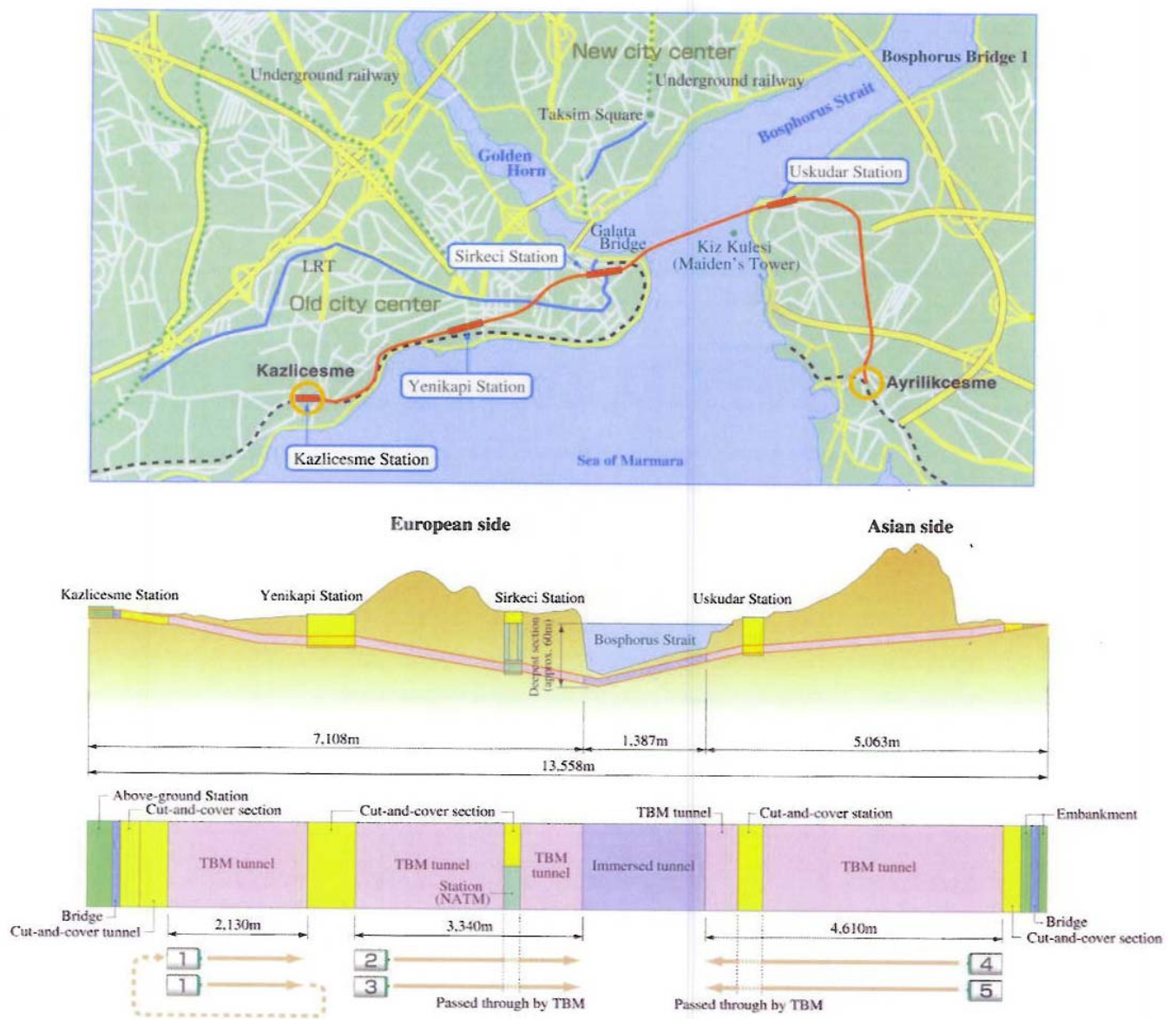


## The Marmaray project – status of work progress

By Detmar Heidenhain, Feb. 2010

### Project overview

The project includes a 13.6 kilometres Bosphorus crossing and the upgrade of 63 kilometres of existing lines to create a 76.3 km high-capacity suburban train line.



The Bosphorus (Istanbul Strait) is crossed by a 1.4 kilometres long earthquake-proofed immersed tube, assembled from 11 sections, each as long as 130 metres and weighing up to 18.000 tons. The sections were shipped from a dockyard some 40 kilometres away (next picture) and then placed down to 60 metres below sea level: 55 metres of water and 4.6 metres of earth. This underwater tube is to be accessed by tunnels bored with slurry TBMs from the European and the Asian side of Istanbul.



Three new underground stations will be built, 37 other above-ground stations along the line will be rebuilt or refurbished. The upgrade of the suburban lines requires the addition of a third parallel track, to increase capacity to 75,000 passengers per hour in each direction. Signalling must also be modernized to allow trains to be as close as two minutes apart. The predicted travel time from one end of the line to the other is 104 minutes.

Construction of the Marmaray project started in May 2004. The immersed tube tunnel section was completed in September 2008. Completion of the project is expected in 2012, regular services are expected to commence in either 2012 or 2013.

After completion, the usage of rail transportation in Istanbul is predicted to rise from 3.6% to 27.7%, which would see Istanbul's percentage rate of rail transportation usage as the third highest in the world, behind Tokyo (60%) and New York City (31%).



*View inside the immersed tunnel*

### **Earthquake risk**

Tunnel construction is only about 18 kilometres from the active North Anatolian Fault, worrying engineers and seismologists. Scientific calculations to estimate the probability that at some time in the next 30 years the area will suffer an earthquake of strength 7.0 or more produced an outcome of 77 percent. The waterlogged, silty soil on which the tunnel is being constructed has been known to liquefy during an earthquake; to solve this problem, engineers have injected industrial grout down to 24 metres below the seabed to keep it stable. The tunnel is made to flex and bend similar to the way tall buildings are con-



structed to react if an earthquake hits. Floodgates at the joints of the tunnel are able to close and isolate water in the event of the walls' failure.

### Docking procedure

The four slurry TBMs (diameter 7.64 m) are to be driven into the sleeves of submerged tunnel elements E1 and E11. Face pressure will be maintained whilst permanent connections of the TBM shields are made to the steel liners in the sleeves. A positional survey of the TBM is to be made at a distance of some 30 – 50 meters from the sleeve.



The docking procedure is completed by the installation of a welded seal between the skins of the TBM and the steel liners in the sleeves and the subsequent infilling of the annular space between the TBM skins and the steel liners back to the last pre-cast concrete segment ring with concrete.

*Refurbishing works for TBMs at Yenikapi Station*

### Delays

The project is currently four years behind schedule, largely due to the discovery of a Byzantine-era archaeological find on the proposed site of the European tunnel terminal in 2005. The excavations produced evidence of the city's largest harbour, the 4th-century Port of Theodosius. There, archaeologists uncovered traces of the city wall of Constantine the Great, and the remains of several ships, including what appears to be the only ancient or early medieval galley ever discovered, preventing the project from proceeding at full speed. In addition, the excavation has uncovered the oldest evidence of settlement in Istanbul, with artefacts, including amphorae, pottery fragments, shells, pieces of bone, horse skulls, and nine human skulls found in a bag, dating back to 6000 BC.

