



Changeability as an alternative to traditional design

Daniel F. Villarraga, Samuel Torres, Mauricio Sánchez Silva

Universidad de los Andes, Bogotá, Colombia

Contacting author: df.villarraga2191@uniandes.edu.co

Abstract

The built environment is subject to multiple uncertainties, therefore, any investment in building assets is risky at a financial, economic and/or physical level. Traditionally, engineers deal with this problem by designing and constructing systems capable to accommodate expected long-term demands without any significant modification to their structure. However, this strategy comes at a significant cost and implies that the system is overdesign during most of its lifetime. An alternative to this approach is conceiving systems that can change over time, so they are capable to overcome adverse conditions and take benefit from emerging opportunities. In this paper we describe how enabling change improves systems' economic performance. In the paper, the consequences of changeability are evaluated with respect to the systems' expected net present value and its variance; this is compared with the traditional financial evaluation of traditional alternatives. This work is a step forward towards understanding of changeability and its advantages over traditional design alternatives.

Keywords: Changeability, Flexibility, Adaptability, Agility, Modularity, Modifiability, Scalability, Efficiency.

1. Introduction

In uncertain environments, systems must be designed so they are capable to maintain their functionality trough their entire service lifetime (i.e., time mission). To achieve that objective, engineered systems are traditionally designed for long-term demands, which in most cases are never met, and that imply incurring in high costs.

Alternatively, systems could be designed to meet a lower demand initially and allowing them to change over time, so that they can better respond to variations in the demand or other non-technical requirements as they occur. Recently, the term *changeability* has been used to denote this system's ability to change. By allowing systems to change, they can better manage uncertainty and take advantage of unplanned business opportunities. Designing for changeability is not only an alternative approach to manage risk but a way to make systems more profitable. The term changeability can be found explicitly in [1], [2], [3], [4], [5]. However, other terms to describe it include: flexibility [6], [7], [8], [9]; robustness [10], adaptability [11]; efficiency [12]; and modularity [13]. It is important to stress that the concept of changeability is in most cases described intuitively, but it is never quantified; which leads to a poor understanding of its importance and limitations.

The objective of this paper is to show that changeability improves the economic performance by increasing the expected net present value and diminishing its variance; this in comparison with traditional design. Furthermore, the paper presents also a way to quantify the changeability of