Towards a Minimal Realisable System Dynamics Project Model

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ABSTRACT

This paper looks at the established Systems Dynamics (SD) methods applied to Software projects in order to simplify them. These methods are highly non-linear and contain large numbers of variables and built in decisions. A SIMULINK version of an SD model is used here and conclusions are made with respect to the initial main controlling factors, compared to a NASA project. The eigenvalues of the linearised system indicate that the important factors are the hiring delay time, the assimilation time and the employment time. This illustrates how the initial state of the system is at best neutrally stable with control only being achieved with complex non-linear decisions. The purpose is to show the minimum level of complexity required for “good” simulation of project behaviour considering the Abdel-Hamid software project model and three simpler versions. These models give clues to the decision structures that are necessary for good agreement with reality.

Keywords: Computer Science, Information Systems, Reduced Models, SIMULINK, Software Development Project Models, System Dynamics, Tarek Abdel-Hamid

INTRODUCTION

Software projects still have a low success rate in terms of reliability, meeting due dates and working within assigned budgets (Smith, 2002; Yeo, 2002; Royal Academy of Engineering, 2004). Factors, which determine successful project management (Abdel-Hamid & Madnick, 1989), may be related to technical production processes, time scheduling in a dynamic environment and individual differences in project managers, members and team processes. Capers Jones (1996) has estimated that such projects only have a success rate of 65%. Projects may be considered as a system in which demands are made (the requirements) and an internal project organisation, is controlled to produce the software goals, while being disturbed by the external environment.

The cost of such disasters such as the UK National Air Traffic System, Health Service computerisation and the London Ambulance Service computerisation is high in both money and human terms.

Despite these failures significant progress has been made in the use of System Dynamics methods to describe the operation of software projects (Rodrigues & Bowers, 1996). Other workers such as Lin and Levary (1989) describe computer aided software design using System Dynamics, expert systems and a Knowledge based management system used in the design of a space station. More recently Häberlein (2004) has discussed the common structures involved in SD models. He contrasted the Abdel–Hamid

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model, which uses tasks completed with an approach based on requirements. Although we do not use this here the idea has considerable merit as the Abdel-Hamid approach has difficulty including requirements phases. His approach would be more suitable to use when modelling agile methods for example. This point was made by him in referring to the universality of the model. Rodrigues and Bowers (1996) and Lyneis and Ford (2007) have established the role of System Dynamics in project management, pointing out the dominating effect of rework and the way factor such as quality or productivity affects project performance.

The models of operation of the software development process were described by the successful System Dynamics (SD) models of Abdel-Hamid and Madnick (1991), which set up equations relating levels such as the number of perceived errors, or the number of reworked errors and relates them to rates such as the error detection rate or the rework rate, significant features of these models included the decision processes. These models were validated against NASA project data for a medium size project and the agreement is strikingly good. The SD model structure is highly non-linear with a number of theoretical assumptions, for example about how the errors in the coding are propagated. These structural assumptions do not allow for System Dynamics models to enable any general rules to be developed by academics to allow managers to make sound judgments based on good analysis. The distinction with models of inventory processes, which are related, is the rationale for this research programme. Early SD inventory models developed by Forrester (1961) were also non-linear and contained a number of factors, such as employment rate, that made the problem too complex for simple rules to be developed. Towill’s group at Cardiff (Disney & Towill, 2002) and others devised linear control system models to enable operational rules to be investigated and optimal solutions to be found as well as stability margins to be obtained (White & Censlive, 2006). Part of the simplification of the Project Model is being tackled in the USA by the newer control system models of software testing (Cangussu et al., 2002) and the approach to control by White (2006). The whole purpose of this research application is to develop simple control system models of the project development process, as in inventory analysis, and obtain rules for stability. This should include the newer evolutionary and agile Project Management methods of Gilb (2005) and others.

Human Organisation Effects

Recent research has identified the importance of the managerial and organisational contexts that create the latent conditions for error and failures. This lack of transfer to and impact on industry is related to an insufficient consideration of system development problems and poorly documented error modelling techniques (Johnson, 1999). Other studies in this field have considered the significance of pre-project activities for developing effective team working and management (Jiang et al., 2002), post-project reviews of process-related factors for competence building in project teams (von Zedtwitz, 2002) and leadership styles for managing group dynamics (Lewis, Welsh, & Dehler, 2002). Few reliable SD models have been derived in this area and no fully validated models are available.

This is particularly difficult with present SD models of projects where 32 states or levels are being modelled simultaneously with over 100 feedback loops.

In order to succeed the Project manager must have a mental model of how the project system operates to achieve the system goals.

It is also important to realise that no matter how successful we are at controlling the external disturbances the goal of a successful project cannot be achieved if the internal processes are not stable. This is only possible if a good internal model is used and the best model available extant is that of Abdel-Hamid.

The purpose of this paper is to set out an analysis of the system dynamics model from a control engineering point of view illustrating how the initial state of the system is at best neutrally stable. It will show how the reduced
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