



## Construction case study

### Snake-arms for tunnel boring machines



OC Robotics supplied Bouygues Travaux Publics with a snake-arm to clean and inspect the cutting head of a tunnel boring machine (TBM) beneath the Port of Miami.

## DEFINE

### Business case

As tunnels are dug deeper, maintenance becomes increasingly hazardous for people. In Miami the ambient pressure was 3.5 bar, at 50degC, with 100% humidity and considerable amounts of salt, mud and rock. In the future tunnel pressure will increase to 12bar making human entry extremely challenging and expensive.

### Objectives

The Port of Miami project provided an opportunity to take the proof of concept design directly to site test. The timescales were compressed and the technical risk was considerable. The implementation required design of a pressure control system, sleeving for the environment, increased reach and integration within a TBM.

## DESIGN

The JetSnake system includes a multi-jointed nose-following snake-arm. The head of the snake-arm contains a 400bar water jet, a high-quality zoom camera and lamps for inspection. (Fig 3). The cameras and lights operate whilst water jetting.

The snake-arm robot has a diameter of 125mm and a fully extended horizontal reach of 3m (excluding the wrist and tools), with a payload of 5kg.

The arm was sleeved to protect it from hazardous environments and has a pressurisation system up to 3.5 bar +/- 0.01bar to operate in hyperbaric conditions.



Fig 2. Testing of JetSnake system



Fig 1. JetSnake (without sleeving)



Fig 3. JetSnake tool – water jet, camera and lights

## DELIVER

### Operation

The JetSnake system arrived in Miami in October 2012 and was set up and operated in a test area within an hour. Installation of the system in the TBM took less than 24 hours with a further day for commissioning.

The head motion, cameras and the ability to follow a path were all tested successfully. The arm was deployed along both straight and curved paths within the complex TBM cutting head geometry. (Fig 5)

TBM production scheduling allowed two extended windows of JetSnake operation. JetSnake was able to identify damage which would otherwise have involved a lengthy manual inspection. Live video feed back to Paris enabled senior managers to watch the inspection at first hand.



Fig 5 JetSnake water jetting – inside TBM



Fig 4. Disc cutter before and after water jet cleaning

### Conclusion

The proof of concept JetSnake system achieved the trial objectives and BOUYGUES TRAVAUX PUBLICS intend to use the solution in future deep tunnelling projects. The Jet-Snake allows inspections even when and where it is not possible to send workers in the excavation chamber. This enhances the maintenance organization and play a part in the optimization of the use of the TBM.