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Staggered Procedures Revisited – Initial Fondest Hopes, Ensuing Applications, and Future Prospects

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ABSTRACT

We begin with a chronology of the staggered solution procedures for the solutions of coupled interaction problems as originally conceived in 1976 for treating structure-external acoustic interaction problems, and subsequent applications to other coupled-field problems. We will then reminisce our interactions with Professor Olek Zienkiewicz during the early stages of the method developments and initial applications to other field problems. We then review the applicability as well as limitations of staggered solution procedures in the ensuing years. The presentation will conclude with recent developments and future potential in the new emerging multiphysics problems

ORIGIN OF STAGGERED SOLUTION PROCEDURE

In the mid-1970s, carrying out fluid-structure interactions within a single analysis code was a challenge. Most major FEM structural analysis codes allowed to have user-interfaces only in a form of Fortran subroutines, but not easily with a distinct independent analysis code, such as fluid analyzer [3]. In addition, incorporating a fluid analysis capability into an existing FEM production(not research) code posed delays and software spaghetti difficulties. A staggered procedure [4] was born to alleviate such logjams by utilizing the two separate fluid and structure codes whose time marching steps would separately advance in time while exchanging interaction data. The success of the first staggered procedure as applied to the fluid-structure interaction problems hinged on stabilization of the prediction stage, which was solved by augmentation of one of the interaction terms. This will be discussed in detail during our presentation.

EXPANDED APPLICATIONS OF PARTITIONED SOLUTION PROCEDURE

The idea of staggered solution was soon recognized as a special case of a more general framework: *partitioned analysis procedures* [1-2, 5-7] for coupled systems in which interacting subsystems can be structures, fluids [8,10], pore-fluid [11,12], soils, aero-elasticity [9], control systems, electromagnetic waves, thermal fields, etc. Applications to a range of coupled problems have been developed as driven by target applications.

FUTURE PROSPECTS OF PARTITIONED SOLUTION PROCEDURE

Partitioned analysis is enjoying renewed attention given growing interest in multiphysics, nonmatching meshes, micro-macro coupling, model reduction and parallel processing. Further developments of the mathematical foundations appears necessary, however, before the topic can settle down and pass to the textbook level. For example, present challenges include transforming the tightly coupled internal variables into loosely coupled entities, robust interface extrapolations, and expanding the modular interface features to accommodate mode single discipline-oriented special purpose simulation codes for expanding multiphysics simulations, and in particular, judicious stabilization strategies in transient or time-marching solution process.

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