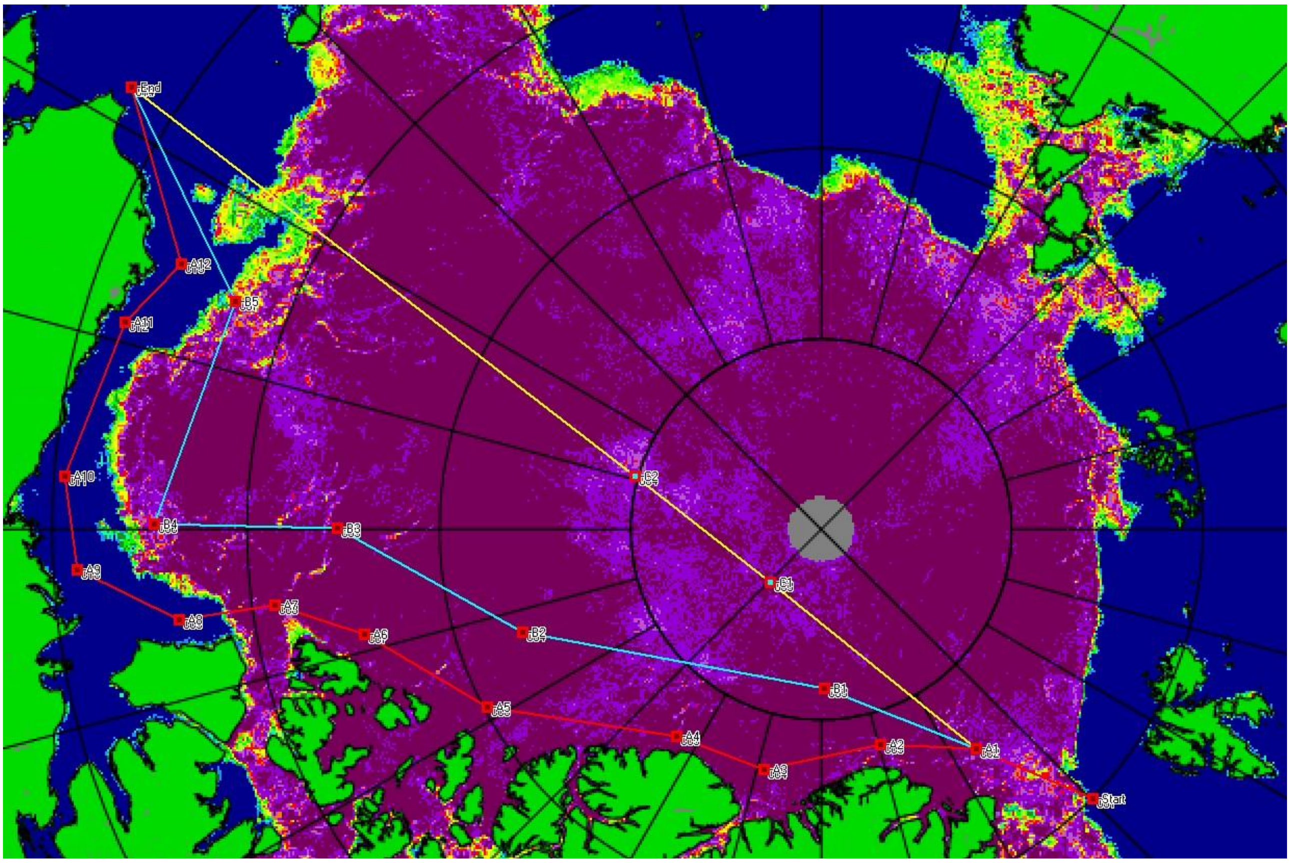

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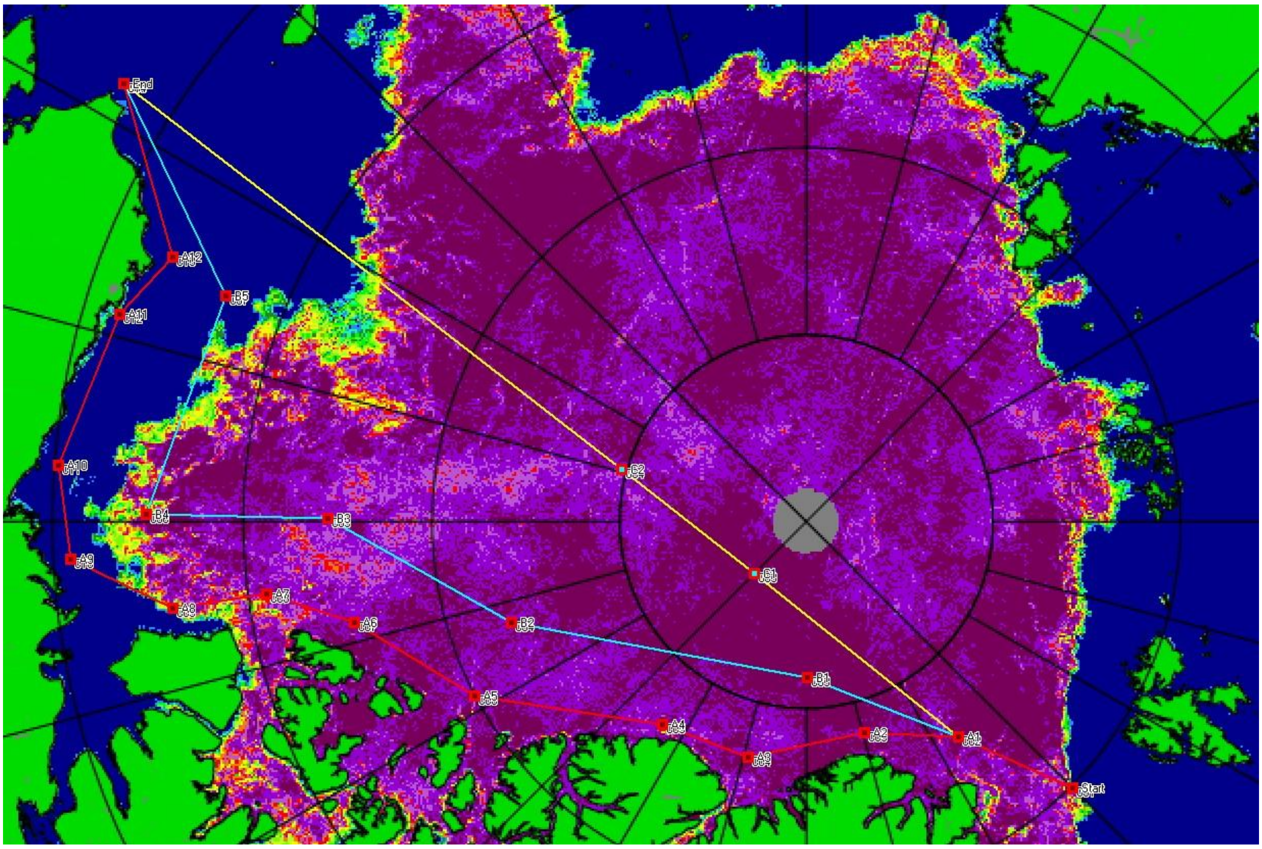

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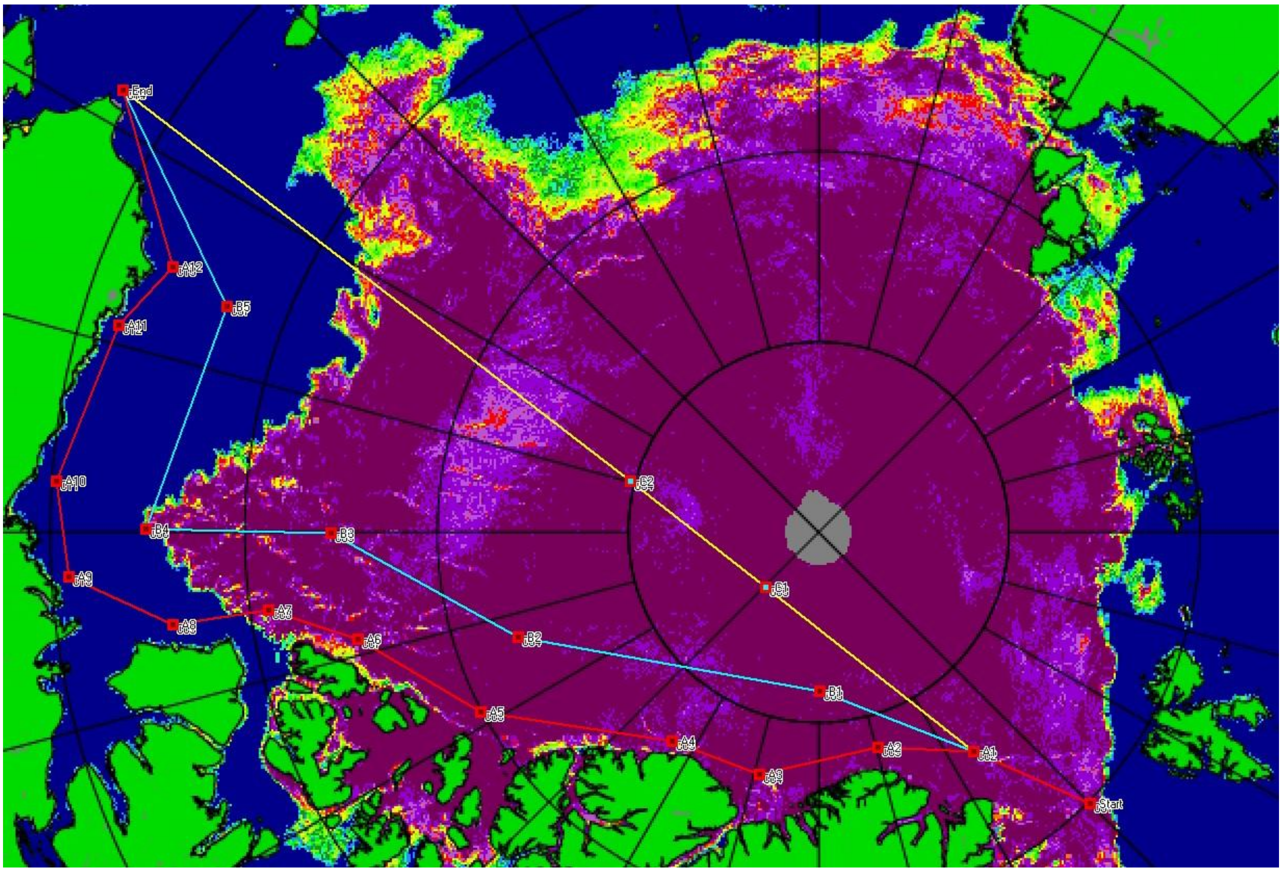
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2023-10-15


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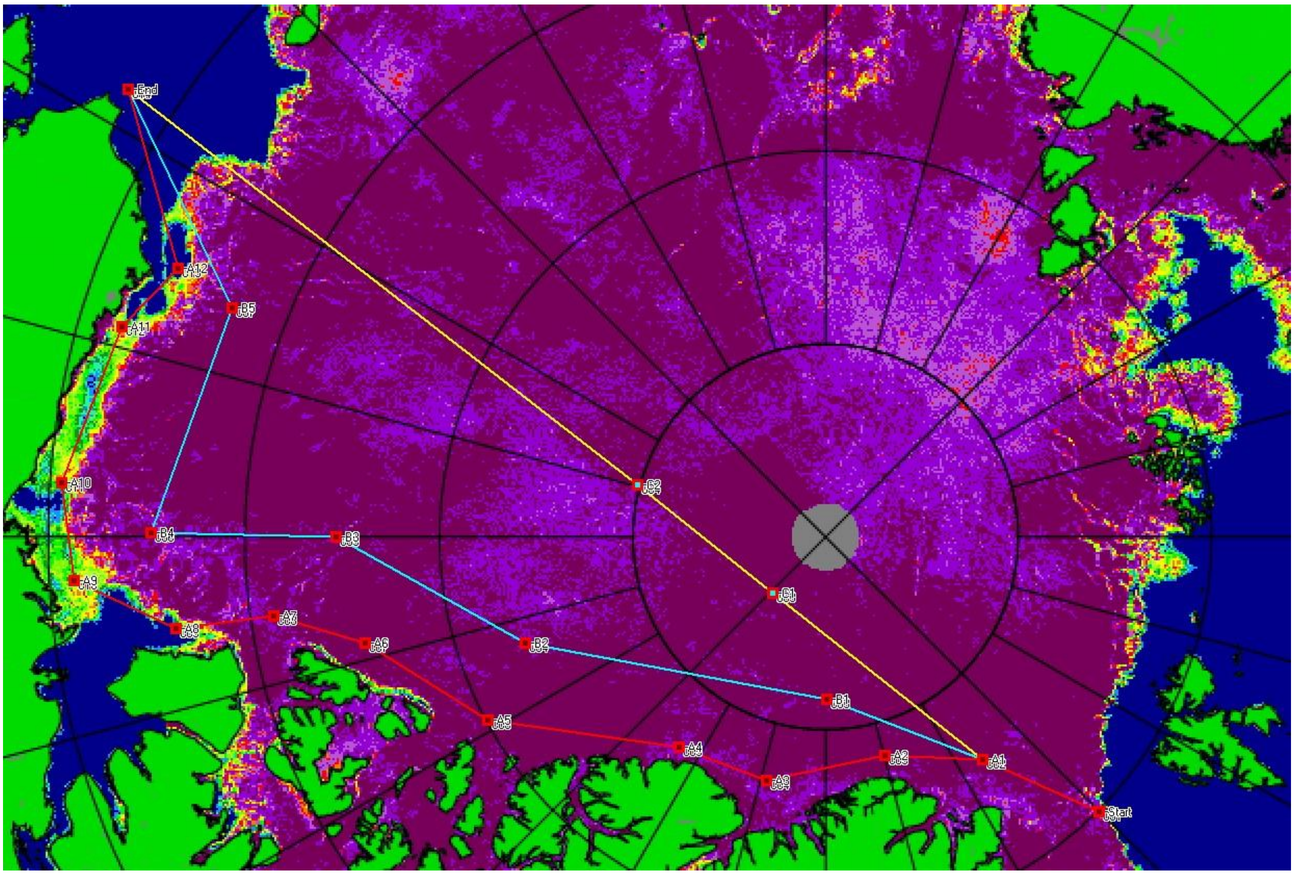
31st of October 2013-2023



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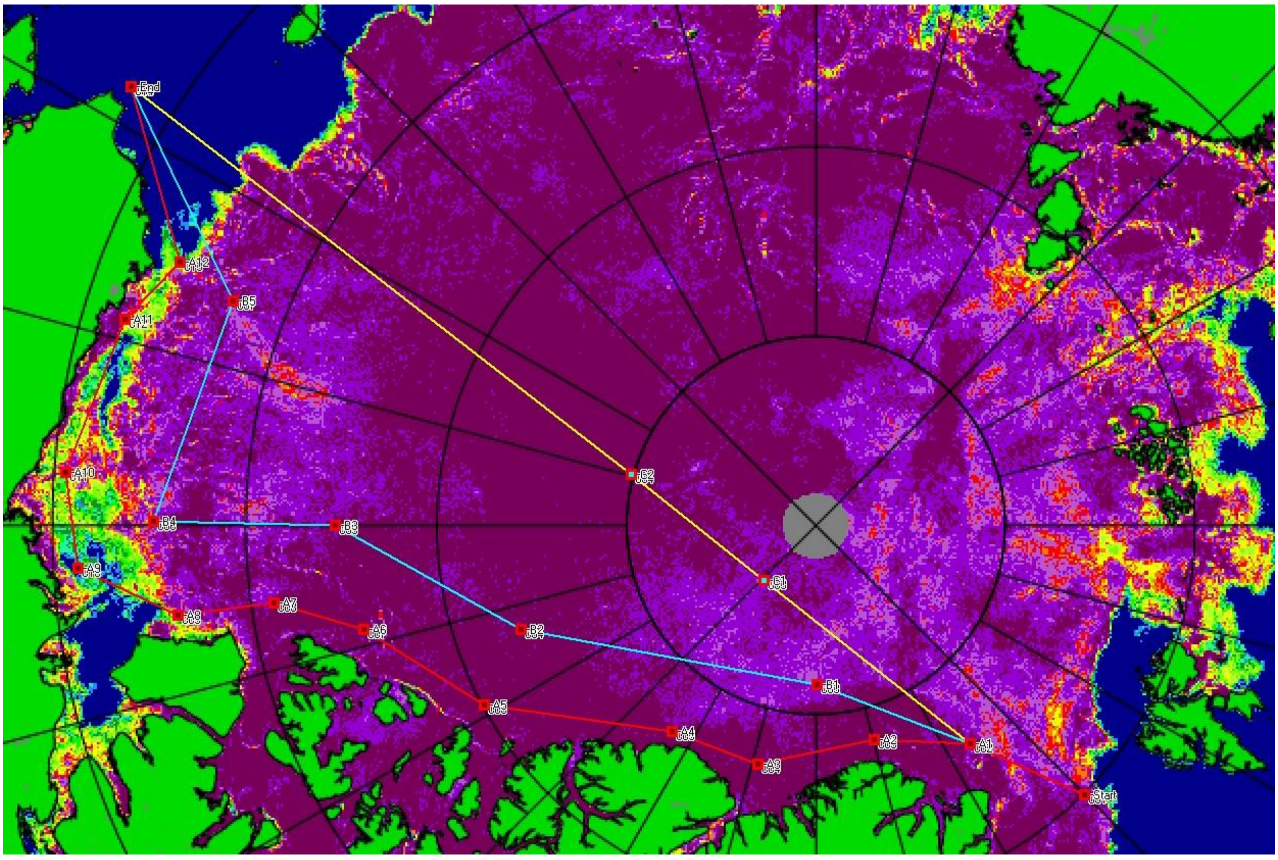

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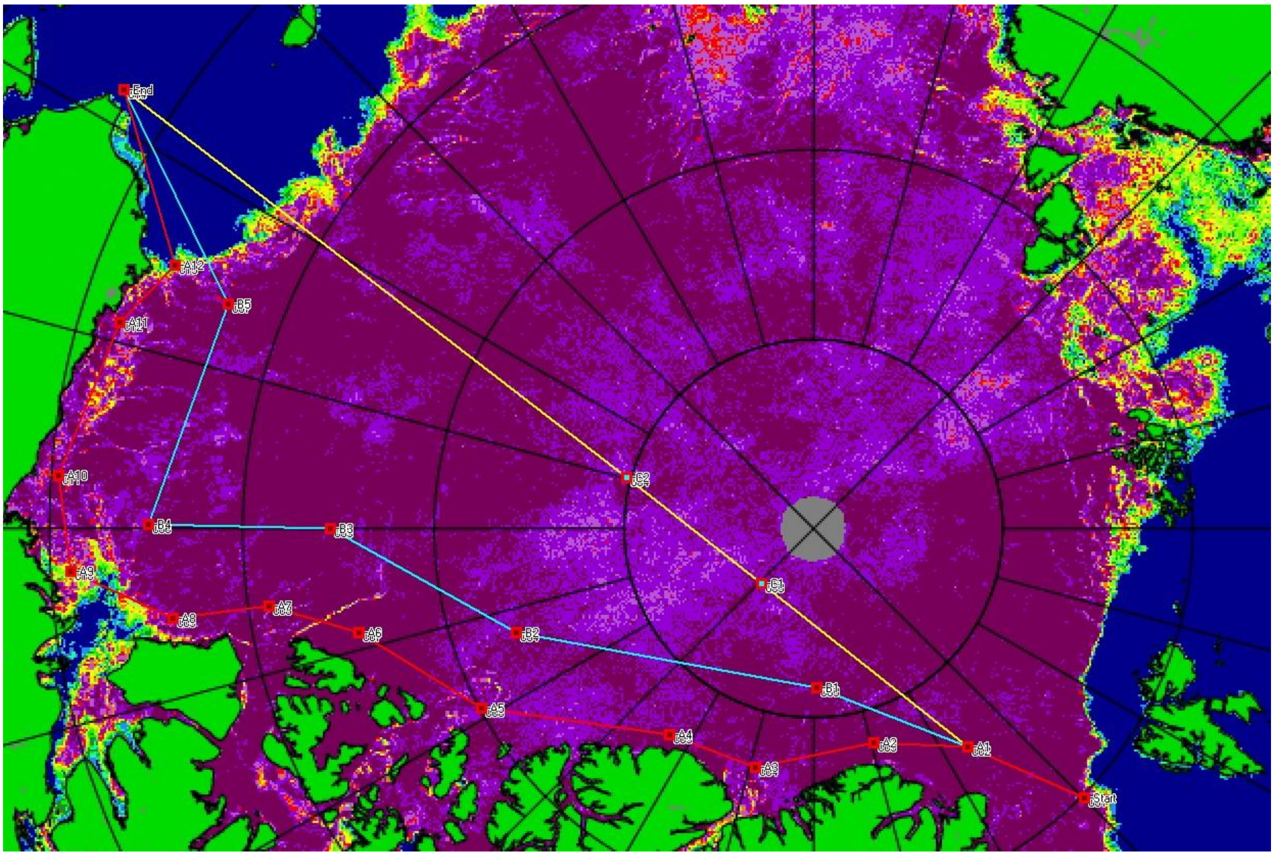

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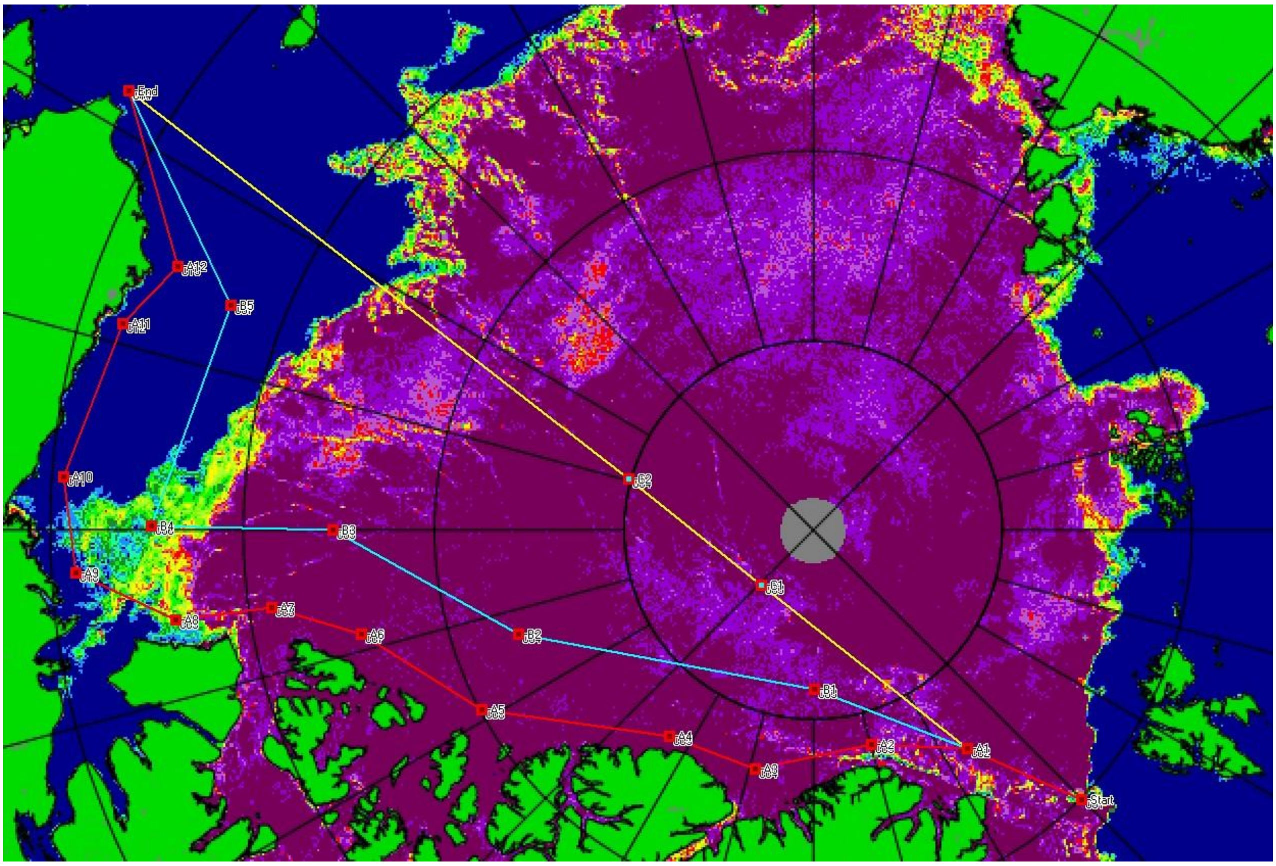

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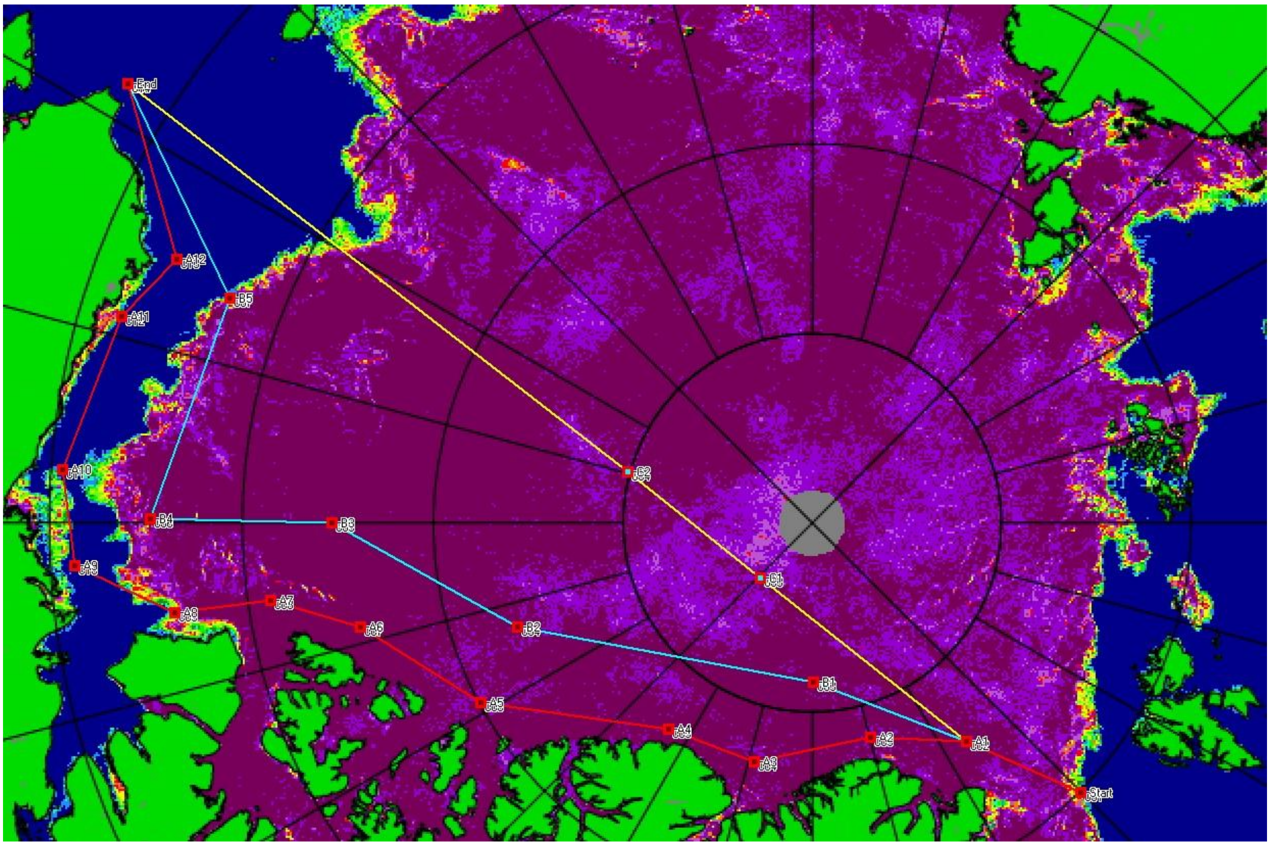

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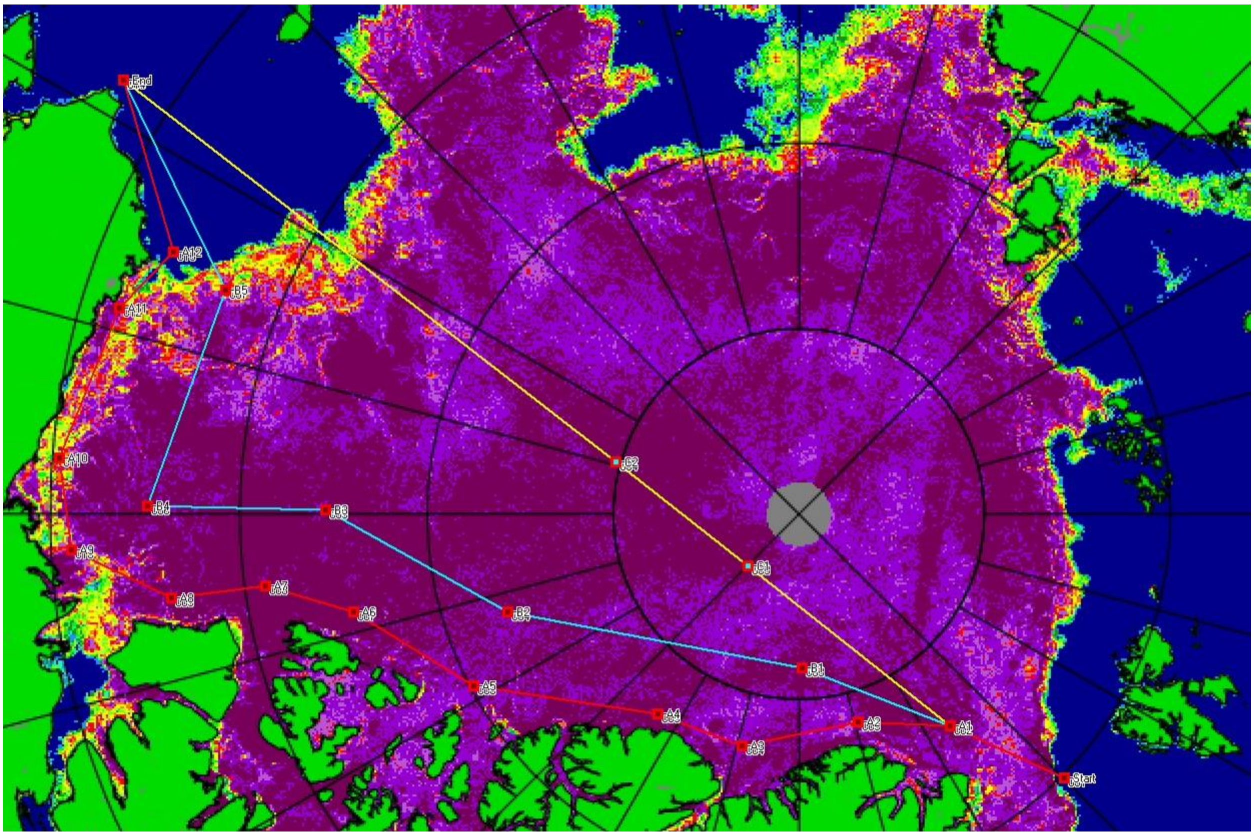

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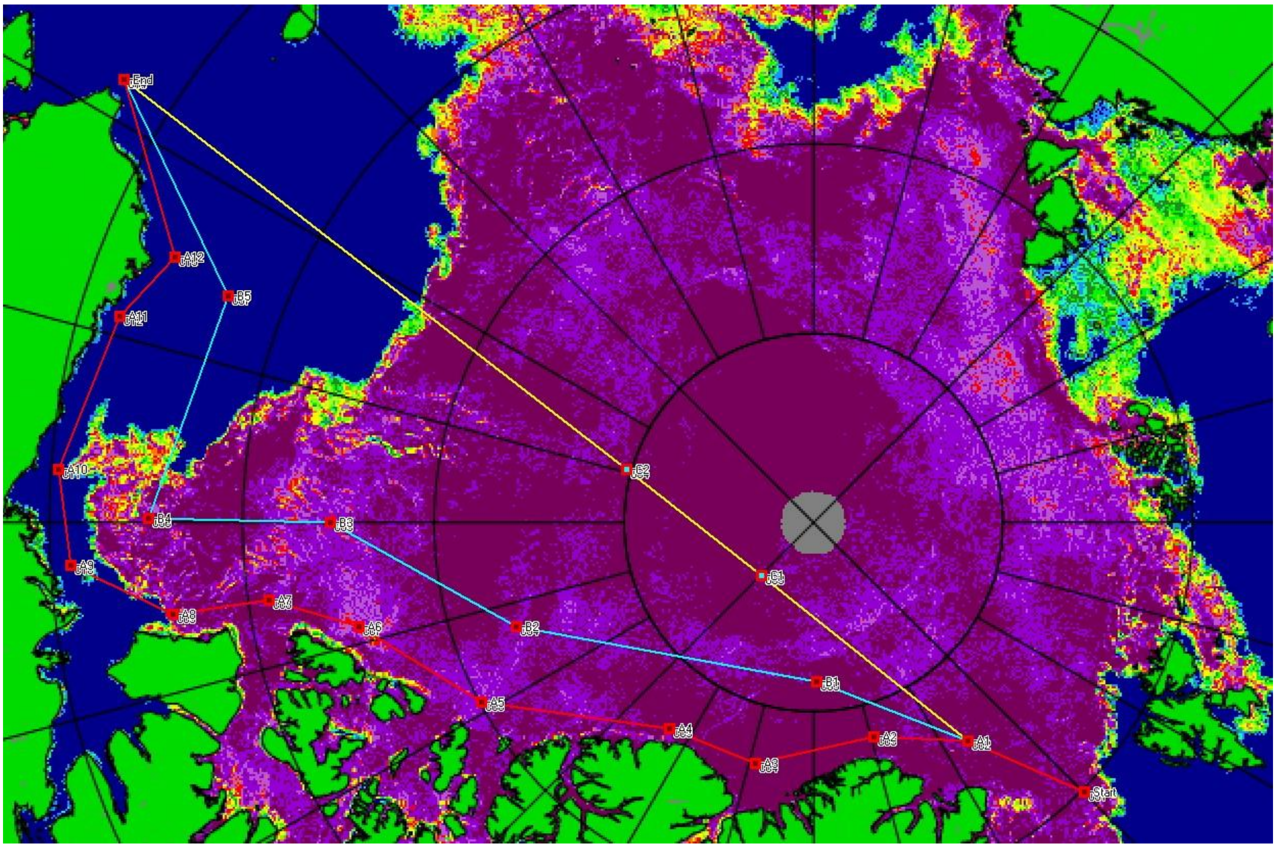

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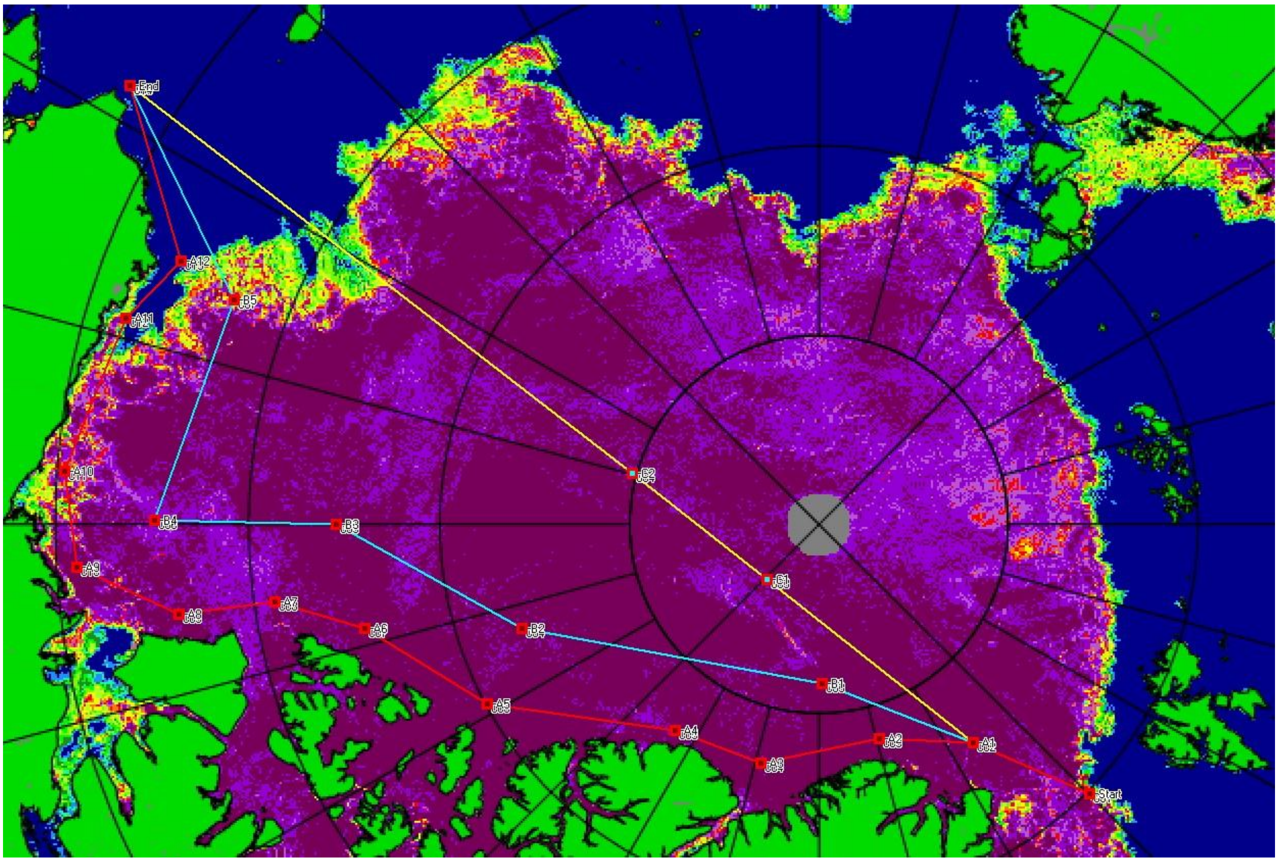

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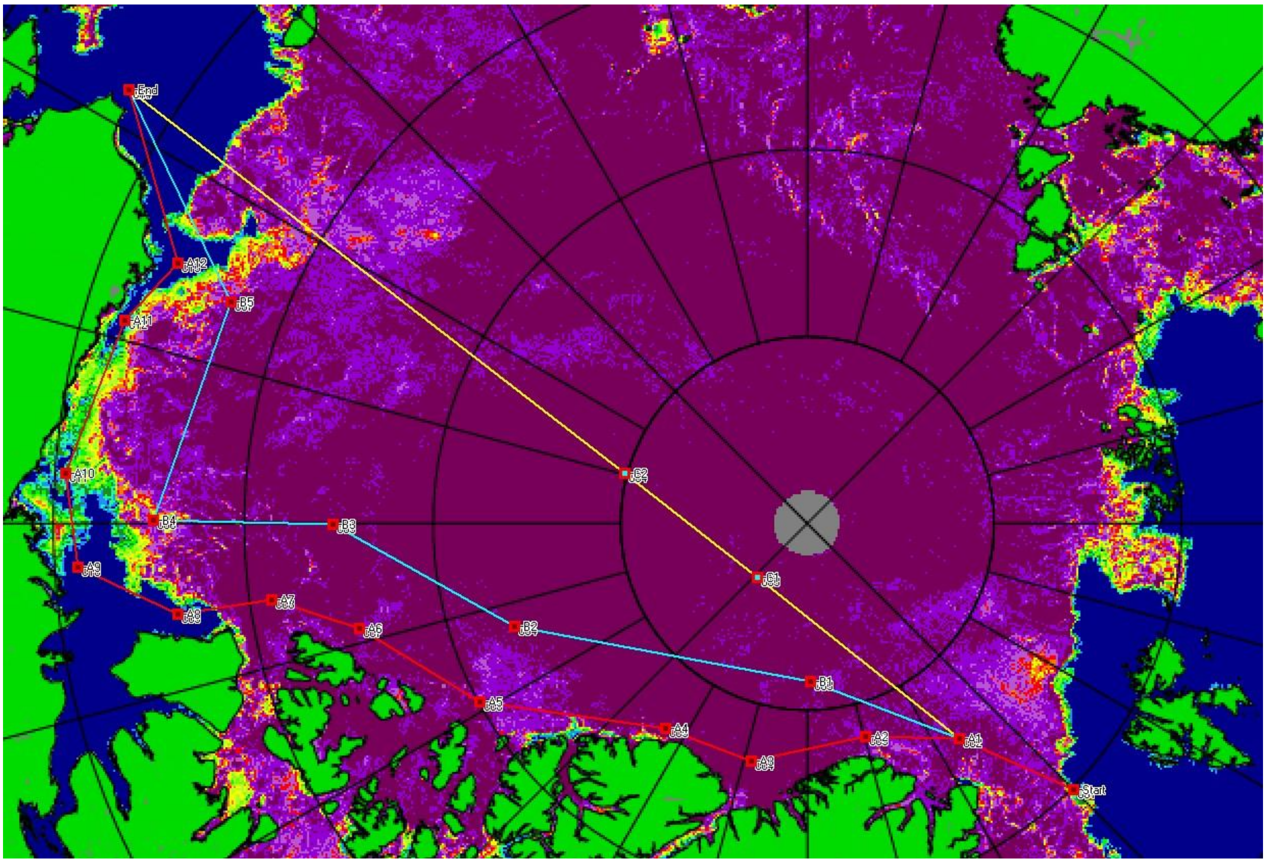

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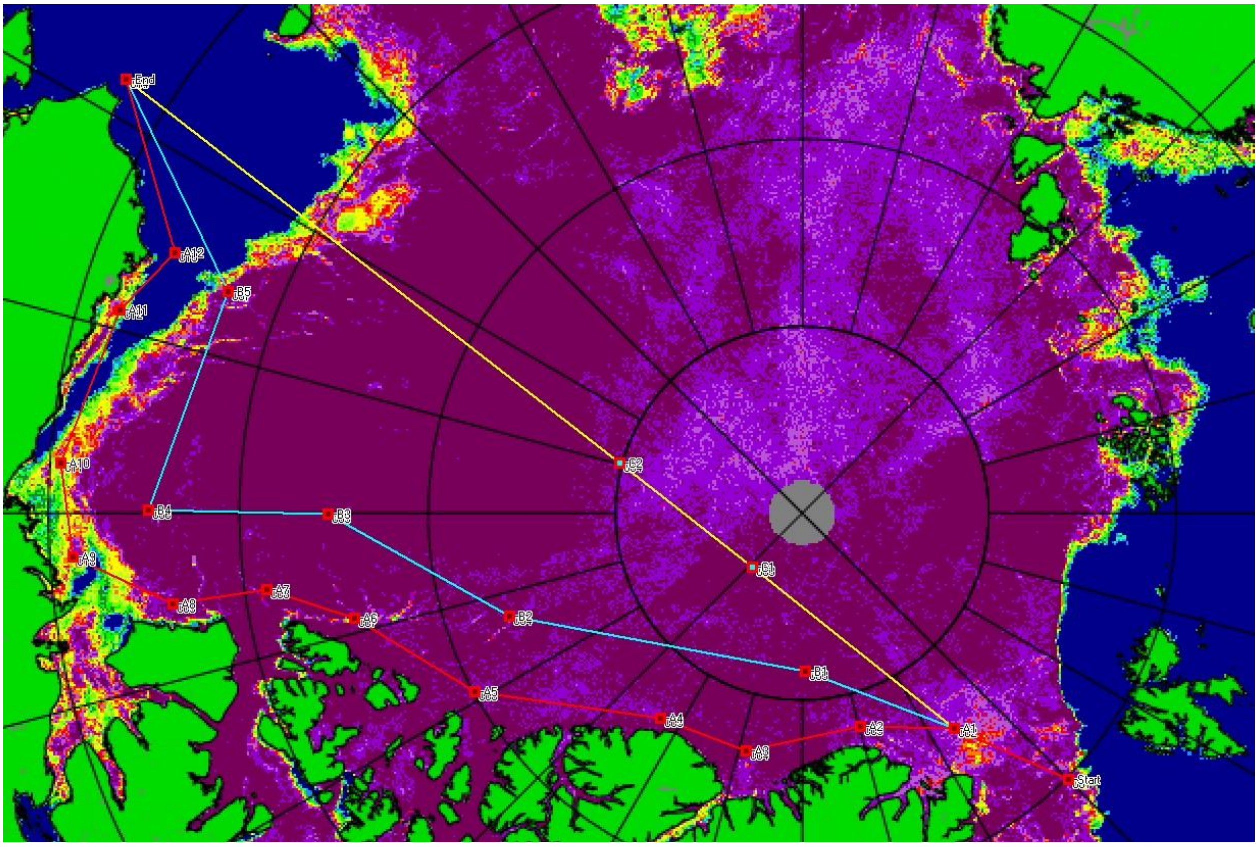

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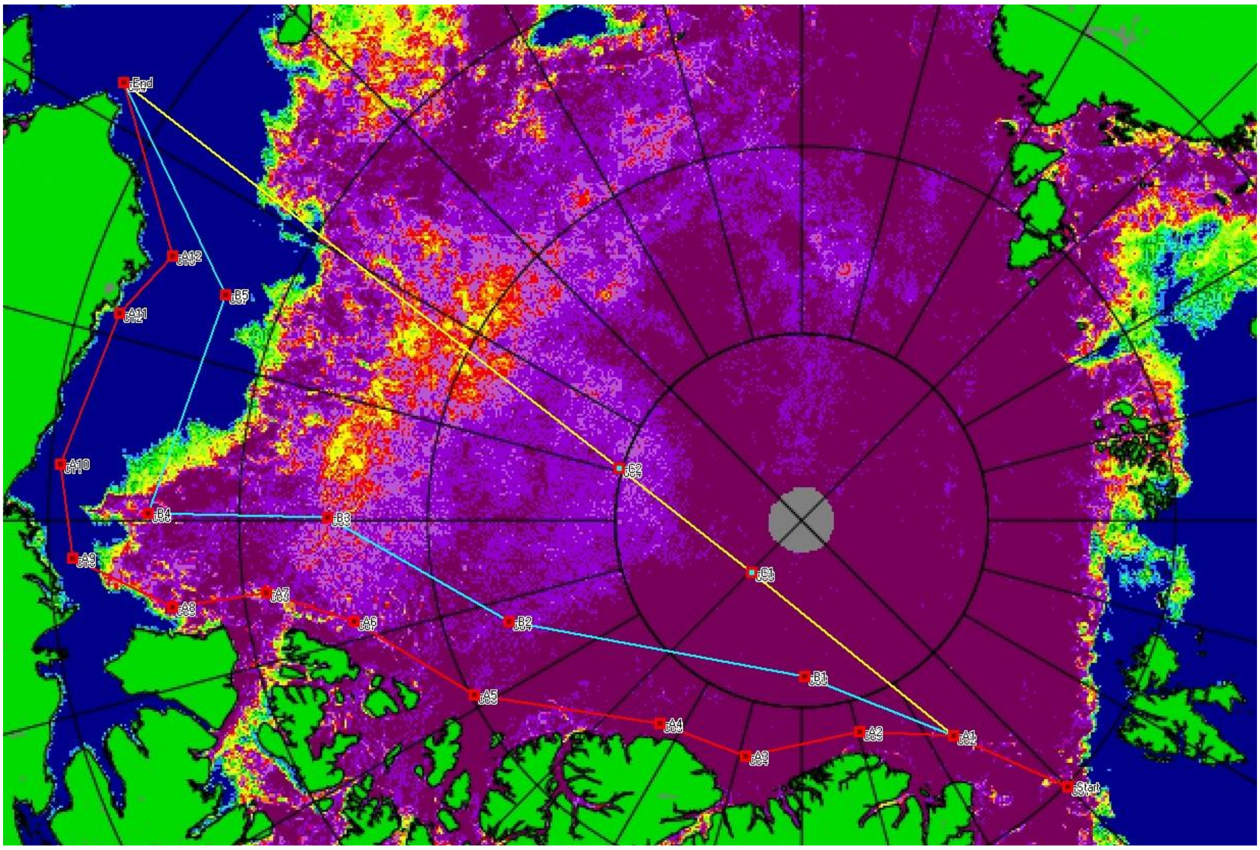

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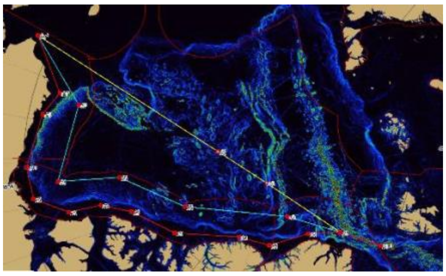


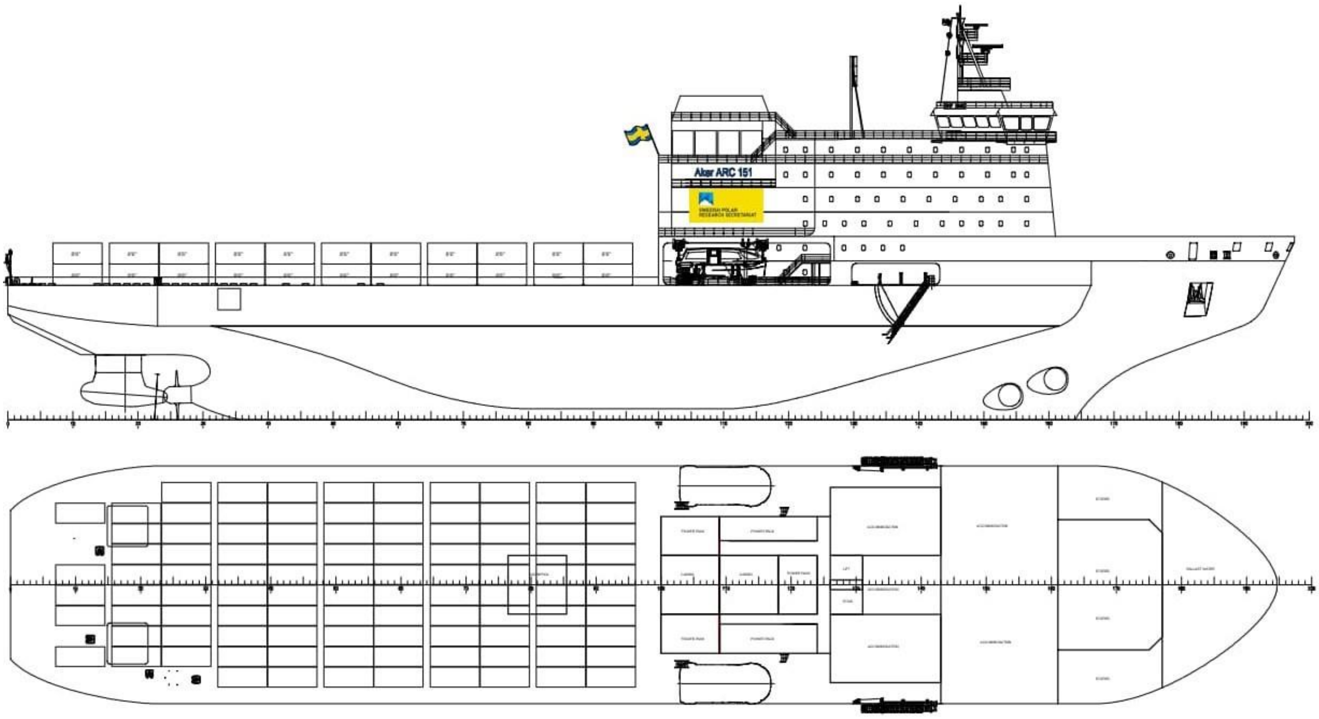
Conclusion

When it comes to calculate time consumption for all the routes it is needed to do a more thorough study regarding, seafloor nature, i.e., subsea obstructions such as mountains, slopes, canyons, volcanic or other seismic action. The ice on the sea surface also needs to be studied in terms such as amount of glacial ice, amount of old, medium, and young ice, ice formations such as ridges, hummocks, thickness etc.

Just to give an idea about time for laying the cable this study has used two speed option of 1 kn. And 2 kn. None of these speeds can be guaranteed without further studies and field tests, one must bear in mind that the nature rules in this part of the world. What seems to be possible one year can be totally impossible the next.

Route 1. 2500 Nm = with 1 kn. = 104 days with 2 kn. = 52 days (Unrealistic)
Route 2. 2300 Nm = With 1 kn. = 95 days with 2 kn. = 47 days (extremely hard)
Route 3. 1900 Nm = with 1 kn. = 79 days with 2 kn. = 39 days (Hard but most favorable of the three).

Appendix 2 Pre-feasibility study for a polar research vessel POLAR RESEARCH VESSEL, DATA SHEET



B	2023-10-17	Small changes
A	2023-10-12	Initial revision for pre-feasibility study
Revision	Date	Alteration Remark

Design Phase 1. Design Idea Confidentiality Confidential Reference Drawing		Copyright of Aker Arctic Technology Inc All rights reserved. No part thereof may be disclosed, duplicated or in any other way made use of, except with prior approval of Aker Arctic Technology Inc	Aker Arctic
Designer Lönnberg, L. Changed by Reviewed by Hovilainen, M. Approved by Snellman, L.		Title Data Sheet	
Aker Arctic Design Aker ARC 151		Pages 3	Drawing Number / Revision
Paper Size A4	Drawing Scale NA	Document Date 2023-10-17	30989-101-000 / B

General
Aker Arctic Technology Inc (Aker Arctic) is developing a pre-feasibility study for a Polar Research Vessel for the Swedish Polar Research Secretariat.
The design is proprietary to Aker Arctic and identified as **Aker ARC 151**.
The information presented in this Data Sheet shall be taken as indicative and preliminary and is subject to change in following design phases.

General description
The primary function for the vessel is to operate in both Arctic and Antarctic waters performing research expeditions of various lengths, with various research targets. The vessel has also a logistics function to transport supplies to the Antarctic.
The vessel is also intended for various industrial projects such as assisting a cable laying vessel in the Polar Connect project, where NORDUnet and the Nordic NRENs are planning the first submarine cable system between Europe, Asia, and North America to secure a shorter route through the Arctic Ocean.

Main generators
The main generators are driven by medium-speed 4-stroke marine engines: four 12 cylinders, and two 6 cylinders and they have a total power of about 40 MW. They can be driven by diesel or methanol fuel.
Additionally, the vessel has 5 MWh battery-based energy storage system for use as spinning reserve, in peak shaving and for other necessary duties.

Main propulsion
The main propulsion is arranged by two electrically powered azimuthing thrusters aft with 11 MW power on each side, and one fixed shaft propeller aft in centerline with 12 MW power.
There will also be two bow thrusters with about 2 MW power each.

Technical features

- Ice class: PC2 +
- DP 2
- Special Purpose Ship (SPS)
- Cabins: 40 single cabins and 30 double cabins (total capacity 100)
- Icebreaking capability: 3 knots at 2,5 m first year ice thickness
- Open water speed 15 knots
- Methanol tank capacity 2900 m^3
- Diesel fuel tank capacity 4900 m^3
- Endurance 100 days with 25% maximum propulsion power (including 3 weeks operation with methanol)
- Helideck for two small reconnaissance helicopters
- 2000 sqm aft deck
- Containers in two tiers
- Moonpool 7,2 m x 7,2 m
- Side shell door with ramp and garage for polar vehicles
- Heeling, anti-rolling system

Main particulars

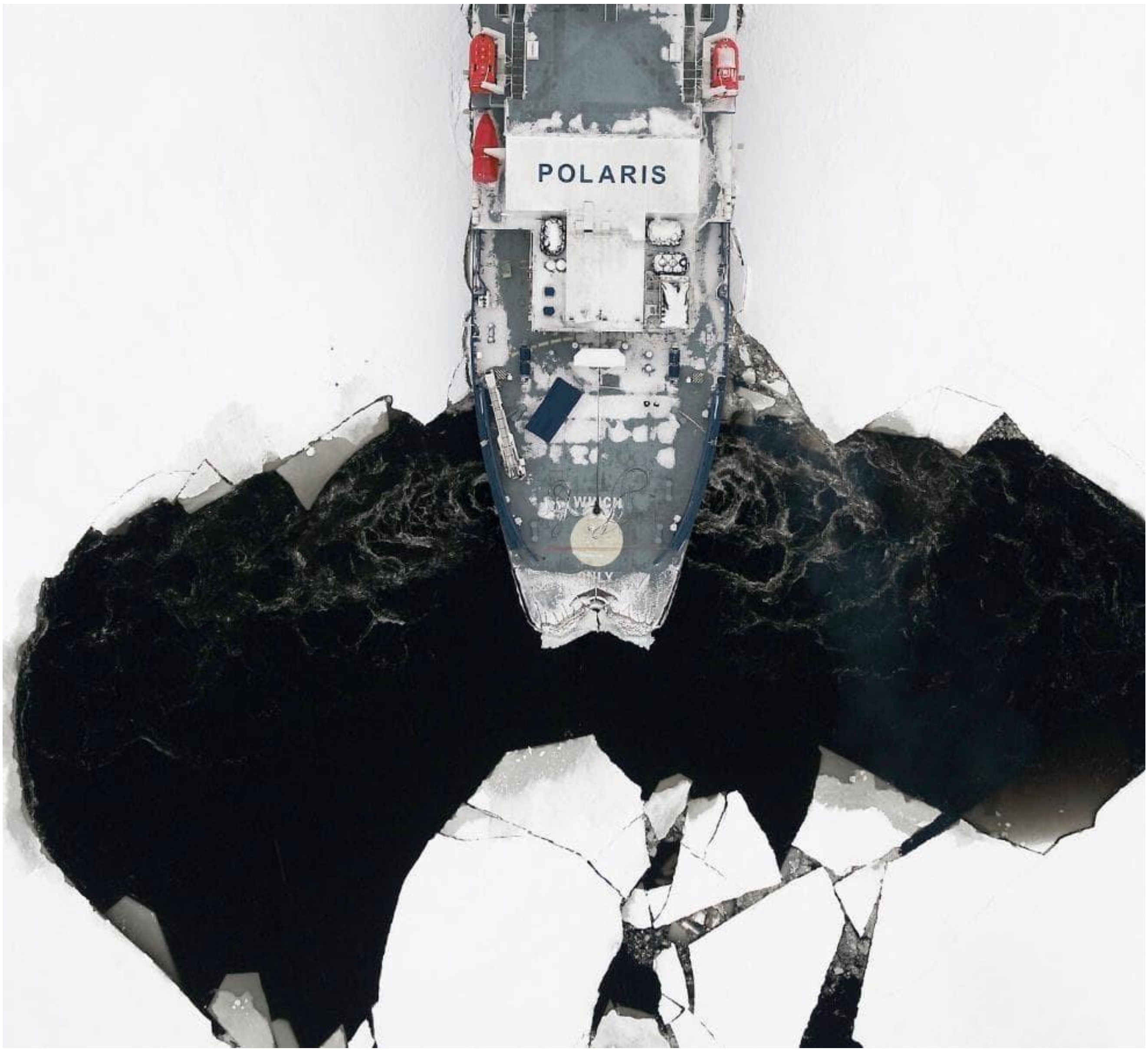
Length overall	about 158.00 m
Length at design waterline	about 144.00 m
Beam, main deck	about 29.20 m
Beam at design waterline	about 28.00 m
Draught, design.	about 10.50 m
Draught, maximum	about 11.00 m
Depth to main deck	about 13.50 m

Appendix 3. Pre-feasibility study for a polar research vessel CABLE LAYER ICE MANAGEMENT PROTECTION.

Cable Layer IM protection

By Sami Saarinen

2023-10-24



AKER ARCTIC TECHNOLOGY

General

- Details of the Cable Layer or cable laying process are not known at this stage
- Presented Ice Management (IM) procedures and related risks are general:
  - Detailed IM procedures can be generated when more detailed information is available
  - Detailed risk assessment can be done when more detailed information is available
- The magnitude of IM needed protection is defined by ice conditions and the Cable Layers own ice capability:
  - The harder ice conditions, the more IM are needed
  - The better Cable Layer's own ice capability, the less IM is needed
- The described IM methods assume that two IMVs, one of which is PRV, participate in IM protection. However, in light ice conditions, only PRV may be actively needed. In such case, PRV acts in one of the described IM roles, depending on the situation.

Key assumptions

- Predefined cable route goes through MY areas (North of Greenland etc.)
- Intended laying period: August – September (typically the easiest ice season)
- Predefined track of the cable cannot be changed during cable laydown
- Cable Layer is properly ice-strengthened and winterized
- Cable Layer's cable launching area (at the sea surface) is protected from ice
- Cable layer can vary speed during laying. Highest speed about 5 knots.
- Cable Layer can stop laying, stay in position and disconnect cable in a controlled manner if needed

Polar Research Vessel (PRV) – Key IM features

- Length / beam / draught = 158 m / 29 m / 11 m
- Total propulsion power 34 MW
- 2 x 11 MW Azimuthing thrusters (at stern)
- 1 x 12 MW propeller at shaft line (at stern)
- PC2 – enable operations in MY-ice

Capable of the following IM tasks:

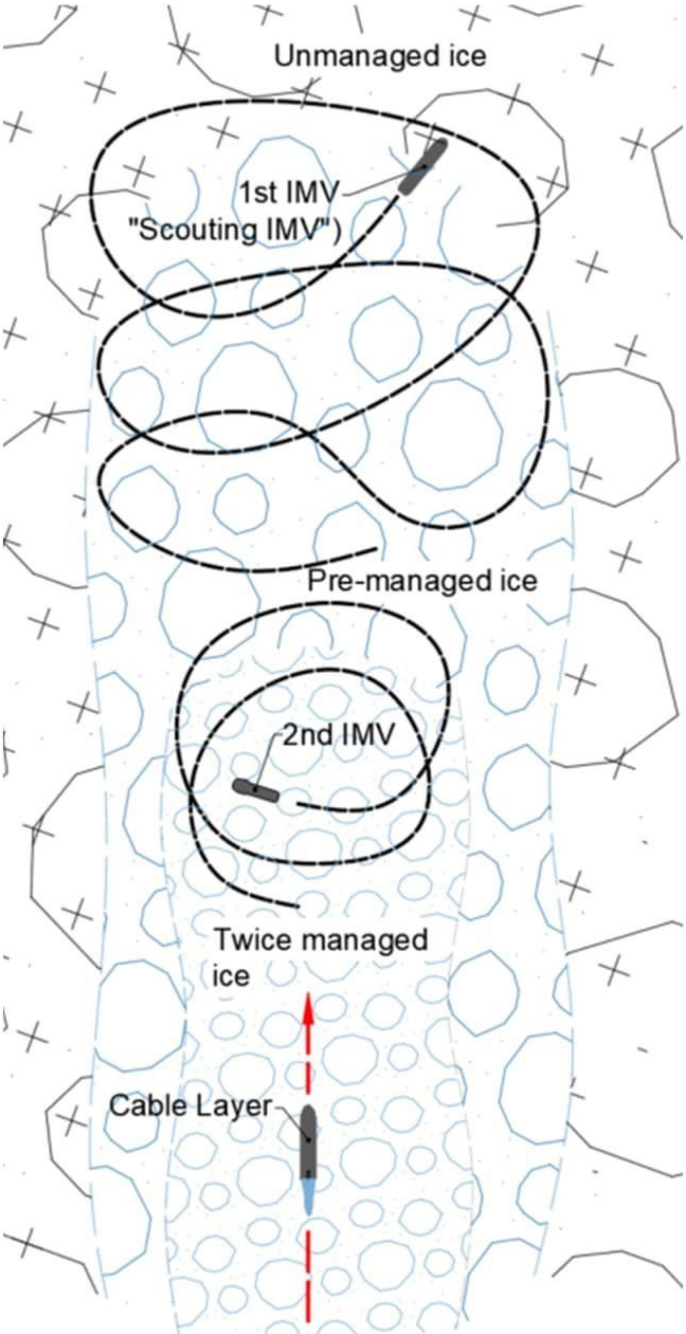
- Scouting, ice intelligence
- 1st IMV duties
- 2nd IMV duties
- Short distance IM

Key challenges and risks

- Ridges, ridge fields
- Multi-Year-old ice (MY-ice)
- Compressive ice
- Getting stack in ice and start to drift
- Ice pushes Cable Layer out of the track

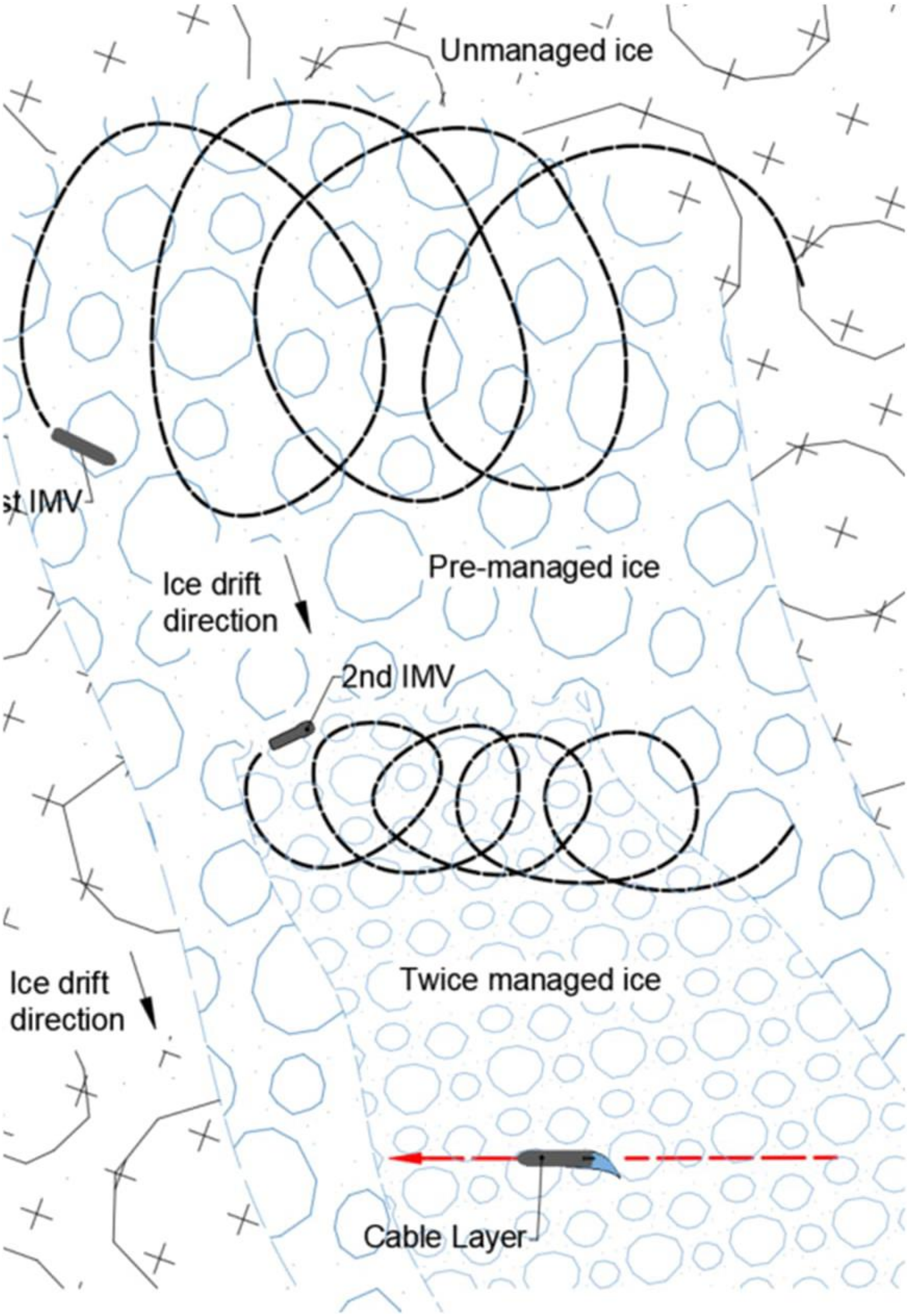
Basic IM procedure

- 1st IMV ("Scouting IMV") operates in some distance in front of Cable Layer
  - Breaks ice before it enters to the area of Cable Layer
  - Explore severity of ice conditions (thickness, strength…)
  - Inform Cable Layer about expected ice conditions
  - Inform Cable Layer if preparations for cable disconnection need to start
- Another IMV operates closer to the Cable Layer (not needed in easier ice conditions or if Cable Layer's own icebreaking capability is sufficient)
- Cable Layer follows her pre-defined track (red line)
- PRV may perform 1st or 2nd IMV duties
- Location of IMVs depends on Controlled Disconnection Time (ref. slide 12) and ice drift direction (if ice moves significantly, see next slide)



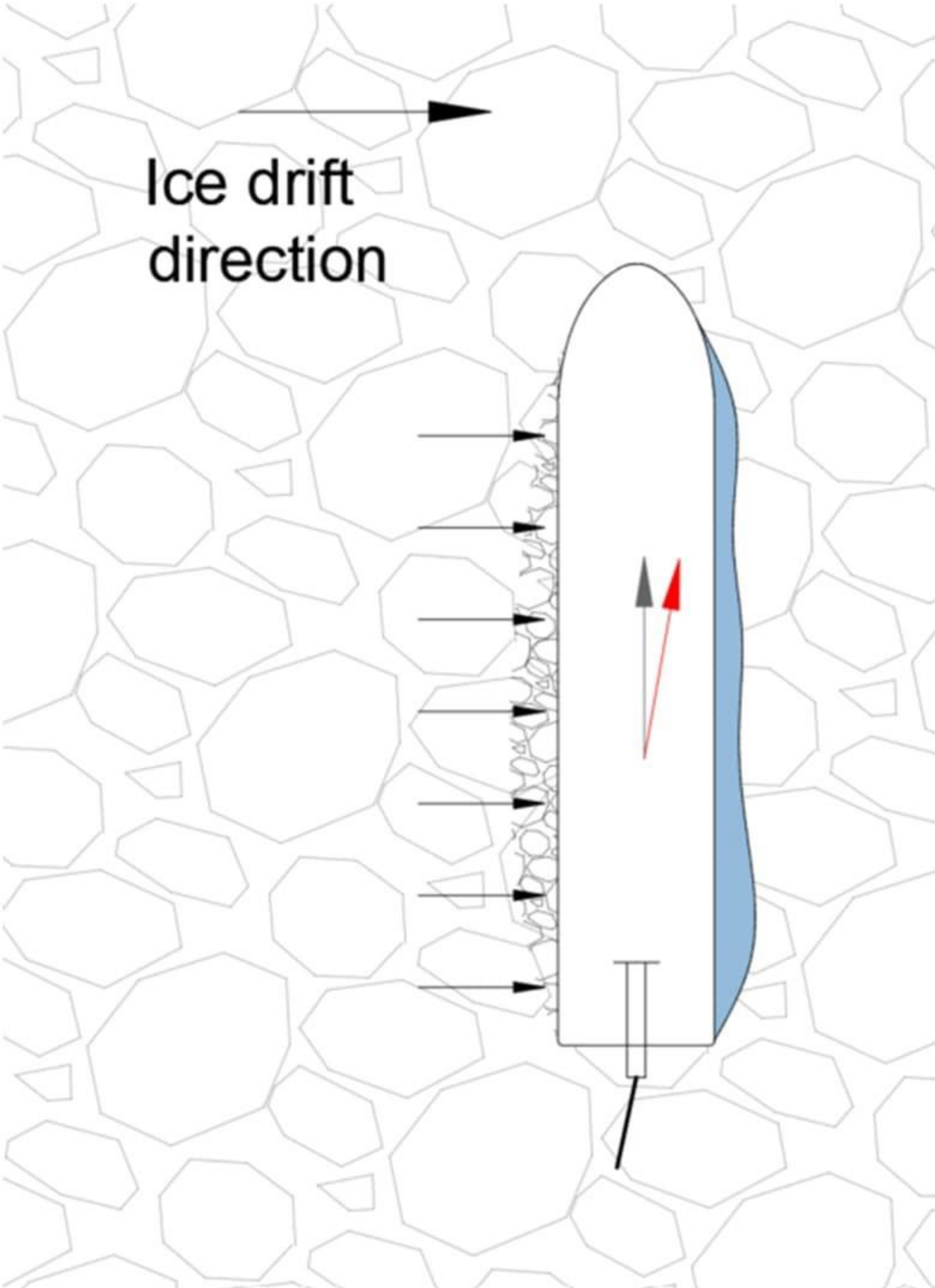
Moving ice

- Both IMVs operate updrift from Cable Layer
- Cable Layer tries to keep her track (red line)
- The speed of Cable Layer is often significantly reduced to stay inside twice managed area
- Cable Layer typically gets ice contacts
- PRV may perform 1st or 2nd IMV duties
- Actual ice drift direction defines the correct location of IMVs



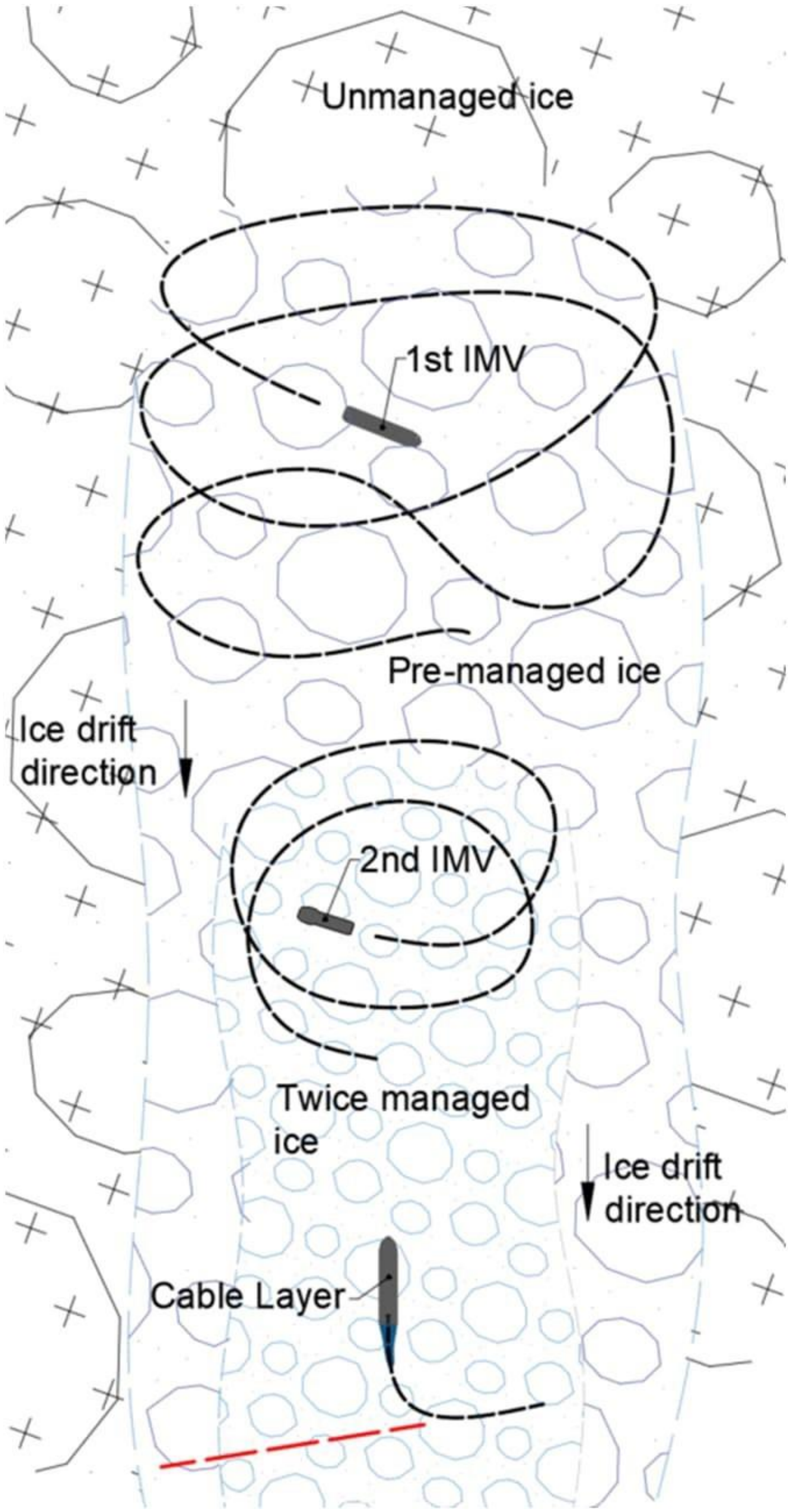
Heavy ice drifting sideways

- IM efforts have not been sufficient
- Ice pressure at another side pushes the Cable Layer sideways, and she cannot stay at her original track (red arrow)
- Proceeding to the original direction is stopped and the bow of the Cable Layer will be turned towards the ice drift (see next slide) to minimize the ice load
- Turning should be made as a precaution if risk of ice pressure grows high
- Risk of damaging cable is high (depending on the cable and Cable Laying arrangement tolerances)



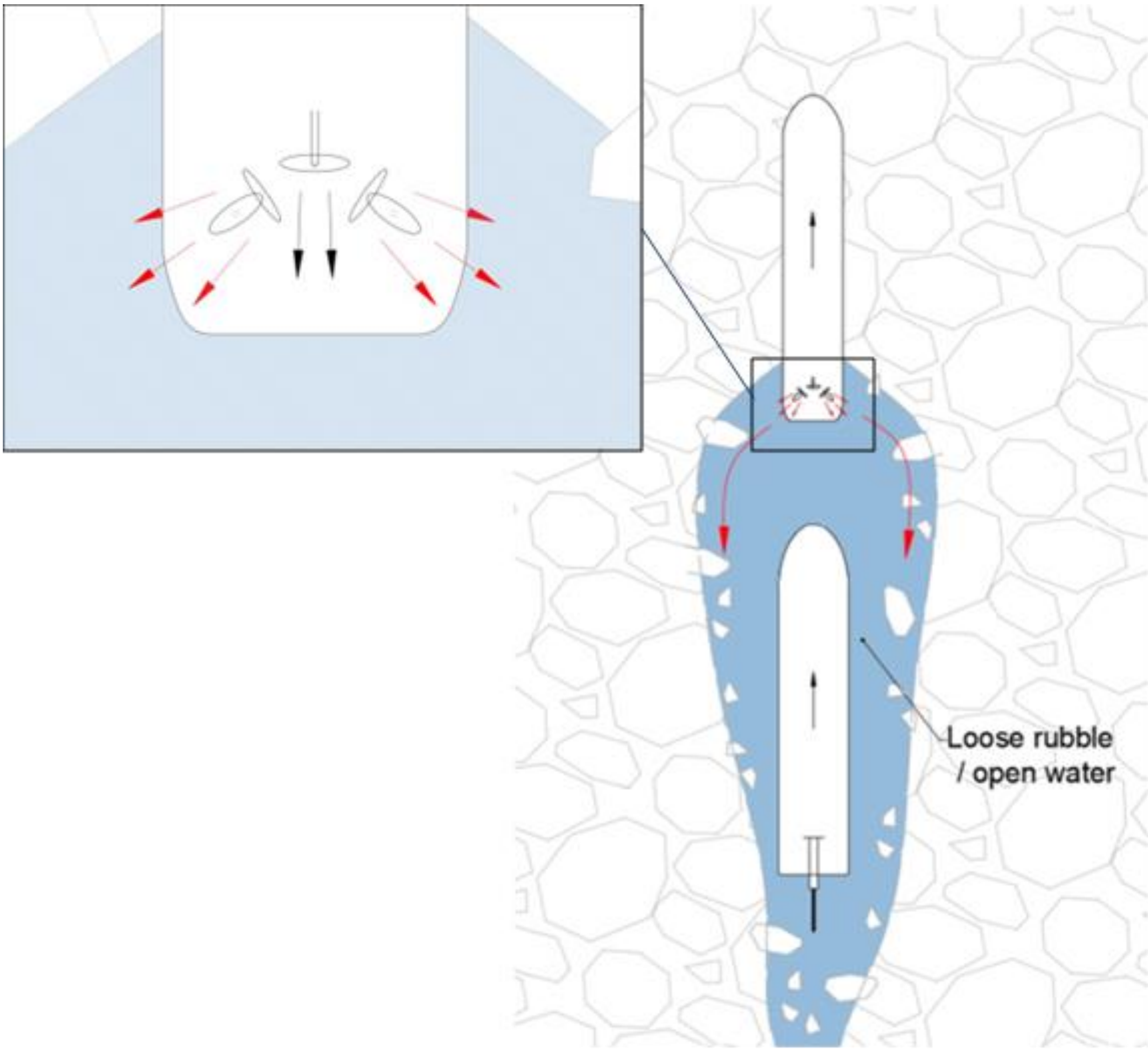
Heavy ice drifting sideways – Operation stopped – "Safety position"

- Cable Layer has stopped, and her bow is aimed towards the ice drift direction to maximize her station keeping capability
- IMVs operate updrift and breaks ice before it enters to the area of Cable Layer
- PRV may also perform "Short Distance IM" to maximize the effect of IM (see next page)



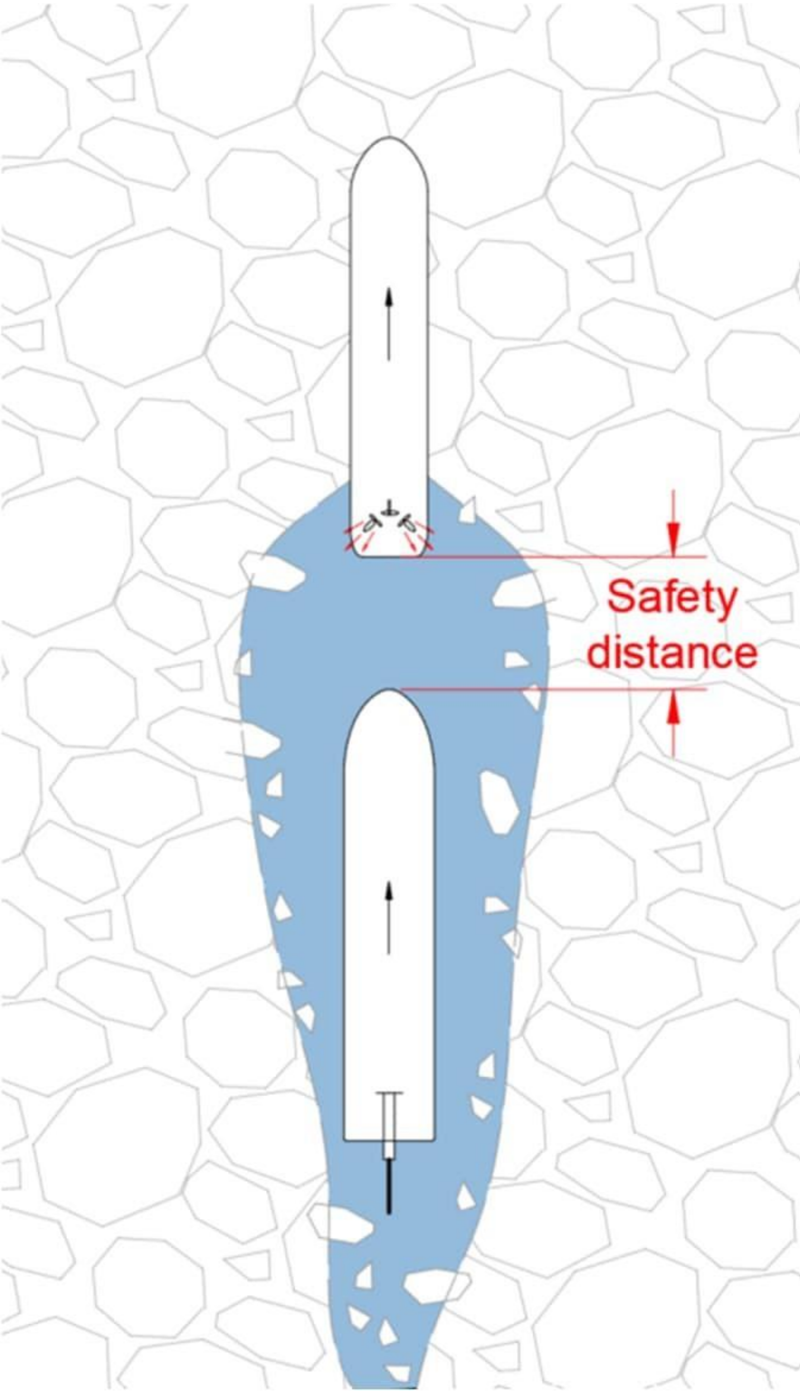
Short distance IM – Flushing

- The PRV operates close to the Cable Layer in front of it
  - Low speed or stopped if ice drifts significantly (ships orientated towards ice drift)
  - Azimuthing thrusters are turned sideways to flush ice sideways
  - Shaft line propeller provides thrust to proceed if proceeded at the same time
- If needed, another IMV operates further and pre-break ice in advance
- Used if the Cable Layer needs significantly good IM protection (like probably cable disconnection or re-connection)
- Compressive ice conditions complicate this IM method because the flushed “closes” quickly.
- Includes collision risk (Cable Layer collides to the stern of PRV; ref. “Safety distance” in next slide), especially if proceeded at the same time. Cable Layer’s quick “emergency stop”, and maneuvering capability reduce the risk of collision



Risk Mitigation – Safety Distance

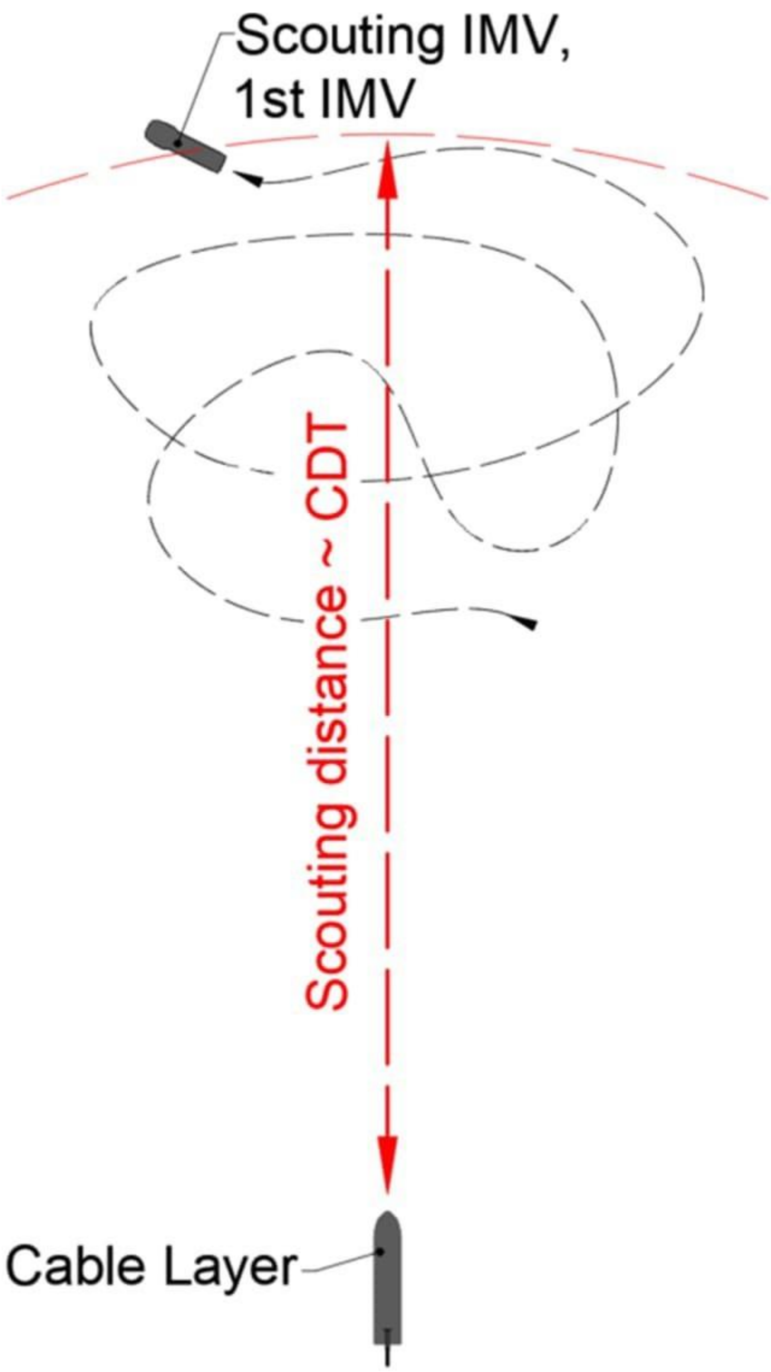
- Applies to all operations done with ships navigating in tandem or close to each other
- In tandem navigation, the key risk is that the 1st ship stops suddenly (for example, due to MY ice), and the following ship cannot stop its movement in time, thus colliding with the stern of the 1st ship.
- Especially important also if the PRV is performing “Short Distance IM” and ice is drifting or both ships are proceeding at the same time (ref. previous slide)
- Requires continuous communication between ships in question
- Requires well-trained, experienced officers who know their ship's capabilities and limitations properly



Risk mitigation – Controlled Disconnection Time (CDT)

- The basic idea is that the Scouting IMV (or 1st IMV) investigate the severity of ice conditions in front of the Cable Layer and informs Cable Layer if ice conditions becomes too difficult for safe Cable Laying. After this, the Cable Layer start preparations for controlled disconnection.
- The controlled disconnection requires time, which defines the distance to the scouting IMV (1st IMV):
- if IMV recognizes ice conditions too difficult, the Cable Layer has time to disconnect cable controllably.
- IMV's protection efficiency is better the closer it can work to the Cable Layer

→ The shorter the CDT, the closer the IMV can operate, and the better IM-efficiency is produced



Risk mitigation measures to consider…

- Good ice performance of the Cable Layer, cable and required cable laying equipment

  → the better, the less IM is required

- Adequate protective structures in the cable laying area

  → to ensure appropriate cable protection during lay down (prevent cable ice contacts)

- Cable Layer's ability to do maneuvers and reverse

  → Enable bypassing difficult ice features (ridges, icebergs, …), wait for easier ice conditions and to get in the best position relative to the movement of the ice.

- Short controlled disconnection time of the cable

  → enables IM operations to be performed closer to the Cable Layer. This improves the protection of Cable Layer, reduces the risk of cable damages and decreases the number of unnecessary disconnections of the cable. The ice conditions experienced by the IM vessel can be a reason for the decision to disconnect the cable.

- Short reconnection time of the cable

- Appropriate ice intelligence (satellite data, drones, …) and ice forecasts

- Trained officers in all associated ships