# Acceleration of iterative solvers for dense linear systems from boundary element method

**S. Schneider*, S. Marburg, H.–J. Hardtke**
Institute für Festkörpermechanik
Technische Universität Dresden,
D-01062 Dresden, Germany
e-mail: sneider@mfm.mw.tu-dresden.de

We are interested in solving the time harmonic Helmholtz equation in the three dimensional case. Further more we like to handle several ten thousands of unknowns. To solve these problems we are using fast methods as the Regular Grid Method (see [1]) or the Multilevel Fast Multipole Method (see [2, 3]). With the usage of these methods the time to set up the matrices needed for the iterative solver is negligible. The most time consuming part is the solution of the linear system. As iterative solvers for these non-symmetric systems we are using GMRES($k$), TFQMR or BICGSTAB($k$) where $k$ denotes the restart parameter. Especially with the Burton/Miller formulation and at higher frequencies all the mentioned iterative solvers are showing slow convergence rates or even fail to converge at all. The simplest way to accelerate the restarted versions of GMRES and BICGSTAB is to chose the restart parameter ($k$) large enough. Due to the increasing memory requirement the value of $k$ is limited by the amount of memory available. Thus we are interested in other possibilities of acceleration. In a first step we use preconditioning. Based on the operator splitting provided by the fast methods mentioned above we are constructing an incomplete LU-factorization of the singular part of the discretized operator. Doing so we achieve an important reduction of the number of iteration needed by the iterative solvers or at least they do not fail to converge. Even with the preconditioning the choice of the restart parameter is still important. Especially the GMRES solver loses it's convergence rate after every restart. This loss can be decreased be keeping the new search directions orthogonal to a certain number of previous directions. This will be realized by using the GCRO (see [4]) or GMRESR (see [5]) method.

## REFERENCES

[1] A. Bespalov. On the usage of a regular grid for implementation of boundary integral methods for wave problems. *Russ. J. Numer. Anal. Math. Modelling*, 15(6):469–488, 2000.

[2] M. F. Gyure and M. A. Stalzer. A prescription for the Multilevel Helmholtz FMM. *IEEE Computanional Science & Engineering*, 1998.

[3] C. C. Lu E. Michelssen J. M. Song W. C. Chew, J. M. Jin. Fast Solution Methods in Electromagnetics. *IEE Trans. Antennas Propag.*, 45(3):533–543, 1997.

[4] E. De Sturler and D. Fokkema. Nested Krylov methods and preserving the orthogonality. In *N. Duane Melson, T.A. Manteuffel, and S.F. McCormick, editors, Sixth Copper Mountain Conference on Multigrid Methods*, volume 1, pages 111–126. NASA Conference Publication 3324, 1993.

[5] H. van der Vorst and C. Vuik. GMRESR: A family of nested GMRES methods. *Numer. Lin. Alg. Applic.*, 1:369–386, 1994.