The whole idea is that we can take the bunch of different components and create a different instrument within weeks is kind of optimistic, but within a few months rather than in a few years.

(Director of Software Engineering, LeCroy)

CBD has its roots in manufacturing. The trend to develop products that have a Component-Based or modular architecture is well established in automotive, electronics, aircraft and other manufacturing types of industries.\(^1\) Since the mid-1960s, when the concept of modular production (Starr 1965) was introduced, modular (later referred to as component-based) product architectures became dominant in manufacturing industries.

In manufacturing, components (or modules)\(^2\) are defined as parts of an assembly, chunks that ‘implement one or a few functional elements in their entirety’ (Ulrich and Eppinger 2000).

A Component-Based system is a system that has two properties: (1) components, and (2) connections (interactions) between components that are well defined and are generally fundamental to the primary functions of the product (Ulrich and Eppinger 2000).

\(^1\)In manufacturing, a product is assembled from parts, as opposed to process industries, where a production process is based on mixing raw materials and/or chemical processes (e.g. chemical, pharmaceutical, food industries).

\(^2\)There is some confusion among practitioners as well as academics regarding the definition of a component and a module. Typically, components imply finer granularity than modules (a module could consist of a number of components). However, in practice and academic literature these two terms are often used interchangeably.
As opposed to a monolithic system, a CB system potentially has a number of advantages for production, and can increase the competitive advantage of a company in the market.

First, a CB system allows changes to be made to isolated functional elements of the product without affecting the design of other components (Ulrich and Eppinger 2000). Thus, changes in a product could be made fairly easily and quickly (as changes in different components could be done in parallel and without causing unwanted side-effects).

Second, from a marketing perspective, having a CB system enables easier customisation by facilitating different product configurations for different users and different markets (e.g. the same car model designed for different countries can be somewhat different), and increases product variety (the range of product models). In particular, a CB system architecture (structure) makes the integration of components easier, which is important for:

(i) upgrades (the possibility to replace a component, typically by a more recent version), as technological capabilities or users’ needs evolve;
(ii) add-ons (adding components by a third party) according to a user’s needs; and
(iii) flexibility in use, as some products can be configured by users to provide different capabilities (e.g. many cameras can be used with a different lens and flash options).

In each of these cases, a CB architecture allows a minimisation of the physical changes required to achieve a functional change (Ulrich and Eppinger 2000). In a CB system components could be integrated relatively easily either by a vendor or by an end user:

- **Vendor integration**: Dell is an example of a vendor that assembles computers from pre-defined components, according to the specific choice of a customer.
- **End-user integration**: Many products are sold by a manufacturer as a basic unit, to which users can add components, often produced by third parties, according to their specific needs. For instance, the computer is a basic unit to which third-party storage devices (e.g. CD-RW, memory key, zip drive) could be added according to customer needs and personal preferences.

Third, standardisation of components allows the use of the same component in multiple products, thus reducing time-to-market, and production costs (Ulrich and Eppinger 2000; Lau and Wang 2007). Time-to-market is shorter because reusing components saves the time required for design and quality assurance of these components. Production costs are lower, because fixed costs for setting up production lines and equip-