Purpose: The quantification of new computed tomography (CT) systems can be challenging with respect to image quality and diagnostic value. Especially for advanced algorithms, such as statistical reconstruction methods, the performance is more difficult to determine because of a larger set of parameters in combination with local dependences in the image domain. Thus, there is the need for a realistic software benchmarking to determine diagnostic performances. In this work, we present a software-bench consisting of a Monte-Carlo simulator (MCS) and a GPU-based reconstruction-engine for characterization of CT systems and reconstruction algorithms. Methods: The MCS is based on EGSnrc, which simulates the whole imaging system. The GPU-based reconstruction-engine is able to reconstruct different iterative and non-iterative reconstruction algorithms. For initial results we simulated a flat-panel detector-based cone beam CT. The MCS determined the projection images of a cylindrical PMMA-Phantom. The 100mm diameter Phantom contains 9 cylindrical regions varying in size between 1mm and 10mm, and in density between -1000HU and 300HU. The simulated projection-images are reconstructed with the FBP and the HYPR algorithms. Results: The system was configured and provided initial results. The influence of different parameters showed different image qualities for FBP and HYPR reconstructions, while HYPR revealed a superior performance. For example, when varying dose and detector-configuration the soft-tissue contrast and spatial resolution was improved by a factor of 2 or more. Conclusion: In this work, we show that the combination of a realistic simulation of projections and reconstruction algorithm is essential for characterization of new systems / algorithms. In particular, the correct simulations of the x-ray interactions are crucial for characterization of image noise and spatial resolutions with respect to radiation dose. We see the need for systems such as ours to determine the clinical value of methods in combination with image quality measures and observer models.