**Abdel A.Z. Barten**
Technical University of Denmark, Arctic Technology Centre; MiljØvej, Building 117, 1. sal, 2800 Kgs. Lyngby, Danmark; Tel: +45 45252106; e-mail: baz@byg.dtu.dk

# DESIGNING ROADS IN GREENLAND USING GIS TECHNOLOGY

ABSTRACT. Designing a road in the Arctic (Greenland) which stretches 157 km between the towns of Sisimiut and Kangerlussuaq was very challenging. Difficult climatic and geotechnical conditions and presence of permafrost required some in-depth analysis and research. Geotechnical investigations were conducted along the entire route. The investigations included field geological and geophysical studies and survey using aerial photography. Based on the investigations a digital model of the area 2 km × 170 km was prepared. Using a Novapoint software a detailed geometric model was created which allowed for calculations of the volume of earthworks and creation of transverse and longitudinal sections of the road. A virtual model of the entire road and a movie were made based on the results of all investigations.

KEY WORDS: Greenland, geographic information system, digital 3D models, planned road, orthophoto, virtual map

## INTRODUCTION

Greenland is the largest island on the planet, part of the Danish Kingdom. The total area of Greenland is approximately 2,4 million km$^2$, but only 384 850 km$^2$ are ice-free. The climate in Greenland is Arctic and even average summer temperatures do not exceed 10 °C. The population of Greenland is about 60 000 people and the main language is Greenlandic. Currently fishing and hunting still play a major role in the economy. The development of new oil fields and the development of the mining industry will require significant capital investment and will take many years.

One of the main obstacles to the development of Greenland is the lack of a well-developed transport network. There are no roads between cities and villages, no railways and inland waterways. Air transport is the easiest, fastest and affordable, but depends strongly on the weather conditions which are often adverse and unpredictable. Thus, the creation of a reliable network of roads that can be used in all weather conditions is a major need for the development of Greenland.

Sisimiut, the second largest town in Greenland, is at a distance of 150–170 km from Kangerlussuaq International Airport and intends to build a new road to the airport. The construction of such a road faces a number of technical problems that can be solved only with the use of state-of-the-art technology and construction methods. For instance, to select the optimal road layout requires extensive fieldwork, including geological, geodetic and geophysical surveys, determining the properties of the soils, and more. On the basis of these studies an aerial surveys along the full length of the planned road layout was carried out, and a detailed single orthophoto, measuring 2 km by170 km was created (Fig. 1). The results of all of these studies are summarized in a geographic information system.

## METHODS AND DATA

The road is planned as a two way road, with a maximum axis pressure exceeding 15 tons. Maximum speed is planned to be 60 km per hour, road layout should avoid turning radii less than 30 m, and maximum slopes exceeding 12%.

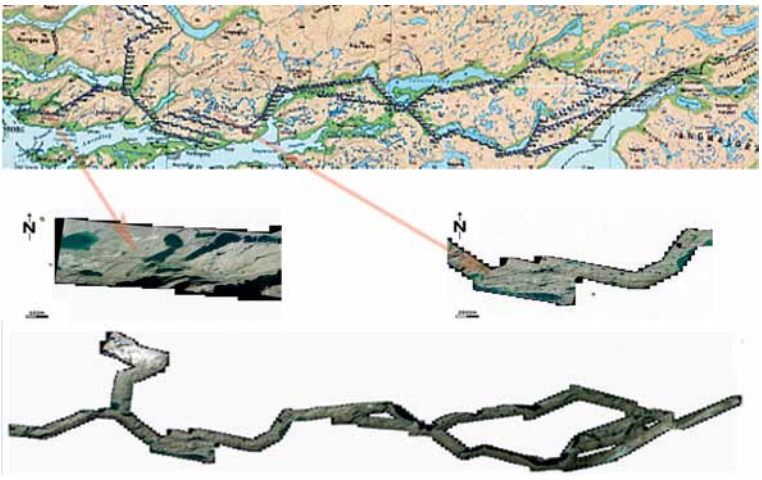

**Fig. 1. Map showing the area and the orthophoto.**

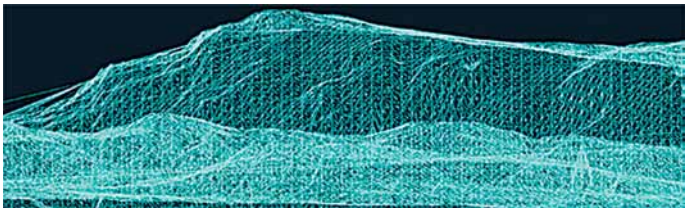

**Fig. 2. Example of the constructed digital terrain model.**

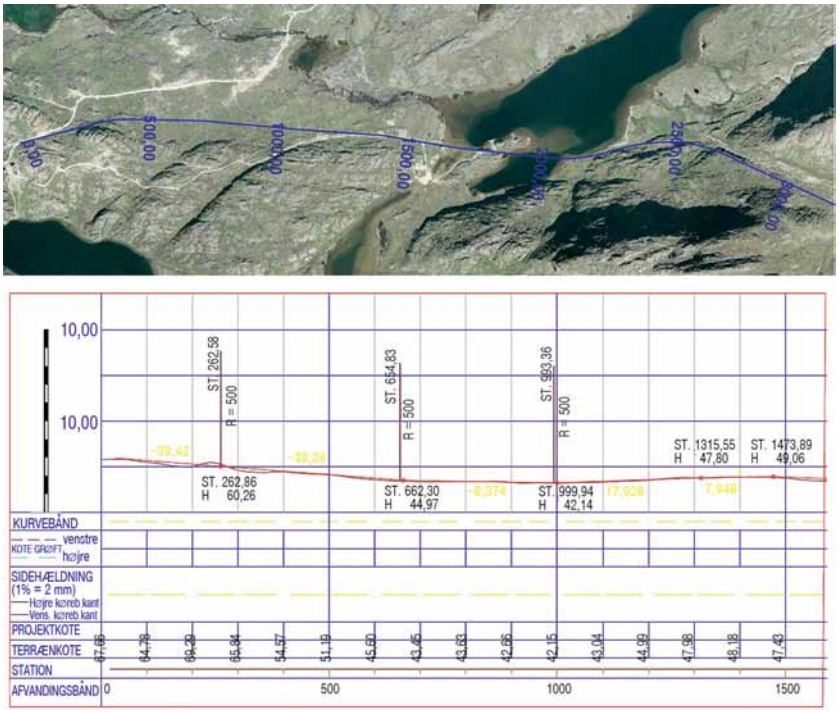


**Fig. 3. Visualization of the planned road layout showing longitudinal and transverse profiles.**

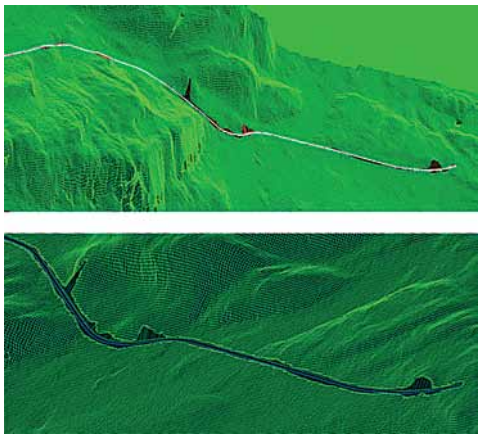

Fig. 4. Terrain and road model.

Fig. 5. Virtual map with the projected road layout.

Fig. 6. Image from the virtual trip by car.

A digital elevation model of 20 m resolution has been created on the basis of the constructed triangulation mesh (see Fig. 2).

Based on the data previously described the planned road layout is visualized in a longitudinal profile and characteristics for every 20 m (see Fig. 3).

The volume of material that needs to be moved to construct embankments or due to excavations was calculated. Together with spatial information these data were also included into the GIS system.

Fig. 7. Photos taken during the virtual overflight at 700 m above the ground.

The software Novapoint was used to create digital models of the terrain and of the planned road. Subsequently the two data sets were combined as shown in Fig. 4.

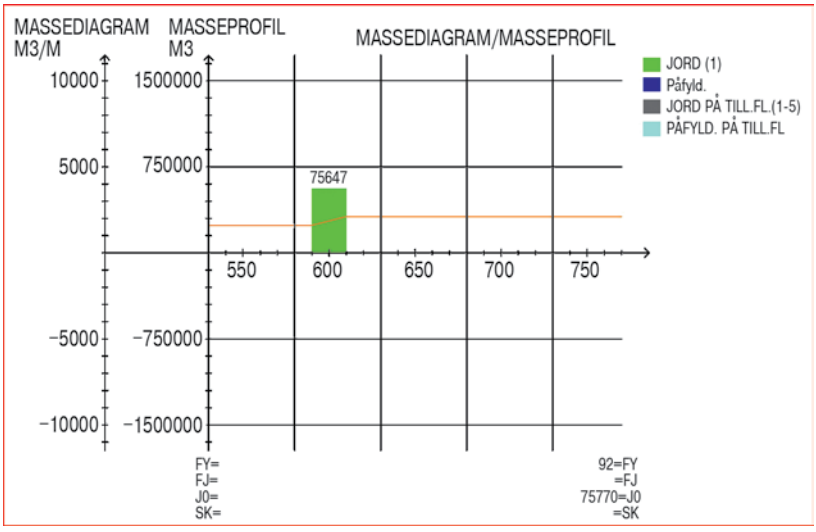


Fig. 8. Volume of road embankments and excavations along the planned road layout.

On the virtual map the orthophoto is used to visualize the projected road layout on the real terrain (see Fig. 5).

The combination of the orthophoto, the terrain model and the detailed road layout in the virtual map lets the user to move freely along the projected road. This visualization is very helpful in discussing and promoting the road project, as well as to monitor the impact of the planned layout. The images below are screenshots from a virtual trip along the planned road (see Fig. 6) and a virtual overflight at about 700 meters above ground (see Fig. 7).

Road embankments and excavations were calculated with the aid of the software Novapoint in the framework of Microsoft Excel. The calculations are shown in Fig. 8.

## CONCLUSION

In the framework of this project, the focus was on the horizontal axis of the road relative to the terrain and on the geological conditions along the planned layout. The complete planned road layout (170 km) was finally divided into 6 individual sections, and the project has now moved into the implementation phase. The construction of a first section of the road, situated within the city of Sisimiut, has recently been started. The construction and maintenance of roads under arctic conditions needs to be done with special focus on the harsh climatic conditions. By creating an interactive virtual map of the Sisimiut – Kangerlussuaq road, an important part of the design and the implementation of the road layout was done. ■

## REFERENCES

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Dr. **Abdel Barten A.Z.** graduated from the Kabul Polytechnic University in 1979 and from the Moscow Mining University in 1983. His research interests are GIS technology for road designing and antrophogy and geomorphology for the development and improvement of methods for calculating the stability of slopes. He has authored and co-authored over 12 scientific publications and participated in numerous international conferences.