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A broadband multicomponent seismic landstreamer for underground infrastructure planning projects - An example from the Varberg tunnel, southwest Sweden

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Over the past few years, demand for infrastructures has continuously increased in Sweden. The authorities are expected to invest significantly on infrastructures especially those that are environmentally friendly and aim at reducing CO_2 emission. Due to limited surface accessibility, the country will particularly move towards developing more and more subways, train tunnels, underground highways and bypasses. The focus will then obviously be in major cities where the underground infrastructures have to be constantly developed or expanded to facilitate the daily life and transportation. The degree to which we can understand geological conditions where these structures are going to be constructed also has great economical and environmental effects. What, however, makes urban environment challenging target for geophysical investigations is the various sources of noise and restriction both in time and space, which require the equipment to be versatile and to produce minimal disruption as well as fast to set up and pack.

As a part of a nation-wide, an academia-industry partnership, project (TRUST, TRansparent Underground STructure), we have developed a multicomponent broadband digital-based sensor seismic landstreamer system that is particularly geared for noisy environments and areas where high-resolution images of the subsurface are needed. The streamer has been tested for its reliability in various locations (e.g., part of the Stockholm Bypass) and for various targets one which was a planned underground train tunnel in the city of Varberg, southwest Sweden that is the focus of this presentation. Potential targets were bedrock surface, fracture zones, weak and shear zones. During nearly three weeks, totally about 7.5 km long, comprising 25 seismic profiles using a source and receiver spacing of 2-4 m, was acquired. A novel approach in the data acquisition was to combine the landstreamer with wireless sensors in areas where accessibility was restricted and, to provide crucial information seismic sensors had to still be placed but not in the form of streamer. Although the area is highly noisy especially in the downtown and areas close to the existing train station, the seismic data successfully allowed mapping the bedrock surface and its undulation and areas where potentially rocks have poor quality or are fractured. Based on these results and modeling work conducted in the area, a detailed and complementary investigation has been recommended and optimal locations for a second phase drilling campaign have been identified. Developed in this study and in conjunction with the Varberg project, some modeling approaches were carried out to quantify data, modeling and interpretation uncertainties, which are extremely valuable for engineering applications.

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