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From toys to tools: The co-evolution of technological and entrepreneurial developments in the drone industry

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Abstract There is undoubtedly hype around drones and their applications for private and professional users. Based on a brief overview of the development of the drone industry in recent years, this article examines the co-evolution of drone technology and the entrepreneurial activity linked to it. Our results highlight the industry emergence described as concept validation, including product as well as market growth with different phases of technological meaning change. We argue that further steps are needed to develop drones from nice toys to professional tools—from photography and filming applications to inspection services and large cargo logistics. For innovation managers and entrepreneurs, we describe what triggers the emergence of a technology and attracts the needed actors to unleash its transformative potential. Our research is based on industry reports, news, and market studies as well as interviews with four industry actors.

1. Drone technology: A new opportunity?

Technological innovations open opportunities for new entrants to transform and recreate industries, creating disruption known as 'innovation shocks.' This term is used by Argyres, Bigelow, and Nickerson (2015, p. 219) "as the introduction by a firm of a new product that stimulates a substantial surge and acceleration in demand for that product—a surge that was generally unexpected by market participants." However, understanding and predicting the evolution of such emerging technologies is a challenge for new entrants as well as for incumbents (Dedehayir & Steinert, 2016). In any case, actors have to deal with it, prepared or not.

In recent years, hype has developed around drone technologies. The global drone market is estimated to grow from $2 billion in 2016 to nearly $127 billion in 2020 (Moskwa, 2016). The emerging drone technology promises to foster innovations

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that will disrupt existing industries. It is expected that drones will be part of our everyday life, just as smartphones are today; not a day goes by without a new product announcement introducing new ways drones can be used in different contexts.

We view drone technology as an example of an emergent technology that has had a long evolutionary path. Advances in artificial intelligence, image processing, and robotics have equipped drones with autonomous functions and have stepped up their transformative potential. Our analysis of drone startups provides the insight to illustrate the co-evolution between entrepreneurial activity and technological developments in the drone industry. We explore the intertwined relationship between technological components evolution and the emergence of new meanings and applications (Norman & Verganti, 2014).

We summarize our research findings in a model visualizing industry and technological emergence. The model describes the drivers for innovation and entrepreneurial activity in the initial moments of a new technological wave and, moreover, presents the indirect effects of entrepreneurial activity in a given emerging technology. We describe for innovation managers and entrepreneurs what events trigger the emergence of a technology and attract the needed actors to unleash its transformative potential.

The article is organized as follows. First, we give a brief overview of the development in the drone industries in recent years. Then, we describe the technological and entrepreneurial co-evolution in this sector, based on industry reports, news, and market studies as well as interviews with four actors in the drone industry. This finally leads to a discussion of entrepreneurial opportunities and an outlook on the coherence of industrial and technological evolutions.

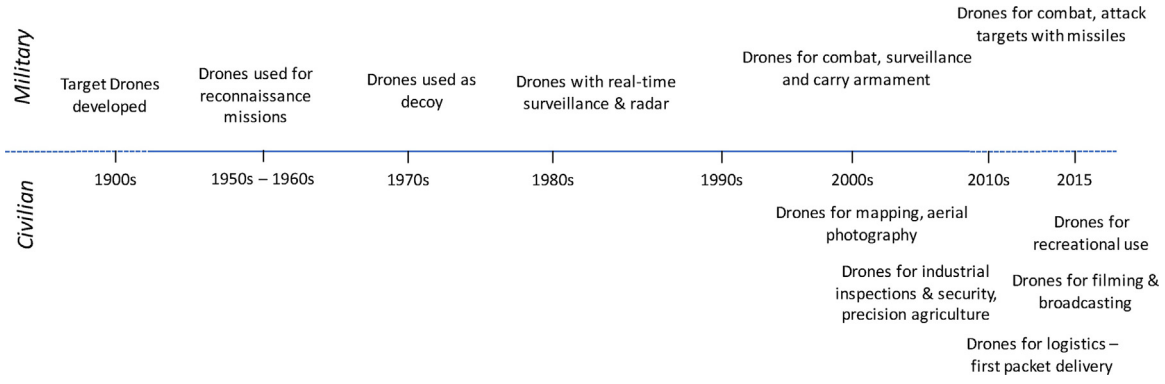
2. Roots of the hype: The emergence of the drone industry

Drones have made headlines quite often in recent years. In late 2016, Amazon's first drone delivery was highlighted to mark "a milestone in the race to use unmanned vehicles to transform how customers buy and receive goods" (Levin & Soper, 2016). But, in some cases, drones have made negative headlines (Forrest, 2015), either because they crashed in a notorious place (like the White House or a hot spring in Yellowstone National Park) or because they have been used in restricted spaces like airports or sports stadiums.

Although the actual notoriety is linked to the popularization of consumer drones, the technology behind this type of drone is an outcome of a complex evolutionary process. First, a clarifying note: the use of the term drone is to describe an unmanned aerial vehicle (UAV) with a certain degree of autonomy (Hazel & Aoude, 2015). As the term has been popularized, it is often assigned to almost any type of UAV, even those that require constant attention by the remote pilot, like radio-controlled planes; this is an important difference in the military context (Villasenor, 2012) and also when it comes to identifying existing regulations that have an impact on the drone industry.

Drones were first mentioned in the early 1900s when they were introduced as targets for military practice, mostly in the U.S. At that time, they had a rather limited autonomy, different from modern target drones. Using unmanned vehicles provided several advantages for military operations. They could be used to gather information on reconnaissance missions or other activities that involved a high risk. From that moment onward, the number of military uses has grown (see Figure 1). The introduction of new technologies has provided

Figure 1. Timeline of the military and civilian uses of drones



Source: Bumiller & Shanker (2011); Holland Michel & Gettinger (2016); Villasenor (2012)