

Design prototyping methods: state of the art in strategies, techniques, and guidelines

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Abstract

Prototyping is interwoven with nearly all product, service, and systems development efforts. A prototype is a pre-production representation of some aspect of a concept or final design. Prototyping often predetermines a large portion of resource deployment in development and influences design project success. This review surveys literature sources in engineering, management, design science, and architecture. The study is focused around design prototyping for early stage design. Insights are synthesized from critical review of the literature: key objectives of prototyping, critical review of major techniques, relationships between techniques, and a strategy matrix to connect objectives to techniques. The review is supported with exemplar prototypes provided from industrial design efforts. Techniques are roughly categorized into those that improve the outcomes of prototyping directly, and those that enable prototyping through lowering of cost and time. Compact descriptions of each technique provide a foundation to compare the potential benefits and drawbacks of each. The review concludes with a summary of key observations, highlighted opportunities in the research, and a vision of the future of prototyping. This review aims to provide a resource for designers as well as set a trajectory for continuing innovation in the scientific research of design prototyping.

Key words: design prototyping, product, service, systems, methods

Setting the stage

A prototype is an artifact that approximates a feature (or multiple features) of a product, service, or system (Otto & Wood 2001). Design and prototyping have been interwoven throughout history. Michelangelo used physical prototypes to communicate construction details, and for marketing to investors (Sass & Oxman 2006). Palladio used full-scale wooden prototypes of architectural elements to plan costly stone works (Sass & Oxman 2006). Henry Ford explored at least nineteen models (some of which were prototypes) before finalizing the revolutionary model T design (Womack, Jones & Roos 2008). The triumph of Dyson's cyclonic vacuum was only achieved after 5,127 prototypes (Dyson & Coren 2001).

There are overall trends in how individual industries approach prototyping (Schrage 1993). Some are driven by achieving specifications (typically those

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