VERIFYING ELEMENTARY ITER MAINTENANCE ACTIONS WITH THE MS2 BENCHMARK PRODUCT

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In ITER, maintenance operations will be largely performed by Remote Handling (RH). Safety regulations and licensing authorities expect to require a significant amount of proof of RH maintainability of critical components before ITER can be put in operation. Virtual Reality (VR) simulation can be used to study maintenance operations during task preparation [1] and provide part of the required proof. Another part of the proof will come from using standardized parts, tools and procedures [2]. In many cases, some additional verification and validation will be required, based on hardware tests in 1:1 scale mockups.

An important limitation in the execution of real ITER RH maintenance procedures will come from limited visual and haptic feedback. To investigate the impact of different feedback factors on performance of maintenance tasks, a benchmark product was developed. The assembly of this benchmark product covers a small but comprehensive and representative subset of elementary ITER maintenance actions, such as tightening of captive bolts, insertion on alignment pins and handling of various connectors.

The benchmark product was tested in a representative two-handed dexterous manipulation test bed at NRG. In the setup, the quality of visual feedback was varied by exchanging direct view with indirect view setups in which visual feedback is provided via video cameras. Interaction forces were measured via a built-in force sensor. The impact of feedback quality on the performance of maintenance tasks at the level of handling individual parts was measured and analysed.

Both visual and haptic feedback were found to influence task performance. The measurement results are used to calibrate similar operations in Virtual Reality simulation scenarios.

[1] B.S.Q. Elzendoorn et al., “Analysis of the ITER ECH Upper Port Launcher remote maintenance using virtual reality”, Fusion Engineering and Design, Volume 84, Issues 2-6, June 2009, Pages 733-735
[2] "ITER Remote Handling Code of Practice", ITER_D_2E7BC5 v1.2