# Chapter 11
# Conceptual Process for Designing High-Technology Products:
## Case Study of a Litter-Collecting Robot

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## ABSTRACT

*In this chapter, a systematic and practical design process and methodology is presented and applied to design a new high- technology product: a litter-collecting robot. Although considerable theoretical and practical models have been developed in product design and development, there are still limited effective models on the practical design process on a detailed level. This chapter elaborates on recent relevant research in the design methodology field and try to improve the details of product design process and apply it to a litter-collecting robot design. The detailed and practical approach demonstrated on the design of a high- tech product in this paper, can be applied effectively to the design process of industrial products.*

## INTRODUCTION

The main goal of this paper is to improve and utilize an advanced design process and methodology in order to design a high technology product to do some specific functions in commercial, residential, and light industrial environment. Although there is substantial academic research on product design and development process, there is limited documented comprehensive research on the practical and wide application of optimizing the product design process. The case study of this research is a new litter-collecting robot. Although this conceptual design process solution may not be the optimal solution for this product, because of time constraints, the main target here is to show an effective practical process in actual product design which is applicable in system design process as well.

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Many studies argue that a critical success factor in product design and development process is following a structured design approach (Brown, Schmied, & Tarondeau, 2003; and Ernst, 2002), and firms that execute a formal approach might have higher rate of survival if they have a formal approach to product design and development (Baker & Hart, 1999).

Bailetti and Litva (1995) focused on the importance of customers requirement information in design process and tried to test the design managers' prospective on the source of customer requirement information. They highlighted the importance of creating a model to ensure the customers' information from various sources are consistent for design. Pahl and Beitz (1993) categorized the design process into the four different stages: first, tasks' clarification and design specifications and development; second, conceptual design; third, embodiment design; and fourth, detail design. Clarification includes the requirements gathering (the demands and desires) and defining limitations, which comes to a specification list. Function logic is a way of completing the first two stages. Suh (1988) explained the axiomatic approach design in his study in three phases: first, problem definition that comes in the functional requirements and constraints of design; second, conceptualizing and devising a solution creatively; and last, analyzing and determining if the proposed design solution is rational and consistent with the predefined problem. As aforementioned, function logic is a method to complete the first two stages by formalizing the second stage of the axiomatic process using the first stage feedback. The analytical stage is assisted by supported functions with the information of the allocation list. In addition; Sturges et al. (1997) believe detailed synthesis methods which usually follow the conceptual design process need specifications of input. The function logic in design is suggested as a tool for systematically promoting innovation, managing the information of conceptual design, and producing such specifications.

Tomiyama et al. (2009) categorized all type of design theories and methodologies as "math-based methods", "methodologies to achieve concrete design goals", "process methodologies" in practical use, and traditional design methodologies in academic world and then elaborated the gap between practical and educational ones.

This study considers most of the theories in the present design process and tried to provide an improved and detailed method of product design on a litter-collecting robot, a new high-tech industrial product. The present approach involves more rigorous attention to and more comprehensive coverage of details in the design. In this design process, apparent inconsistencies and contradictions in each of the existing available commercial/ prototype designs are identified, and several guidelines for removing inconsistencies and adapting to changes are provided. The problem is defined and analyzed by using generic brainstorming techniques through a survey team that reviews user responses. The problem identified by users are categorized under several headings, including function/need, change/drivers, people, environment, market window, technology, materials and manufacturing, usage locations, form/style/aesthetics, quantity/cost, parallel products, standards/guidelines/ protocols/laws.

Second, in the requirement engineering section, the production characteristics are analyzed from different perspectives of product design specifications and an engineering framework for proposed design is provided. Several ideas through a team of experts generated, evaluated, and improved to have an acceptable concept for the litter-collecting robot. At the end of this part, a system identification matrix (SIM), main and subsystems, inputs, outputs, and product architecture schematic (PAS) of the litter-collecting robot are provided. Traditionally, a robot is designed as a tool for achieving a specific objective. However, a common platform among robots with different purposes is desired to minimize the cost and time required for robot system development.

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