# Simultaneous Product Family Configuration and Supply Chain Configuration using Systems Engineering Concept

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## Abstract

*This paper deals with the difficult problem of joint product family and supply chain design. We present a conceptual framework that simultaneously considers the construction of the bill of materials and the design of the supply chain network. For the bill of materials, product, module and component are considered. For the supply chain network, suppliers, Manufacturing plants, Assembly plant and distribution centers are considered. Effective product family configuration is highly important for the products that are complex and need to be efficiently respond to customers demand, for this reason supply chain configuration are essential to be simultaneously considered in product family configuration. This simultaneous configuration showed by a conceptual framework based on the Systems Engineering. Systems engineering is useful approach in complex products which used in large project that save time, cost and risk of project. Verified V-model of Systems Engineering adopted to show this simultaneous interactions between PFC and SCC.*

**Keywords:**
Simultaneous Configuration, product family configuration, Supply chain configuration, Systems Engineering, V-model.

## Introduction

To respond efficiently to customer demand, companies propose diversified products. This diversity affects design, production and distribution processes [3]. In this context, a great challenge is how to design the product family and its supply chain simultaneously.

This global relation of PFC and SCC is the way to efficiently manage the interactions between PFC, SCC [2] which reduces costs, and time to have diversified products, which will potentially increase sales.

The contribution proposed in this paper is an extension of a project that is carried out with an industrial partner. Our partner designs and manufactures large projects that include electro-mechanically products that need to be adapted for each situation.

The work presented in this paper covers a new area for this practitioner: the joint design of product family and supply chain as an integrated framework.

Joint product family and supply chain design requires that a company creates a product family with a number of configuration possibilities [1]. Within a product family, we want to define BOM on each products of product family which elements of BOM are modules and components [5]. Within a supply chain we want to define suppliers, manufacturing plants and assembly plant [4]. Integration of them could be used by Systems engineering approach.

Systems engineering is an interdisciplinary field of engineering and engineering management that focuses on how to design and manage complex systems over their life cycles [7]. The need for systems engineering arose with the increase in complexity of products which have many components in BOM. The V-model of System Engineering is a term applied to a range of models, from a conceptual model designed to produce a simplified understanding of the complexity associated with systems development to detailed, rigorous development lifecycle of product. The V-model is a graphical representation of the systems development lifecycle. The V represents the sequence of steps in a project life cycle development. It describes the activities to be performed and the results that have to be produced during product development [6]. The left side of the "V" represents the decomposition of requirements, and creation of system specifications. The right side of the V represents integration of parts and their validation. The general V-model of system engineering are depicted in figure 1.

The V-model provides guidance for the planning and realization of products. The following objectives are intended to be achieved by using V-model for a complex product realization [6]:

- **Minimization of product realization risks**: The V-model improves project transparency and project control by specifying standardized approaches and describing the corresponding results and responsible roles. It permits an early recognition of planning deviations and risks and improves process management, thus reducing the project risk.

- **Improvement and guarantee of quality**: As a standardized process model, the V-Model ensures that the results to be provided are complete and have the desired quality. Defined interim results can be checked at an early stage. Uniform product contents will improve readability, understandability and verifiability.

- **Reduction of total cost over the entire product realization and system life cycle**: The effort for the development, production, operation and maintenance of a system can be calculated, estimated and controlled in a transparent manner by applying a standardized process model. The results obtained are uniform and easily retraced.

- **Improvement of communication between all stakeholders**: The standardized and uniform description of all relevant elements and terms is the basis for the mutual understanding between all stakeholders. Thus, the frictional loss between user, acquirer, supplier and developer is reduced.
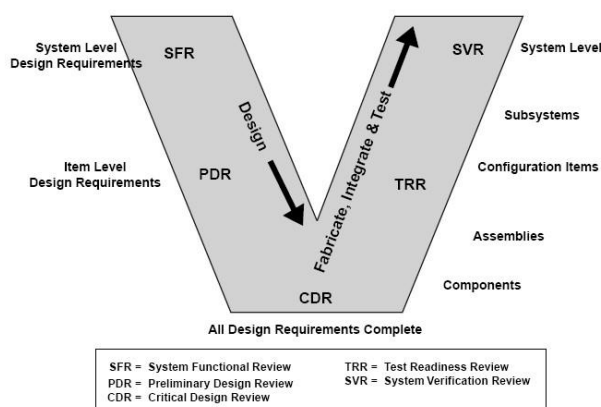


Figure 1-V-Model of System Engineering

In this paper we want to simultaneously configure product family and supply chain by a System Engineering of V-model.

## Problem Statement

In product family design, the challenge is to precisely define the BOM for each final product in the product family. This BOM must take into account the modules and components of each of the products. These modules and components may also make up other products in the family. An example of a BOM of product family is given in Fig.2.
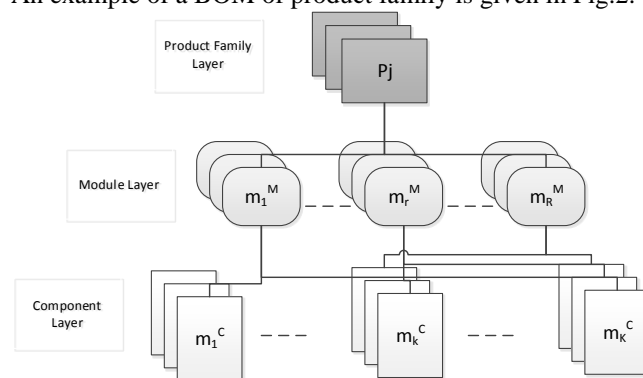


Figure 2-BOM of Product Family

A product family consists of product variants with the aim of satisfying specific market segments.

In Supply chain Configuration the aim is to configure a network of supply chain with minimum cost and time and maximum quality in each echelon. Supply chain echelon in this paper until the products are realized considered as: Suppliers, Manufacturing plants, Assembly plant and Distribution centers are sufficient. Structure of Supply chain for realizing the product family configuration are shown in figure. 3.
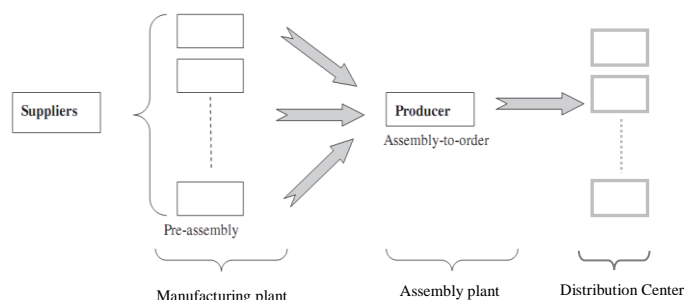


Figure 3-Supply Chain structure

The two problems of Product family configuration and supply chain configuration are fully investigated separately in previous research. But for Realizing a complex products such as aircraft, ships and floats is not easy in logistical consideration and could be consider like a big project. Therefor it is necessary to consider a supply chain network simultaneously in configuration of products. The V-model of System Engineering is an appropriate approach to simultaneously configure product family and supply chain together. If we want to adapt the general V-model of System Engineering, left side of the model is dedicated for product family configuration and right side of model is dedicated for Supply chain configuration. Each side of V-model have 4 steps that mapped one-to-one interrelation.

The 4 steps of left side are a top-down structure and are: in first step customer needs from markets and future demands of products are determined. In second step products of product family are defined to cover customers need. In third

step all of modules to be used in products, based on modularity configuration are listed and in last step components need for product family are listed. In the left side of V-model all of elements that need for realizing a product based on hierarchical breakdown structure are specified, these 4 steps are called Product family configuration.

There are 4 steps of right side of V-model likely in left side are stated that have down-top structure: in first step suppliers for supplying components are selected. In second steps for manufacturing module, the manufacturing plants are determined and in third steps an assembly plant is specified and in last step distribution centers to sell products are defined.

Verified V-model based on these descriptions are depicted in figure 4 and show the Interrelation of Product family configuration and supply chain configuration.
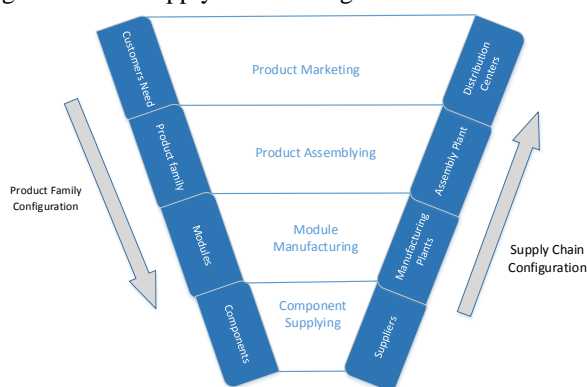


Figure 4-Verified V-model for Product family configuration and Supply chain Configuration

## Conclusion and Future study

This paper tackles the difficult problem of joint product family and supply chain design. The issue has been attracting an increasing amount of attention in recent years. However, most studies deal with a specific part of the problem, or they propose intractable models. The aim of this paper is to integrate product family into a supply chain design by an approach of System Engineering. Because of the nature of complex products in product family, just designing the product family are not effectiveness and need to simultaneously join Supply Chain in Product Family Configuration. The V-model of SE are an appropriate method to use for these complex products such as Aircraft.

The V-model with some verification are used to configure Simultaneous configuration.

For future study it is proposed to have detailed BOM of products and therefore having detailed in supply chain. In each of steps of verified V-model some tasks and interactions need to noted and reach a better results.

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