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# Adopting key lessons from agile manufacturing to agile software product development—A comparative study

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**Abstract**

Many industrial new product development (NPD) software projects apply nowadays agile methodologies. These methodologies, such as Scrum, eXtreme Programming (XP), and Feature-Driven Development (FDD) date back to 1990s, and the Agile Manifesto was declared in 2001. However, already before that the concept of agile manufacturing (AM) was discovered to describe a corporate ability for quick adaptation to changing requirements. There is surprising amount in common between these two fields. This raises a question of whether NPD software development companies could take even more overall advantage of those different agile approaches. This interdisciplinary paper explores the commonalities between the key concepts of AM and some of the most popular agile software methods, and consequently suggests potential new areas for software process improvement (SPI) in large-scale NPD organizations. An industrial case example illustrates how agility in embedded software product development can be enhanced by following typical NPD principles. We conclude that there is potential for further improvements in software product development industry in general by seeing agility as a wider, organization-oriented business concept following the AM/NPD learning. Current agile software process models cover only a subset of this space.


*Keywords:* Agile software process models; Software process improvement; Agile manufacturing; New product development; Agile enterprise

## 1. Introduction

Many new product development (NPD) companies operate nowadays in uncertain and dynamic competitive environments. There are many sources of turbulence, stemming from such factors as intensified global competition, reduction in lead-time and life expectancy of products, diversification of demand, and new technologies (Ismail et al., 2006).

The companies must nevertheless be able to compete in sustainable ways. In the early 1990s, the concept of agile manufacturing (AM) was devised to address those considerations (Goldman et al., 1995; Preiss, 2005). The key is to cope with irregular and unpredictable demand, unlike in traditional mass production.

Software production faces currently many similar problems and challenges. In software product development, agile principles were addressed mostly independently starting from the late 1990s. The Agile Manifesto was declared in 2001 (Agile Manifesto, 2001). Many lightweight software development process models and methodologies emerged (e.g., XP), in particular in response to the problems with the traditional software development models (Waterfall) faced in the new competitive environments.

Many of the AM principles are by nature general-purpose and technology-independent. Although software product development and software production have certain unique properties and profound differences compared to typical manufacturing operations, it is by and large not obvious how exactly the two fields are related, and how much cross-domain knowledge could be shared. That line of reasoning leads to the following specific questions to study in this paper:

1. How do key AM concepts and current agile software development models compare?

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2. What new manufacturing concepts could potentially be adopted to software production?

There is no one straightforward way to tackle such broad questions. This is further complicated by the fact that many of the concepts and terms lack rigorous and generally agreed definitions. This paper therefore approaches the questions by composing an extensive comparison table with multiple different viewpoints. Such an approach produces a composite answer showing that there are indeed many essential similarities, but also that the AM discipline addresses many larger-scale business and organizational areas much more extensively than the current agile software development models.

The rest of the paper is organized as follows. Section 2 explores the background and related work of AM research and agile software development. Section 3 develops the comparison matrix, and Section 4 analyzes it with inferences and insights (Question 1). Section 5 further illustrates the comparison points with an industrial product development case example. This is followed by concluding discussion and implications in Section 6 (Question 2). Finally, Section 7 summarizes the work with pointers to further research.

## 2. Agile manufacturing and agile software production

### 2.1. Agility in different disciplines

Agility is not unique to either manufacturing, neither NPD nor software development. The key driver with flexible manufacturing systems (FMS) and other related production means is that in many industries facing unpredictable changes in product demands and customer needs more adaptive operative capabilities are needed.

Following that line of strategic thinking, ultimately the entire value network of the company—including the NPD function with software development—can be viewed with respect to agility. Agility can then be addressed in different business competence areas, such as:

- business agility
- enterprise agility
- agile organization
- agile workforce
- IT agility
- agile manufacturing
- agile supply chains
- agile software development

Notably the concept of agility is currently not exactly or uniformly defined in all those fields. Although the general objective should be the same (sustainable profitable business), the different disciplines address it from different points of view and at different levels. They are also partially overlapping.

It is not obvious how exactly the different dimensions and levels of agility are related to each other. This is partially an open research question. In particular, it is not clear how much and under what specific circumstances they contribute as a system to the business success of a large NPD company.

### 2.2. Agile manufacturing

The principles of AM were discovered to address the needs of the new post-mass production competitive environments. It was no longer possible to achieve significant improvements by developing the old mode of operation, but a paradigm shift was necessary (Dove, 2004).

There is no one exact definition of AM. Table 1 shows some formulations presented in the related literature over the years.

Table 1 reflects the point, that in the widest sense AM is an integrated enterprise concept comprising not only the actual production (operations) planning and control, but also such areas as business interfaces, supply chains and workforce factors (Sanchez and Nagi, 2001; Yusuf and Adeleye, 2002; Vázquez-Bustelo and Avella, 2006). In particular (new) product design is then one part of it.

AM enterprises are first and foremost proficient at change (Kidd, 1997). This capability enables then the key facets of flexibility, responsiveness, and proaction. A flexible organization is able to respond to unpredictable changes in demand cost-effectively and in a timely fashion, while proaction creates future capabilities. A robust organization can accommodate even disruptive changes with no or little extra cost and adverse effects (e.g., lower quality). Agility is thus a fundamental characteristic of the company market interface (Katayama and Bennett, 1999).

The manufacturing strategy determines the overall mode of operation of a manufacturing company (Platts, 1999). An intelligent agile manufacturer shapes its strategy according to the competitive environment drivers. The strategic mode of operation choice could then be set along the ‘change proficiency’ and ‘speed to customers’ dimensions (Zhang and Sharifi, 2007).

Taking all this together, a truly AM company is capable not only of responding to changes reactively, but also creating actively further changes to the environment, and taking advantage of the new opportunities. Such capabilities are in general enabled by mutually enforcing flexible people, processes and technologies (Gunasekaran and Yusuf, 2002).

### 2.3. Agile software development

In general, the origins of the current agile software development models date back to late 1980s and early 1990s. They have stemmed from such concepts as Rapid Application Development (RAD), prototyping and evolutionary/risk-driven (Evo, Spiral) life-cycle models