

# Photogrammetric 6DOF Measurement on Machine Tools

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## INTRODUCTION

The achievable precision of workpieces is highly influenced by thermally induced deviations. For that reason a measuring method is needed to characterize the thermo-elastic machine state with following requirements:

- detection of complete pose of machine (displacement and inclination) at any time
- sufficiently high accuracy (single-digit micrometer range)
- high measuring speed

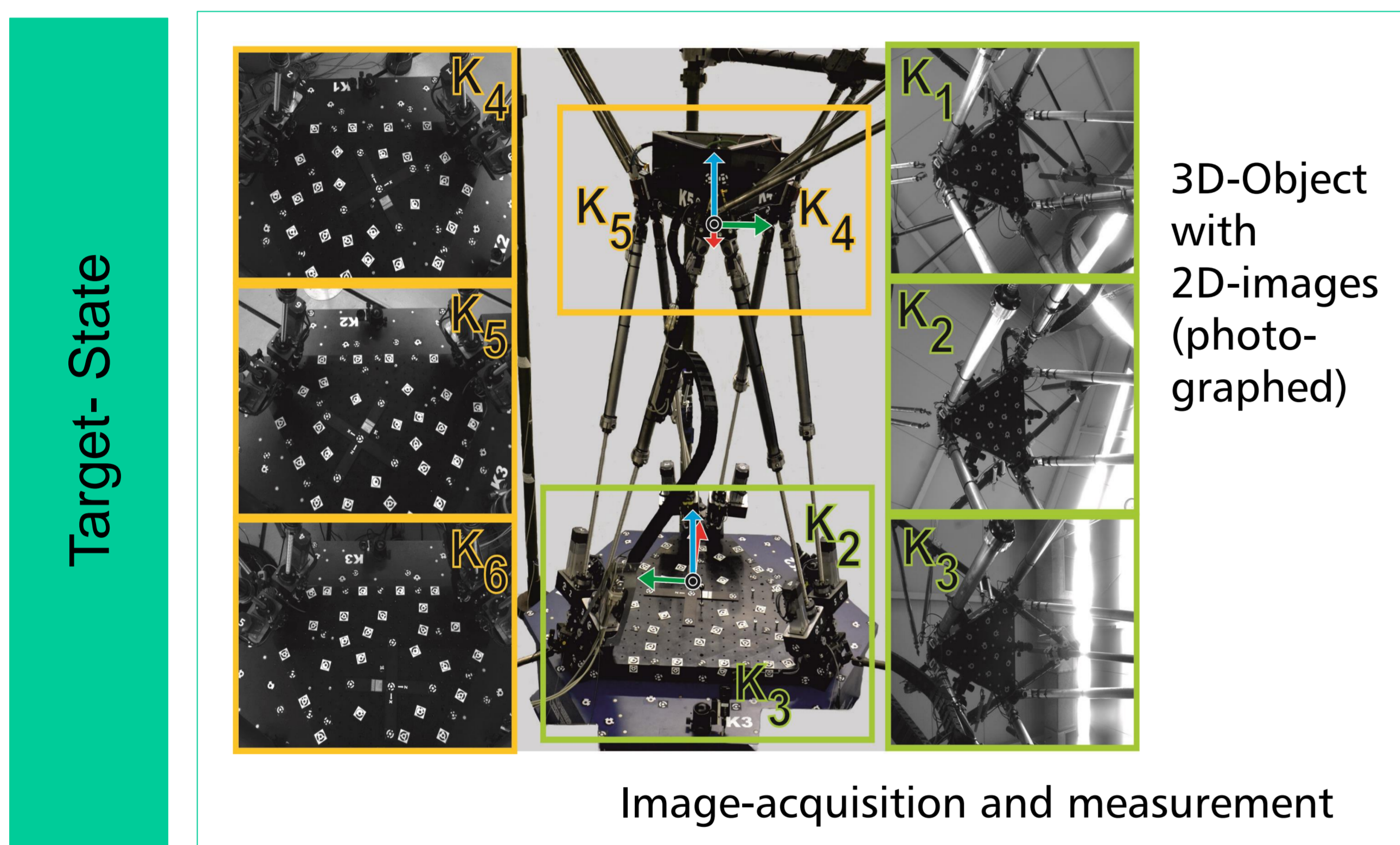


Figure 1: Principle of photogrammetric pose measurement. A parametric 3D-model can be realized for structure model based correction with image measurement.

## RESULTS

Non-contact detection of the thermal displacement of the end effector of a machine by photogrammetric methods achieves good results. It works well throughout the entire work area with a high local resolution as well as a displacement accuracy of  $10\mu\text{m}$  and an inclination accuracy of  $20\mu\text{m/m}$ .

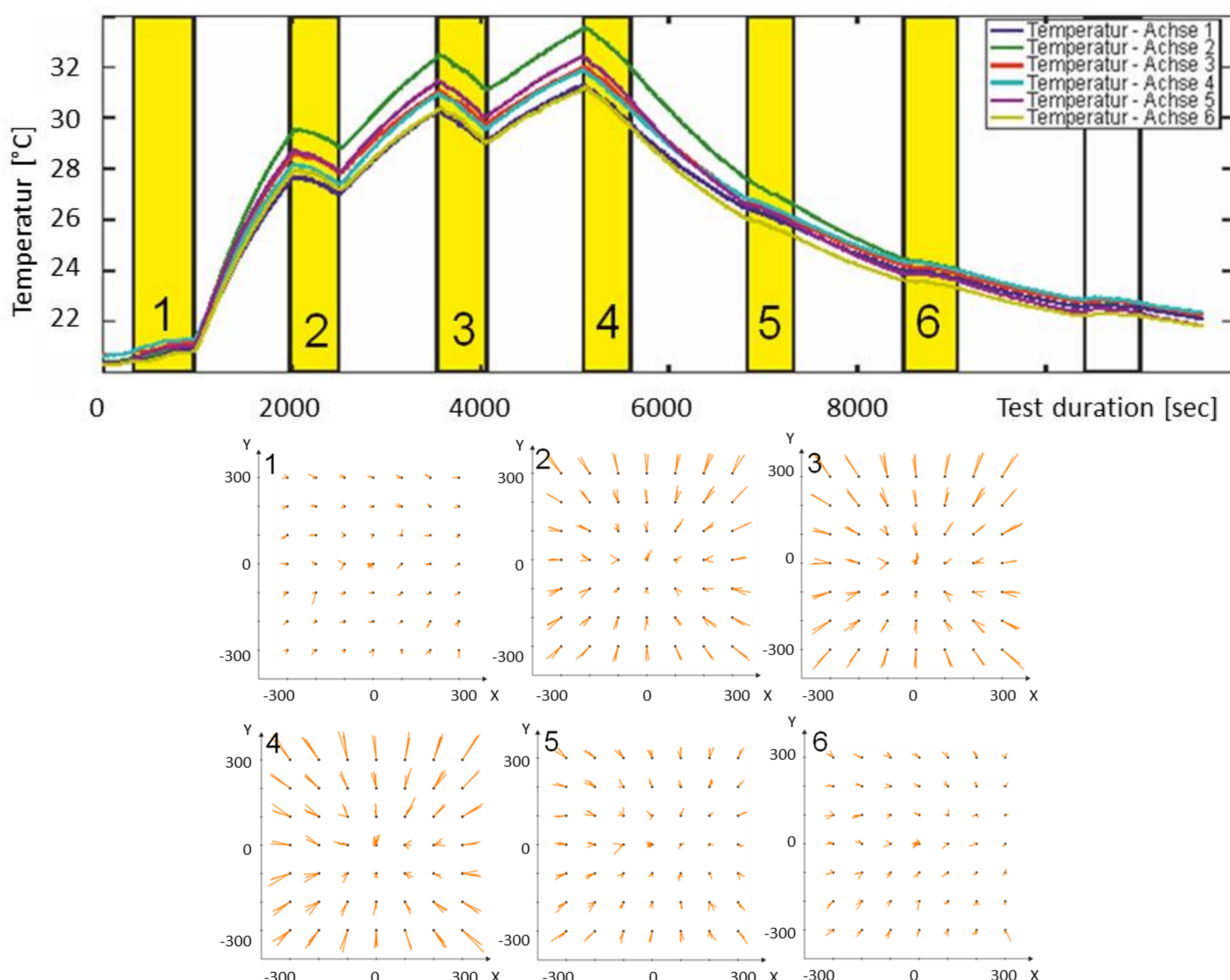


Figure 2: Measurement of displacement/ inclination in the entire work area:  
 - raster in working area with operating point distance of 100 mm  
 - in total 180 poses per measurement run are detected  
 - measuring time: about 6 minutes.

## PHOTOGRAMMETRIC MEASUREMENT SYSTEM

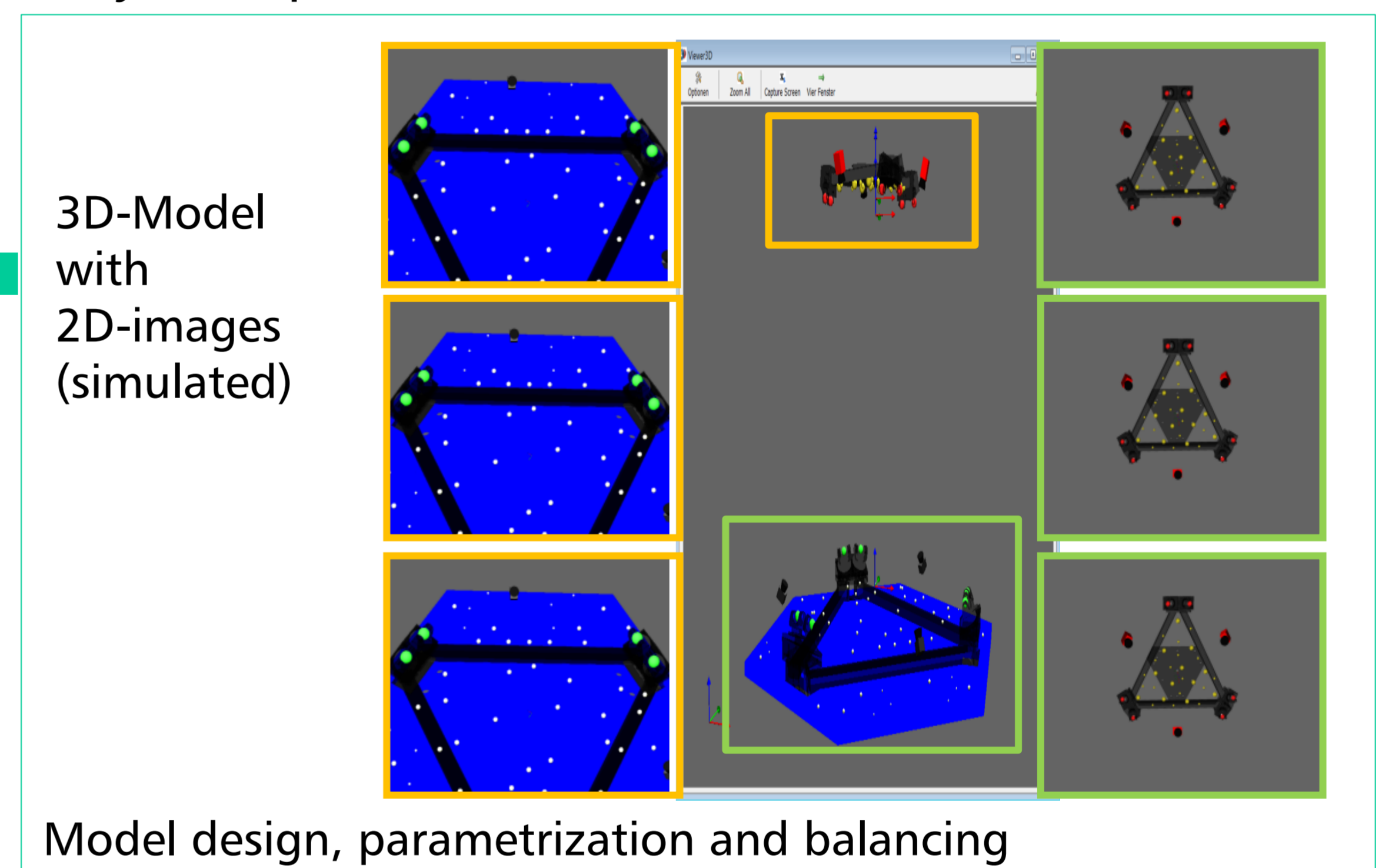
A promising approach is the following photogrammetric measurement system. With an extended 6DOF evaluation it obtains 3D- information of the object from 2D-images through image measurement. Therefore two "sub-systems" are installed, which are based on each other.

System 1 (K1 to K3) cameras on the frame side:

System obtains good accuracy for displacement measurement but moderate results for inclination measurement, due to low opening angle (machine part covers not much of the image).

System 2 (K4 to K6) cameras on the platform side:

System obtains good accuracy for inclination measurement (machine part fully covers field of view in the images), but low accuracy of displacement.



Actual-State

The results of displacement measurement in the work area are shown in Figure 3. For the experiment all axes of the mobile demonstrator are evenly loaded.

Figure 3 shows the results of displacement measurement in one single operating point. In this case the mobile demonstrator works cyclical: Just one axle is loaded and regularly aimed at the operating point, while the other axes cool down. Then the next axle gets loaded. When all axes have been moved, the next cycle begins.

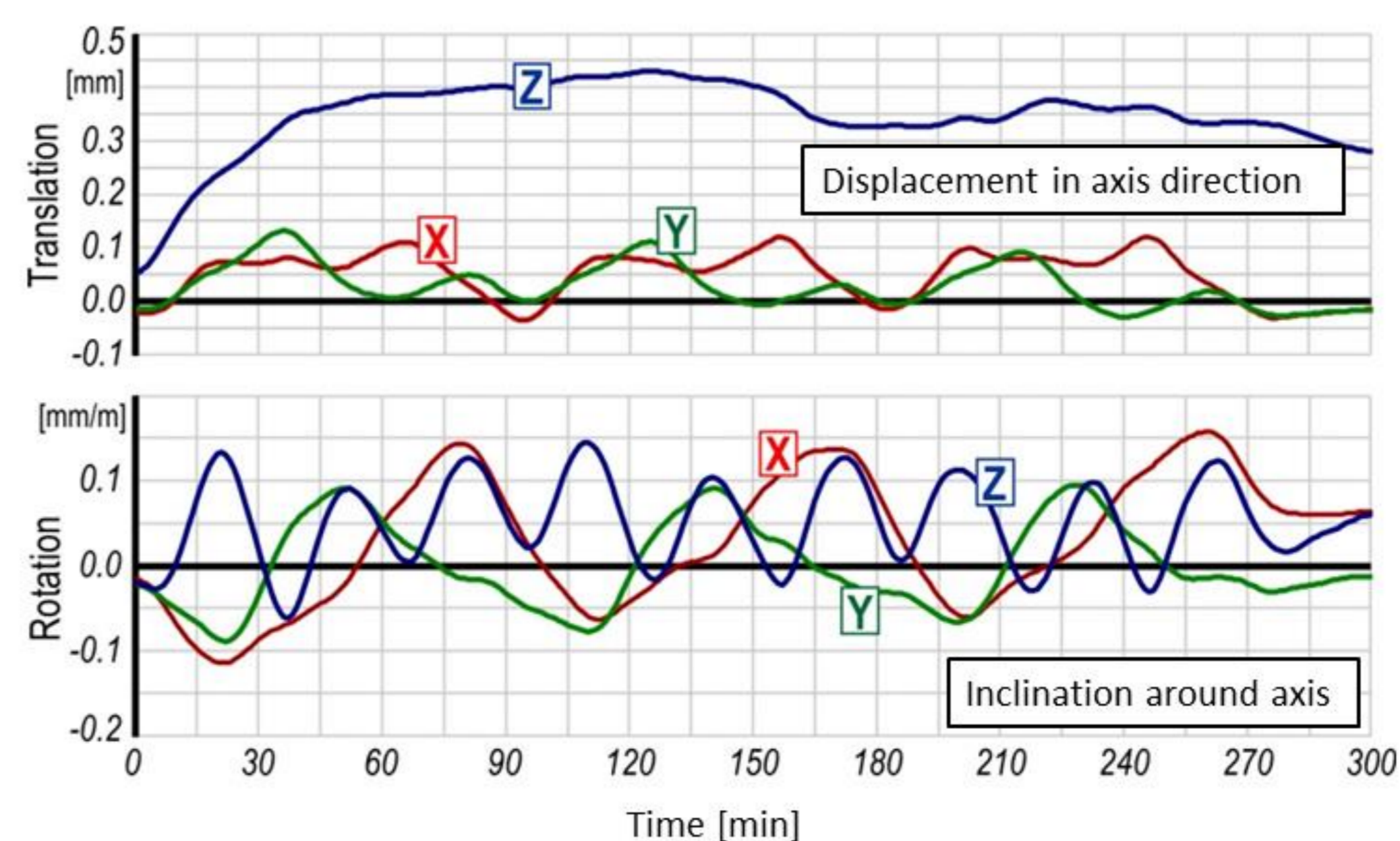


Figure 3: Measurement of displacement in one single measurement point.  
 -- Operating point is  $X=Y=Z=0$   
 -- Three complete load cycles of all axes are measured