Patents

A Method to Evaluate the Development of RPAS Technologies

By Dr Alexander Koldaev & Peter van Blyenburgh

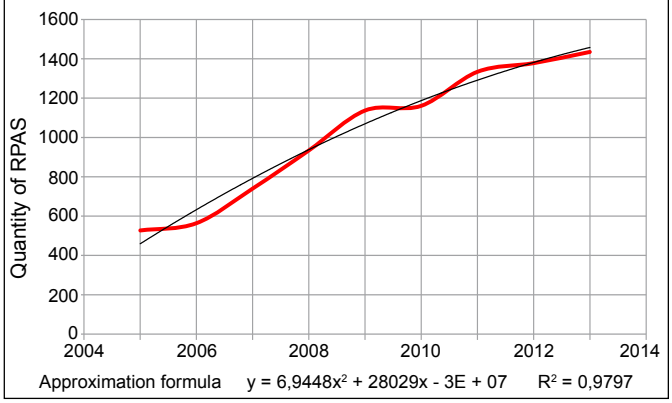
Over the last decade the rapid development of unmanned aircraft systems (UAS), or, according to ICAO terminology, remotely piloted aircraft systems (RPAS) has been observed. In accordance with the data published by UVS International, the total number of known RPAS has increased from 527 in 2005 to 1435 in 2013, nearly three times as much.

Figure 1 **Quantity of RPAS & Developers/Producers**

Year	RPAS	Developers/Producers
2005	527 (not incl. 17 heritage RPAS)	207
2006	564 (not incl. 39 heritage RPAS)	252
2007	740 (not incl. 40 heritage RPAS)	312
2008	934 (not incl. 40 heritage RPAS)	369
2009	1137 (not incl. 53 heritage RPAS)	422
2010	1161 (not incl. 83 heritage RPAS)	500
2011	1334 (not incl. 90 heritage RPAS)	511
2012	1378 (not incl. 203 heritage RPAS)	478
2013	1453 (not incl. 255 heritage RPAS)	519

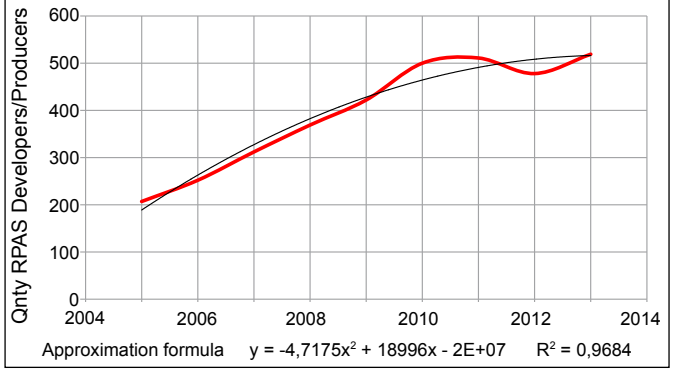
This steady growth is well described by a polynomial function.

Figure 2 **Evolution of RPAS Developed/Produced** (Using MS-Excel)
(Function – red line; Approximation – black line)



The number of RPAS developers/producers has increased during the same period of time from 207 to 519 (nearly two and half times as much). This function tends to saturation (see Figure 3).

Figure 3 **Quantity of RPAS Developers/Producers** (Using MS-Excel)
(Function – red line; Approximation – black line)



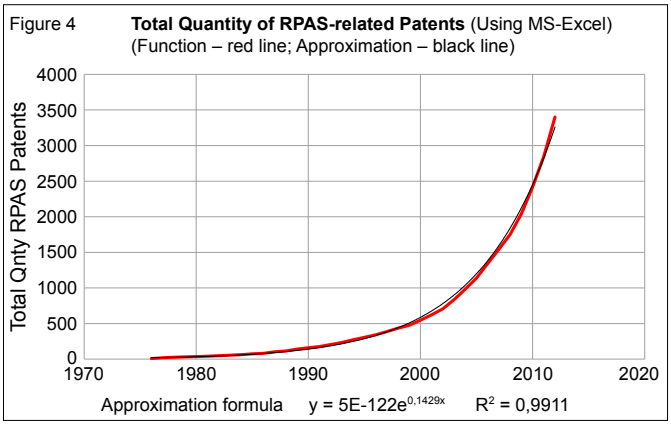
An extended patent search and scientific study on the development of RPAS technologies were conducted by Dr. Alexander Koldaev on the basis of available patent information.

The results were comprehensively analyzed and further developed into a practical application by Peter van Blyenburgh and are now offered as an informational service by Blyenburgh & Co, France (see www.uas-patents.org).

The United States Patent and Trademark Office (USPTO) was selected as the source of information. The USPTO database contains more than 8,400,000 patents (up to 25 March 2013). The USA is the world leader in the development of unmanned technologies with 373 RPAS or 25.99% of the world total number (according to the current UVS International data). That is why the American RPAS-related innovation and knowledge base registered with the USPTO is the biggest in the world.

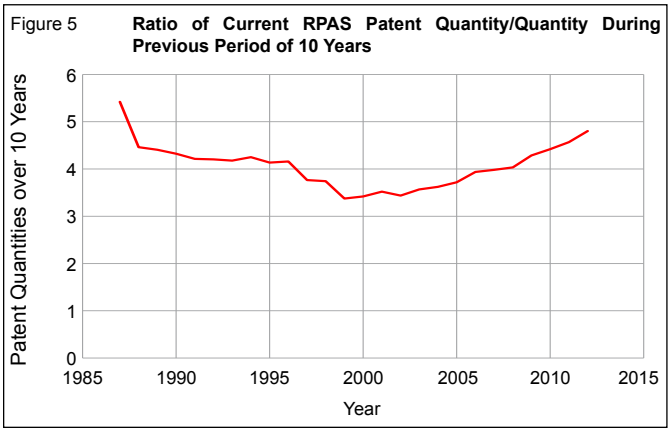
Among the 224,505 utility patents granted in the USA in 2011, foreign assignees accounted for 51.6 % and American assignees for 48.4 %. Consequently, the USPTO database was used to track global trends of technological development, including RPAS-related technologies. It was found that over 3500 patents related to RPAS had been granted by the USPTO during the last 37 years (up to 25 March 2013). The time series was constructed and studied by using mathematical statistics methods. The growth of the total RPAS patent quantity is an exponential function (see Fig. 4).

Figure 4 **Total Quantity of RPAS-related Patents** (Using MS-Excel)
(Function – red line; Approximation – black line)



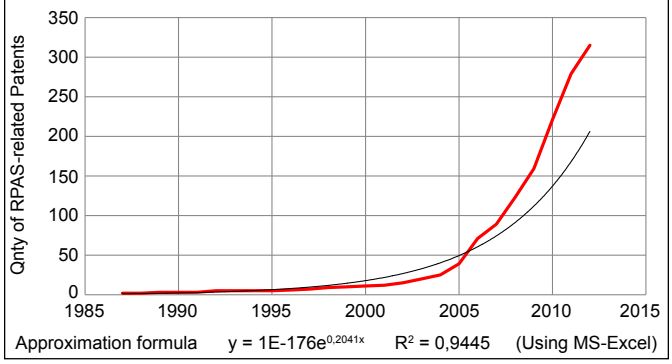
Steady exponential growth of the quantity of RPAS-related patents was discovered. Every 10 years the quantity of RPAS-related patents has increased approximately four-fold (see Fig. 5).

Figure 5 **Ratio of Current RPAS Patent Quantity/Quantity During Previous Period of 10 Years**



The identification of the innovation profile of technological leaders is also useful barometer. As an example, the Boeing Company is one of the world's leaders with 9043 patents, was granted 338 patents relevant to RPAS (up to 25 March 2013) (see Figure 6).

Figure 6 **Total Quantity RPAS-related Patents for the Boeing Company**
(Function – red line; Approximation – black line)



Approximation formula $y = 1E\text{-}176e^{0,2041x}$ $R^2 = 0,9445$ (Using MS-Excel)

A modern RPAS is a very complex system-of-systems. This specific RPAS characteristic is not reflected in the United States Patent Classification (USPC), nor in the International Patent Classification (IPC), nor in the Second USPTO Cooperative Patent Classification (CPC), a joint partnership between the USPTO and the European Patent Office (EPO); under the terms of this agreement, these two offices have agreed to harmonize their existing respective classification systems (European Classification (ECLA) and United States Patent Classification (USPC) and to migrate towards a common classification scheme. However, these classifications are not very useful in the field of RPAS-related patent search.

With the objective to analyse RPAS-related patents and their innovative technologies, a special classification was developed. It has a typical patent classification construction: class/sub-class/group/sub-group. A combination of different existing RPAS classifications was taken as a starting point. Then an extensive patent search was conducted on the basis of properly selected key words as search quiries. Each of all the found patents was carefully studied and classified, which required a high degree of understanding of RPAS at system and sub-system level. When there was no clear place in the classification for a specific patent, the classification was extended and supplemented with additional structural elements. By applying this methodology, the original RPAS classification scheme was significantly improved and harmonized with all existing RPAS data. The resulting new classification is based on the open architecture principle and it definitely can and should be further extended and improved, as new RPAS-related technologies appear.

All found patents were classified and sorted according to this new classification. As a result of this distribution, the patents selected in accordance with the defined RPAS-related sub-system technology areas (airframe, propulsion, launch and recovery systems, communications links, payloads, command, control and avionics systems, and others, including applications) were referenced, and a truly functional all-encompassing RPAS-related information database was established.

As an example, the following airframe-related sub-classes and the percentage of the patents in each sub-class are indicated:

01.	Airframes:	
01.01	Fixed wing & deployable wing	27,96 %
01.02	Rotary wing	16,29 %
01.03	Flexible wing	13,15 %
01.04	Hybrid wing (tilt-wing, etc.)	3,52 %
01.05	Scissor wing	5,74 %
01.06	Inflatable wing	7,04 %
01.07	Lighter-than-air	6, 11 %
01.08	Water surface take-off/landing	0,37 %
01.09	Tilt-rotor convertible	3,70 %
01.10	Flapping wings	0,93 %
01.11	Wing-in-ground effect	1,11 %
01.12	Stealth	1,67 %
01.13	Combined configuration	5,93 %
01.14	Projectile	4,44 %
01.15	Aerospace plane	1,85 %
01.16	Others	0,19 %
	Total	100,00 %

In terms of pace of innovative development relatively new RPAS technology categories, such as Command, Control & Avionics – Airborne (including Navigation, Collision Avoidance, Image Flow Recognition, and Artificial Intelligence), Communication Links, and Payloads (including Imaging Sensors, and Non-Imaging Sensors) prevail over traditional technologies such as Airframes and Propulsion.

The effectiveness of modern RPAS considerably depends on its payload(s), and this is confirmed by the large number of patents devoted to different types of payloads. The patent classification system elaborated has taken the following payload classes in consideration.

09.01	Imaging Sensors	09.02	Non-Imaging Sensors
09.01.01	Electro-optical	09.02.01	Signal intelligence
09.01.02	Infrared	09.02.02	Magnetic
09.01.03	Radar	09.02.03	Electric
09.01.04	Synthetic aperture radar	09.02.04	Acoustic
09.01.05	Lidar / Ladar	09.02.05	Meteorological
09.01.06	Laser	09.02.06	Bacteriological
09.01.07	Hyper-spectral	09.02.07	Chemical
09.01.08	Multi-sensor unit	09.02.08	Biological
09.01.09	Array of sensors	09.02.09	Radiological
09.01.10	Others	09.02.10	Multi-sensor unit
		09.02.11	Array of sensors
		09.02.12	Others

Some important practical conclusions came out from the conducted research. For example, a modern enterprise involved in RPAS development should have at least three engineers in the field of electronics, communications and computer technologies for each aeronautical engineer.

A dedicated web site (www.uas-patents.org) has been created with the objective to inform the international RPAS community and the world's specialists in the field of patent search. This web sites make it possible to evaluate the extent of the RPAS-related patent information that is now available, and to request a quotation for the purchase of access to the available patent data bases.

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