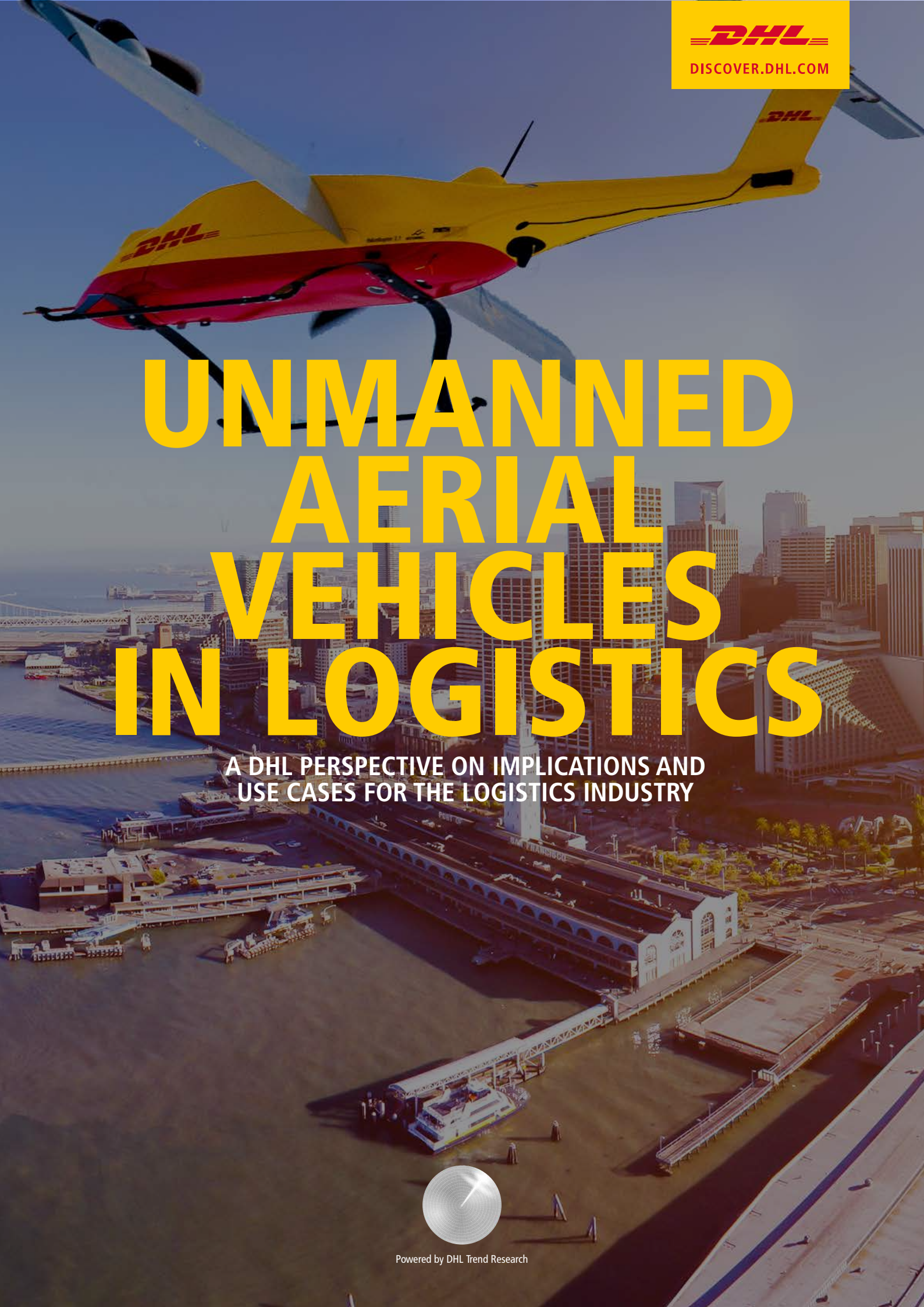

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UNMANNED AERIAL VEHICLES IN LOGISTICS

A DHL PERSPECTIVE ON IMPLICATIONS AND USE CASES FOR THE LOGISTICS INDUSTRY

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PREFACE

Flight of fancy or a fascinating new feature of modern living? Some doubt that our skies will ever be filled with pilot-less aerial devices. Others say that this future will be ours very soon. In different ways, both opinions are close to the truth.

This trend report takes a fully grounded look at the role of these devices in our near-future. It deals with current capabilities and circumstances, exploring the positive potential as well as the existing limitations of 'unmanned aerial vehicles' (UAVs), also known as drones – but this report deliberately avoids the name 'drones' as it has some profoundly negative connotations.

Today there is plenty of talk (and perhaps too much blue-sky thinking and hype) about civil applications for UAVs, but actual use cases are surprisingly thin on the ground.

Three impacts are at work here – technological capability, regulatory pressure, and public acceptance – and this report highlights the interplay between all three in current applications drawn from various sectors, including the logistics industry.

In exploring such an intriguing topic, this report is likely to raise issues and questions for many readers. Therefore DHL warmly invites you to visit the DHL Innovation Center in Germany which showcases proven UAV technologies. Please come and discuss your needs and joint development opportunities with us.

Yours sincerely,

Matthias Heutger

Dr. Markus Kückelhaus

1 UNDERSTANDING UAVs

Recent worldwide media attention has put unmanned aerial vehicles (UAVs) in the spotlight. Their many different applications make for great headlines – they are being used for military purposes in Pakistan (US Army), for development aid work in Africa (Matternet), and for parcel delivery in Germany (DHL Paket).

Some organizations are using UAVs specifically because of this high level of interest. Good examples are the world's largest online retailer, Amazon and the world´s largest logistics company DPDHL, which are testing UAV delivery. And countless start-ups have jumped on the bandwagon to gain publicity and boost sales (e.g., Zookal's stated intention to deliver textbooks via UAVs in Australia).[1]

However, for any emerging technology, it can be a double-edged sword to attract a lot of attention. There may be considerable benefits from all the limelight; for example, a new technology could stand more chance of receiving subsidies if considered 'of national importance'. But there is also the danger of creating false expectations – too much initial hype can leave people disillusioned and disappointed after the dust has settled – and there may be a public backlash against the perceived power of new technology to substantially influence and alter our everyday lives.

In addition to typical hype-cycle effects, there are two main drivers for the huge impact of UAVs:

1. The potential for actual disruption in specific industries (including security services, and in film and television) and

2. The emotional response to unmanned flying systems, caused largely by:

   a) Privacy concerns and the debate about how much technology should be included in our daily lives ("Do we want to crowd urban skies with UAVs capable of tracking and filming our daily routines?")
   b) Safety concerns

Perhaps the reality of UAV deployment is far less glamorous than the media hype suggests. The ideal mission for a UAV is described as one that is too "dull, dirty, and dangerous" for manned aircraft.

The purpose of this report is to provide an introduction to this exciting topic, present use cases from a broad variety of industries, and discuss potential applications in and for the logistics industry. We aim to review the hype and provide a realistic assessment of UAVs.

1.1 Scope

It is important to distinguish between military and non-military use of UAVs. Until recently, media coverage has focused mainly on military use, coining the term 'drone' and leaving many with negative attitudes towards this new technology. Michael Toscano, President of the Association for Unmanned Vehicle Systems International, is quoted in the Washington Times saying "The word [drone] instantly conjures up mental images of large predators firing missiles at hostile targets around the world".[2]

This report focuses solely on non-military applications. It is clear though, as with many other examples of technical development, that major advancements are likely to find their roots in military UAV usage and application.

In this report, we do not look into very long-distance (e.g., transatlantic) unmanned flight operations, because UAVs capable of performing these operations are likely to function in a comparable way to existing cargo airplanes (e.g., with horizontal take-off at airports). As such, they are not game-changing in the same way as are smaller UAVs designed to replace road delivery in megacities or overcome infrastructure challenges in Africa.

The scope of this report is also limited by timeframe. As technology and the regulatory environment are both subject to substantial change and development, the outlook in this report is restricted to the next ten years.

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[1] http://www.cnn.com/2013/10/18/tech/innovation/zookal-will-deliver-textbooks-using-drones/

[2] http://www.washingtontimes.com/news/2013/aug/14/drone-industry-journalists-dont-use-word-drones/

1.2 Regulation

The regulatory environment plays a crucial role in UAV adoption. Currently, there seems to be little common ground on designing effective rules across borders, let alone continents. Regulations vary widely from country to country. Major legislative changes could be realized over the coming years, particularly in the USA.
But regulators are constantly being criticized for moving too slowly on the matter. Mary Cummings, Director of the MIT Humans and Automation Laboratory, urges politicians to act in her Boston Globe article: "Congress needs to hold the FAA's feet to the fire before this technology takes flight and leaves the US commercial market behind."[3] She cites estimations of a USD 10bn yearly loss for the US economy caused by overly strict regulations.
But regulating bodies believe they have solid arguments for taking their time. Amazon's plans to use UAVs for deliveries have been grounded for the time being, with the FAA declaring that they will not allow UAVs to be used for delivering packages to people for a fee.[4] Three major reasons explain why UAV regulation is a delicate matter:

Congested Airspace

For now, most UAVs operate outside controlled or restricted airspace, and this minimizes interference with other airspace users. But if UAV operations are to become widespread in logistics and other industries, integration will be essential. UAVs will be operating in all types of airspace and sharing this with airplanes, helicopters, and other flying systems. Airspace is already overcrowded in many regions, especially around major cities, and air traffic control operations typically work near to maximum capability (see Figure 1). An out-of-control UAV is a massive threat, capable of bringing down an airplane with several hundred passengers on board.
In August 2013, an Alitalia pilot reported sighting a UAV as close as 200 feet to his plane during his final approach to JFK International Airport in New York, triggering investigations by the FBI and the FAA.[5]

Outside of extreme events and worst-case scenarios, it will still be a substantial challenge to regulate additional UAV traffic and integrate it into existing patterns.

Figure 1: Air traffic at 09:30 am in Western Europe; **Source:** Flightradar24

Inherent Risks

While trains, boats, and to a lesser extent cars follow restricted pathways, UAVs can move anywhere and everywhere. And because they are airborne, failure of a vital system (e.g., the engine or navigation system) could cause the UAV to fall from the sky at any time and place. However, the chance of a system crashing into pedestrians is highly unlikely, even with today's early UAV designs. In 2012, the US military drone safety record for the previous 12 months was better than for manned fighters and bombers.[6] Nevertheless, effective safety measures and operational procedures in case of engine failure or loss of navigation must be ensured, to guarantee previously defined safety levels that satisfy regulating authorities.

Public Concern

In addition to the tangible (and technically controllable) challenges of congested airspace and inherent risks, there is another, less-defined area of concern in the public domain. Regulators need to address the public's negative perception of UAVs – there is a general level of fear, and people seem to think UAVs pose some kind of threat.
A large part of this fear is probably related to privacy issues: Cameras and other sensors (potentially invisible) attached to the flying system could be used for constant surveillance of every step one takes.

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[3] http://www.bostonglobe.com/opinion/2013/12/08/drones-and-and/MgLXPHtr0nvWqwkltSORYM/story.html

[4] http://www.independent.co.uk/life-style/gadgets-and-tech/amazons-drone-delivery-grounded-by-the-faa-9561807.html

[5] http://www.wired.com/threatlevel/2013/03/ufo-black-drone-fbi/

[6] http://www.bostonglobe.com/opinion/2013/12/08/drones-and-and/MgLXPHtr0nvWqwkltSORYM/story.html

Plans by the national German railway company, Deutsche Bahn, to use UAVs with attached infrared cameras to reduce graffiti attacks on its property[7] evoked a strong response with blog entries such as "This is the worst of dystopian science-fiction coming true. […] This sets the precedent for more of the same throughout the world. And it's not going to stop at spying on Graffiti Sprayers."[8]

When talking about the regulatory environment and the adoption of new technologies, it is worth considering the 'Law of Disruption' model. This describes an interesting pattern of how fast different types of change manifest themselves, and the model is very applicable to the current UAV situation. Technological advancements are rushing ahead of social and political change. That is exactly what we see happening with UAVs today.

From a technological perspective, various use cases are already feasible, but many of these are not accepted yet by the public. Social change is occurring at a substantially slower pace than this technological progress, and the last domain to react and adapt is the political one (see Figure 2). Following this model, we might anticipate regulatory barriers for UAVs to remain in effect for some time.

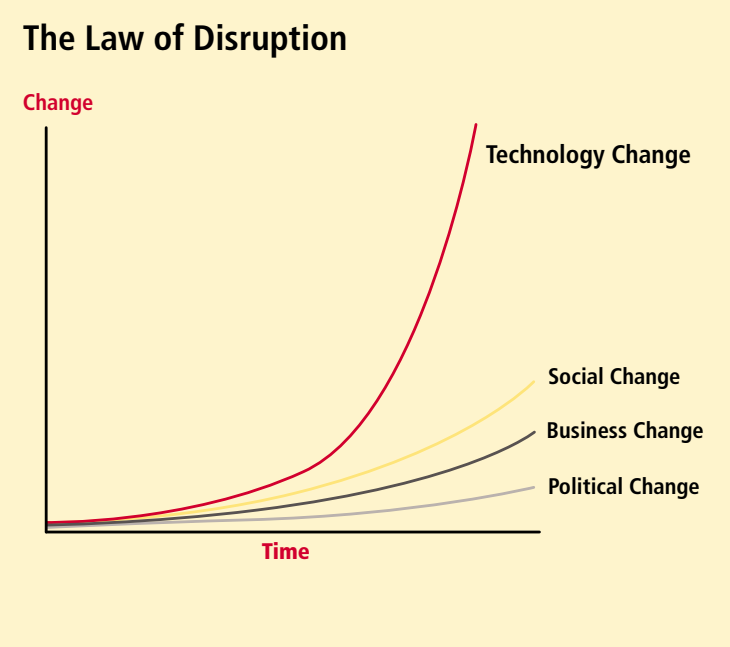


Figure 2: The Law of Disruption; **Source:** Larry Downes

[7] http://www.bbc.co.uk/news/world-europe-22678580

[8] http://www.abovetopsecret.com/forum/thread983050/pg1

1.3 Technology

The selection of available UAVs has greatly expanded over the last few years and it has become difficult to keep track of the entire range. The market offers diverse systems, and there is no universal classification. The US military uses a tier system with specific UAV requirements (e.g., they must offer particular levels of range or endurance).

In general, systems tend to be classified by measurements or specifications, which can relate not only to range and endurance but also to size, maximum take-off weight, service ceiling, and price. Other major distinctions are the build type and the engine used. The following table gives a brief overview of the advantages and disadvantages of different build types (see Figure 3).

Build Types

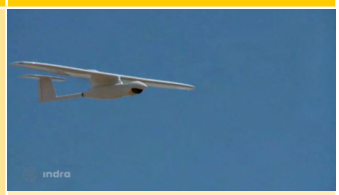
	Advantage	Disadvantage	Visual
Fixed-Wing	• Long range • Endurance	• Horizontal take-off, requiring substantial space (or support, e.g., catapult) • Inferior maneuverability compared to VTOL (Vertical Take-Off and Landing)	 **Source:** Indra Company
Tilt-Wing	• Combination of fixed-wing and VTOL advantages	• Technologically complex • Expensive	 **Source:** sUAS News
Unmanned Helicopter	• VTOL • Maneuverability • High payloads possible	• Expensive • Comparably high maintenance requirements	 **Source:** Swiss UAV
Multicopter	• Inexpensive • Easy to launch • Low weight	• Limited payloads • Susceptible to wind due to low weight	 **Source:** Microdrones

Figure 3: UAV build types

Figure 4: DHL-"Paketcopter"

The main types of engine used today in non-military UAVs are the electric engine and the internal-combustion engine. The electric engine is environmentally friendly and operates without much noise; these are important advantages especially in densely populated areas. It is relatively inexpensive to charge the battery, but battery weight is a drawback and UAV range can be limited by battery capacity.

Figure 5: Multicopter used for taking low altitude aerial photos; **Source:** Soliforum

A UAV powered by a comparable internal-combustion engine is likely to have superior range, due to the energy density advantages of fossil fuels and because range can be simply extended by adding fuel tanks. Hybrid systems are currently being developed, trying to combine the best of both worlds – the internal-combustion engine is used for longer distance flights, and the electric engine is used for take-off and landing in areas requiring quiet operation.

This report does not exclude any specific type, but its focus is rather on electrical engines and multicopters, because these appear to be the most promising choice for the logistics industry applications that are discussed in this report (see Figure 4 and 5). This reflects both cost and feasibility arguments: While long ranges and high payloads are technically feasible today, UAVs of this type tend to be expensive and may be a bad choice in densely populated environments such as cities, because of horizontal take-offs and noisy engines. This matters less outside urban areas, and in the following chapter we review the varied tasks being carried out by UAVs today.

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