Sky Limits

Delivery drones and air taxis in cities?

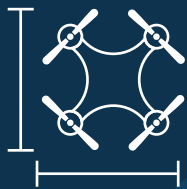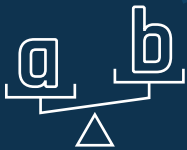Twelve research-based recommendations for handling future traffic in lower airspace

Summary

In 2019 and 2020, the science communication initiative *Wissenschaft im Dialog* (WiD) collaborated with Berlin's Technical University to carry out the *Sky Limits* project. The project, full title "The sky is the limit – future use of urban airspace", was funded by Germany's Federal Ministry of Education and Research (BMBF). Based on the results of research carried out in this project, the following twelve recommendations were formulated, as a plan of action for the possible integration of delivery drones and air taxis into urban airspace in Germany.

Es bedarf:

1. The debate about the use of drones for deliveries and individual transport must become more objective and more detailed.

2. The competing images of the future must be considered and negotiations must pay attention to these diverging images of the use of delivery drones and air taxis.

3. The debate must be widened out to take in society as a whole because drone flights are always *public*.

4. The inclusion of the population must be formalised, for example by convening citizens' assemblies.

5. It must be recognised that, at present, the population is not in favour of the introduction of delivery drones and air taxis to deliver consumer goods and transport people.

6. It must be appreciated that, currently, the implementation of drone technology is only acceptable in medical emergencies.

7. The real added value of delivery drones and air taxis must be made more plausible for the population and the development of the technology must be guided by the needs of the population.

8. Continuing in-depth technology assessment must be carried out on the potential use of delivery drones and air taxis.

9. A conceptual guiding principle must be agreed which embeds the use of delivery drones and air taxis within a paradigm of sustainable and integrated transport.

10. Policy-making must be proactive and promote the development of clear air traffic management rules *before* drone technology is introduced.

11. Local authorities must be alerted to the issue and equipped with greater structuring and management abilities for a potential introduction of delivery drones and air taxis.

12. A German drone charter must be drafted to ensure that the use of airspace by delivery drones and air taxis is guided by the common good.

1. Introduction

The potential use of unpiloted aerial vehicles (UAVs), usually simply called drones, is gaining ever more attention in discussions about the future of cities in general and city traffic in particular. The use of drones, which at first was exclusively military, has been considerably extended in recent years to include applications in civilian contexts (such as data collection, inspection, monitoring etc.). This spread is being driven by technical progress on batteries, telematics and materials and also by hopes of potential efficiency gains and cost reductions. It is currently leading to the creation of a new and fast-growing sector within industry and services.

Drones are already in use in many areas, such as agriculture, building and the energy sector, and are also used for safety-related tasks by authorities and organisations in many locations. However, their use for transport purposes is still at the beginning of its development. The most active proponents of the use of transport drones (manufacturers, transport service providers, e-commerce companies) emphasise the advantages to be gained from relief and redistribution of traffic and shortening of travel times, and also from the exploitation of new commercial areas in the transport and logistics market. In addition, they mention the positive environmental effects that are said to result from the entirely electric propulsion. The transport of small items weighing just a few kilogrammes is already occurring in a few places[1]. Research is currently being pushed ahead as a matter of urgency to develop certified solutions for individual transport in so-called air taxis, with German technology companies playing a major role. According to the stated aims of these companies[2] and the European Aviation Safety Agency EASA, it should be possible to use air taxis as soon as 2023. National policy-makers are also addressing the use of delivery drones and air taxis and are developing approaches to evaluation and regulation at a variety of levels, as can be seen in such initiatives as the German federal government's action plan "Unmanned Aircraft Systems and Innovative Aviation Strategies"[3].

These developments could mean that lower airspace develops into a third traffic level in the very near future. This would represent nothing less than a historic turning point in the public use of space. The momentousness and the social implications of this type of airspace usage are not entirely foreseeable today; it is likely that drones will develop into a new sparring arena for future transport policy.

The BMBF-funded *Sky Limits* project was initiated against this background. Employing approaches

---

[1] Matternet (2020). Matternet Launches Drone Delivery Operations at Labor Berlin in Germany (https://mttr.net/);
Merck Group (2020). Delivery drone helps internal logistics take flight (https://www.merckgroup.com/).

[2] Airbus (2018). „Blueprint: The roadmap for the safe integration of autonomous aircraft." (https://airbus.com).

[3] Bundesministerium für Verkehr und digitale Infrastruktur (2020). Unmanned Aircraft Systems and Innovative Aviation Strategies (https://www.bmvi.de).

from the disciplines of technology assessment and social science mobility research, the project set out to investigate the opportunities and risks of airspace usage by delivery drones and air taxis and to derive recommendations with regard to its future development. The central elements of the project, which was carried out by the Technical University of Berlin and *Wissenschaft im Dialog* (WiD), were:

- systematic appraisal of international research debates,

- analysis of active players and their constellations and prognoses,

- examination of the attitudes and acceptance of the German population and

- identification of potential areas of conflict relating to the potential use of drones and air taxis.

The present paper summarises the findings of the two-year *Sky Limits* project and presents twelve recommendations for action[4]. These have been developed on the basis of research evidence and can act as a guide for future political decision-making. They are primarily aimed at those involved in drawing up policy - particularly transport policy - at a national level in Germany but also address researchers and local community representatives.

When formulating these recommendations, our starting point was a phenomenon recognised in the sociology of technical development: while (new) technologies may offer promise of added value, they can also act as catalysts of social exclusion and generators of injustice. As a result, and in line with the standard understanding of technology assessment, the recommendations formulated here are aimed at a use of technology which is firmly directed **towards the common good.** Their goals were to achieve fair distribution of the benefits and costs of drone use and to counter exclusion effects; the form and extent of this use were seen not in terms of asserting individual interests but rather as the result of a public negotiation process.

To explain the rationale behind the twelve recommendations presented here, section 2.1 first summarises the central research findings of the *Sky Limits* project. Section 2.2 then presents the recommendations derived from these findings.

---

[4] The recommendations formulated here are based on our literature and stakeholder analyses, an attitude survey carried out with a representative sample of the German population, and the recommendations and results obtained in a co-creation workshop and a comic workshop. All results are available (in German) at www.skylimits.info.

2. Project results and recommendations for action

Sky Limits (January 2019 – December 2020), a two-year research project funded by BMBF as part of its Innovation and Technology Analysis initiative, consisted of three work phases. In the initial situation analysis phase of the project, we first assessed the current state of research. In parallel, we also built up a network of experts and analysed the positions of different stakeholders in potential future airspace use by carrying out ten expert interviews and one stakeholder workshop. We then assessed the attitude of the population to drone technology using both qualitative and quantitative research methods. In the final phase, dedicated to participation and synthesis, we brought together experts and citizens for a critical exchange of views and developed recommendations for real action by policy-makers, businesses and planners.

The next section (2.1) describes the methods and central findings of the three phases from which the recommendations presented in section 2.2 were derived.
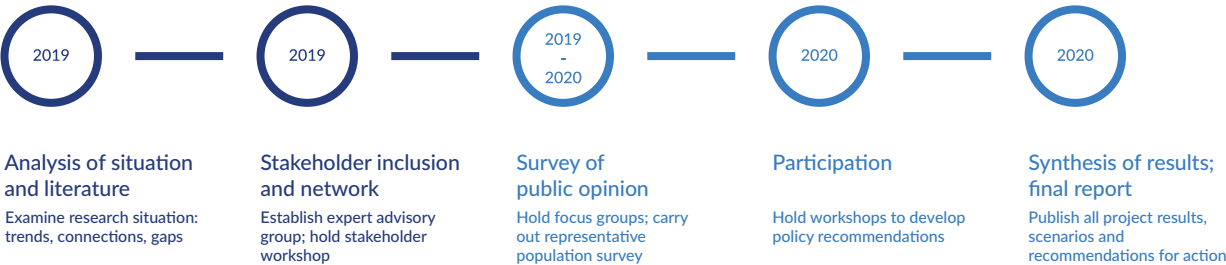
2019	2019	2019 – 2020	2020	2020
Analysis of situation and literature	**Stakeholder inclusion and network**	**Survey of public opinion**	**Participation**	**Synthesis of results; final report**
Examine research situation: trends, connections, gaps	Establish expert advisory group; hold stakeholder workshop	Hold focus groups; carry out representative population survey	Hold workshops to develop policy recommendations	Publish all project results, scenarios and recommendations for action

Figure: The phases of the *Sky Limits* project

2.1 Central project results

Literature analysis

A comprehensive analysis of the literature was carried out to assess the current international situation with regard to research on "drones for transport purposes". Using a systematic, software-supported procedure, we evaluated 111 publications on this topic that had been published between 2013 and 2019 by researchers, government bodies and players from commerce and civil society.

The central results of the evaluation are:

- The uses envisaged for delivery drones and air taxis are strongly commercially-motivated and face wide-ranging awareness of potential legal, ethical and safety-related problems.

- The solutions invoked to mitigate the potential individual and societal risks of using these technologies tend to be legal and technical.

- The greatest barriers to the introduction of drone technology are generally seen as being the lack of a legal framework and the fact that the technology is not yet fully developed.

The publications investigated – especially the more recent ones – nevertheless give increasing consideration to practical questions of social acceptance, environmental consequences and sustainability and also to the (town-) planning and infrastructure requirements of potential transport drone use. It is striking that, especially in relation to the social added value of the technology, the postulated value is often described only in abstract, general statements that have not yet undergone adequate objective verification or been considered in detail. There is a particular lack of knowledge with regard to the traffic- and environment-related effects of the use of delivery drones and air taxis compared to alternative forms of transport.

Stakeholder analysis

In our stakeholder analysis, we identified and categorised the central German stakeholders in urban airspace use by delivery drones and air taxis, entering their locations on a stakeholder map. The data were obtained primarily from ten comprehensive expert interviews with members of the project's expert advisory group and also from the results of a stakeholder workshop with a broad spectrum of participants representing research, commerce, politics and civil society organisations. It became apparent that formalised cooperation between specific key players in urban airspace use in Germany is currently very limited and is confined to a small number of regional development clusters. Indeed, analysis of the perspectives and positions held by the stakeholder groups investigated in this project showed that their visions sometimes diverged strongly where usage scenarios for delivery drones and air taxis were concerned and sometimes conflicted with each other. It must be emphasised that awareness of problems with regard to the technology does exist, especially among the players from civil society. Until now, though, there has been little in-depth debate about drones and almost no visible networking.

Attitude research

The attitude of the population to delivery drones and air taxis was investigated using a two-stage sequential mixed methods design. We convened five focus groups in Berlin (2), Stuttgart (2) and Erfurt (1) during September and October 2019, enabling us to gain qualitative insights into the positions of the public with regard to drone technology. The results of the focus groups showed that the participants held attitudes towards delivery drones and air taxis that were distinct, multi-layered and complex. Total rejection and unconditional agreement were only rarely expressed. Instead, it was apparent that participants saw a variety of criteria as being relevant; some were object-related (safety, usefulness, effects on quality of life, sustainability), some were subject-related (interest in technology) and some were context-related (such as the integration of

Sky Limits

technology into policy or transport systems). These criteria exert an influence on whether, and to what extent, people favour the use of delivery drones and air taxis.

On the basis of the qualitative findings of the focus groups, a quantitative telephone survey was then carried out between 20 and 29 January 2020. We surveyed a representative sample of the population made up of 1,000 respondents in order to systematically investigate the level of acceptance of delivery drones and air taxis in the German population. The data obtained provide the most extensive insights currently available into the attitudes of the population towards delivery drones and air taxis.

The evaluation of the survey makes it clear that a majority of the population holds a sceptical attitude towards delivery drones and air taxis. Most respondents were not in favour of the introduction of this technology. Only 25 per cent of respondents were in agreement with the use of delivery drones to deliver consumer goods and products. Only about one in five respondents (21 per cent) was in agreement with the use of air taxis for general transportation of people. In contrast with the generally negative attitude towards general use, however, the great majority

"I think it's amazing that there are no pilots any more. I'm not sure if I'd be prepared to put myself at the mercy of the technology like that" [Berlin].

was in favour of the use of delivery drones (63 per cent) and air taxis (65 per cent) in medical emergencies.

The readiness of individuals themselves to make use of the technology was also low. Only 21 per cent of respondents agreed with the statement that they would use delivery drones for the delivery of consumer goods and products. Only 18 per cent were able to imagine using air taxis for personal transportation. However, a majority once again accepted the use of drones in medical emergencies. 60 per cent of respondents agreed that they would use delivery drones within the context of a clearly defined medical emergency. More than half (57 per cent) of the respondents could imagine themselves using air taxis in a medical emergency.

Personally, I would generally use drones for the delivery of consumer goods.

| 13 | 8 | 11 | 22 | 46 |

Personally, I would generally use air taxis for my individual mobility.

| 11 | 7 | 10 | 20 | 52 |

Personally, I would use drones in emergencies only e.g. for the fast delivery of medicines.

| 38 | 22 | 12 | 10 | 18 |

Personally, I would use air taxis in emergencies only e.g. for fast transport to hospital.

| 34 | 23 | 13 | 12 | 19 |

● strongly agree ● somewhat agree ● neither agree nor disagree
● somewhat disagree ● strongly disagree

Figure: Personal intentions to use delivery drones and air taxis. *Wissenschaft im Dialog*/TU Berlin/forsa | Survey period: 20-29 January 2020 | Based on 1,000 respondents | Results in per cent, differences can occur due to rounding

Sky Limits

"I'd find it practical and innovative, it's kind of exciting, I'd like to try it out" [Stuttgart].

A number of factors were crucial to the generally negative attitude of the respondents to drone technology. These factors had already shown themselves to be central in the focus groups. Statistical analysis revealed a significant positive effect of the respondents' expectations with regard to usefulness, safety and improvement in quality of life on their acceptance of drone technology. Two thirds of the respondents could not see any individual added value in drone technology. At the same time, there was a very high level of doubt among respondents as to the safety of delivery drones and air taxis in public areas.

The respondents also expressed somewhat critical views and the majority assumed that delivery drones and air taxis would have a negative effect on the quality of life in cities. Furthermore, a majority of respondents doubted that the technology would be environmentally friendly. At the same time, though, a majority (over three quarters of respondents) expressed a very clear wish that it should be. The reliability of the technology was also more important to respondents than delivery or transport to a place or at a time of their choice and more important than flexibility or speed. The potential noise and stress and the limited view of the sky were seen as particularly bad.

It also became clear that there is a wish on the part of the public for regulatory changes regarding the use and implementation of delivery drones and air taxis in airspace. As a result, definite action by policy-makers is felt to be necessary.

Participation

We held two one-day workshops in order to gain insights into the perceptions held by different stakeholder groups about the opportunities and risks of delivery drones and air taxis, and to ensure the inclusion of different societal groups in the future organisational process. A comic workshop for children and young people was held in August 2020 at which the participants imagined what city life with drones might be like and expressed these ideas in picture form. The narratives of the children and young

Parcel deliveries with drones would not have added value for me personally.

strongly agree	somewhat agree	neither agree nor disagree	somewhat disagree	strongly disagree	don't know / no answer
50	16	10	11	13	1

Passenger transport with air taxis would not have added value for me personally.

| 50 | 16 | 10 | 12 | 12 | 1 |

I think parcel deliveries with drones would be safe.

| 10 | 13 | 23 | 24 | 30 | 2 |

I think passenger transport with air taxis would be safe.

| 8 | 16 | 22 | 25 | 28 | 1 |

● strongly agree ● somewhat agree ● neither agree nor disagree
● somewhat disagree ● strongly disagree ● don't know / no answer

Figure: Personal added value in everyday life and safety of delivery drones and air taxis. *Wissenschaft im Dialog*/TU Berlin/forsa | Survey period: 20-29 January 2020 | Based on 1,000 respondents | Results in per cent, differences can occur due to rounding

people demonstrated ambivalence, with a general openness towards the potential uses of drone technology on one side and scepticism towards safety aspects and social effects on the other. The drawings produced by the young participants revealed a high level of reflection about the potential consequences of the technology for society as a whole which often led to a call for political involvement and negotiation.

In the second workshop – a co-creation workshop held in October 2020 – 20 participants, who included both citizens and experts from research, commerce and civil society organisations, discussed the future use of delivery drones and air taxis in urban airspace. The participants compiled a list of 20 recommendations and issues requiring consideration with regard to this topic. The list included a request that legal responsibilities be defined in the near future - especially those falling to local authorities as the bodies representing the legitimate interests of city populations - and a plea that the social costs and individual added value of the use of city airspace be distributed fairly. The need for continuing technology assessment was expressed, ensuring that particular attention be given to the costs and benefits of delivery drones and air taxis in environmental terms.

The participation phase of the project made it clear that there are, at present, insufficient ways for the general public to be involved and thus insufficient opportunities for negotiation between those with differing interests. It also became apparent that the participants tackled the topic not only with great interest but also with an immensely rich fund of ideas and clear individual positions. Overall, it became clear that citizen participation holds enormous potential for reflection, consideration and involvement and that there is both a desire and a demand for greater involvement of the public in shaping airspace use.

Legal assessment

The relevance of this final report for policy and planning is underlined by a legal assessment commissioned in November 2020. It was carried out, and has now been published, by the mobility law research unit at Braunschweig Technical University. This assessment investigated the legal options available at a local level to regulate the potential use of drones. Opportunities for local players to exert an influence are mainly to be found in national air traffic law. However, these opportunities are largely restricted to safety-related aspects and so far do not permit any active structuring or integration of drone traffic in local situations. The assessment nevertheless supports the assumption that, in future, the effects of drone traffic could form grounds for demands on local authorities as specified in Article 28 (2) of Germany's constitution.

2.2 Recommendations for action

The project's findings in relation to the potential use of delivery drones and air taxis in urban airspace enabled us to formulate and justify a set of recommendations for action by policy-makers, commercial players and planners. In the opinion of the *Sky Limits* project, these recommendations should be followed so that the use of airspace as a third traffic level can be developed for the common good.
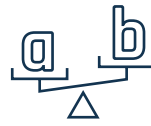
1

The debate about the use of drones for deliveries and individual transport must become more objective and more detailed.

Our analysis of the literature and stakeholders showed that future visions of the use of delivery drones and air taxis are often accompanied by generalised narratives about positive effects on traffic and the environment. Such narratives are used by commercial players in particular. However, they are not yet supported by adequate objective evidence. Thus, claims that air taxis will shorten journey times are often based purely on the flight time while claims that delivery drones will have positive environmental effects are often based solely on the fact that they are electrically powered. The necessary infrastructure as a whole is not factored in. Up to now, the additional infrastructure essential for delivery and individual transport has not received adequate attention and drone technology has not yet been subjected to an overall energy audit. There is therefore a need for a more objective, fact-based debate. This will only be possible once the claims of social added value have been subjected to scientific scrutiny. An objective assessment of the potential of drone technology, with more detailed treatment of its different specific applications, can only be made on the basis of confirmed facts. As well as in-depth research studies in the form of complex modelling and comparative eco-audits, there is also a need for political decision-makers to openly turn their backs on simplified usage scenarios like the ones suggested by some e-commerce and mobility companies.

2

The competing images of the future must be considered and negotiations must pay attention to these diverging images of the use of delivery drones and air taxis.

As our stakeholder analysis showed, there are currently a great many competing images of the future with regard to the type and extent of usage of lower airspace. Private commercial players, in particular, are actively striving for the most generous and unlimited use of delivery drones and air taxis that can be achieved within the bounds of the technically and commercially possible. It is apparent that these aims are at odds with the positions of other stakeholder groups, especially those involved in city development and mobility research. These stakeholder groups, unlike private commercial players, explicitly link their assessment of the technology to the function of drones as public transport entities; they require drones to serve the common good, to be sustainable and to be aligned with the needs and interests of society. When incorporating the different positions into the current discourse, therefore, it is necessary to consider the pre-existing conflicts between their different goals and images of the future. In this way, possible overlap between the interests can also be identified and negotiated for future development corridors.

3

The debate must be widened out to take in society as a whole because drone flights are always *public*.

The project's stakeholder analysis made it clear that players from different areas of delivery drone and air taxi development are networking and cooperating to an increasing extent. Up to now, though, there has been no inclusion of civil society organisations or the general public in this process. If delivery drones and air taxis are used in urban – and thus *public* – airspace, the advantages and potential of the technology and the results and risks of its use become subjects of *public* controversy. A meaningful and

target-oriented discussion is only possible when all the groups affected by the use of such technologies are included. The debate must therefore be opened up. It cannot be allowed to include only the viewpoints of commercial and scientific players and representatives of organisations; instead it needs to be raised to a new level and include society as a whole. This process needs to focus on the cautious and critical public position revealed in our attitude research and to discuss it in an inclusive way. Open questions about potential safety risks and the real usefulness of the technology for the community must also be considered and so must ethical misgivings.

4

The inclusion of the population must be formalised, for example by convening citizens' assemblies.

As shown by research on the acceptance of technology, the attitude of the public with all their doubts and objections will play a crucial role in the success or failure of the integration of delivery drones and air taxis into the city traffic of the future. Active inclusion of the public will allow comprehensive and substantive debate about the use of urban airspace. This debate is important, firstly to provide a sure and informed footing on which the public can base its attitudes and secondly to enable these attitudes to be taken into account. An additional factor to bear in mind is that the negotiation process can also lead to a basic denial of access to airspace. As this project has shown in its attitude research and participatory formats, citizens have clear ideas and positions on this subject and would like to be involved. Young people, in particular, tend in principle to be open to this technology and its potential. At the same time, they are also able to consider it critically and conceive of potential solutions. In future, therefore, space can and must be created for regular and continuous discussion using established formats that are dialogue-based and solution-oriented. This will provide a forum in which fears and scepticism, but also freedoms and limitations, are discussed and taken seriously. A formalised structure

should be established for these discussions – citizens' assemblies or facilitated workshops, for example.

5

It must be recognised that, at present, the population is not in favour of the introduction of delivery drones and air taxis to deliver consumer goods and transport people.

For delivery drones and air taxis to be successfully implemented and fulfil hopes of added value and relief of road congestion, the public must accept them. However, the data gathered in the project's attitude research indicate that a majority of the German population is currently not in favour of the introduction of delivery drones and air taxis and would not personally use this technology. The critical factors leading a majority of people to reach these decisions were doubts with regard to safety, the lack of everyday usefulness and the low level of expectation of improved quality of life. Compared to earlier attitude surveys, the data gathered in this project also suggest that general acceptance is declining. The largely negative attitude of the public to the use of delivery drones and air taxis offers no support for the directions currently being taken by transport and sponsorship policy. Indeed, the two are diametrically opposed to each other.

6

It must be appreciated that, currently, the implementation of drone technology is only acceptable in medical emergencies.

By contrast with the prevailing sceptical and negative position on delivery drones and air taxis, our attitude research showed that a majority accepted, and even favoured, their use exclusively in medical emergencies. This means the use of drones in medical emergencies currently offers the greatest amount of overlap between the numerous political and industrial efforts on the one hand and the uses that are acceptable to the public on the other. Thus, were the technology to be implemented in accordance with its potential

to achieve acceptance, it would be promoted and politically facilitated only for use in medical emergencies. Considering the risks and the various possible disadvantages of drone technology, however, the narrow usage corridor "medical emergencies" needs to be defined in terms that are precise and politically binding so that it can be distinguished from non-essential uses.

7

The real added value of delivery drones and air taxis must be made more plausible for the population and the development of the technology must be guided by the needs of the population.

As the project showed, the promises made for the use of drone technology are often generalised and abstract. Facing them on the other side are numerous pragmatic questions, a basically sceptical stance among members of the public and highly-developed risk awareness with regard to the safety and negative implications of the technology. The project's literature survey and attitude research suggest that the added value of the technology is largely vague because societal needs are only marginally met and the added value is not individually relevant. To ensure that public airspace is developed sensitively for the common good, with a high level of acceptability, it will therefore be necessary to align future technological development more closely with public needs and expectations.

8

Continuing in-depth technology assessment must be carried out on the potential use of delivery drones and air taxis.

As the literature survey in this project shows, the debate about delivery drones and air taxis has so far been dominated by technical, economic and regulatory considerations. However, the potential of delivery drones and air taxis to serve the common good has not yet been adequately investigated. This finding is particularly relevant in respect of the potential negative effects such as

noise, stress and the risk of accidents. Because of the intrinsically public and highly mobile nature of the technology, these aspects would be highly intrusive for the general population. Bearing in mind that usage scenarios are becoming ever more realistic, therefore, continuous technology assessment must be carried out to investigate and temper the potential for social conflict. Even though only one tightly-defined application of delivery drones and air taxis was found to be acceptable to a majority, namely their use in medical emergencies, it is especially important that the development of this usage be monitored with regard to its potential social, economic and ecological effects. Within, and because of, the highly dynamic development of this sector, technology assessment must also extend beyond this one specific application; it needs to highlight potential knock-on effects and to be able to offer reliable guidance to political decision-makers.

9

A conceptual guiding principle must be agreed which embeds the use of delivery drones and air taxis within a paradigm of sustainable and integrated transport.

The systematic literature analysis and the evaluation of expert interviews make it clear that traffic in the form of delivery drones and air taxis is clearly to be seen as part of the overall traffic volume. As such, it is subject to additional evaluation targets, especially those relating to carbon emissions and mobility issues. In the context of achieving carbon-neutral transport, this means that delivery drones and air taxis (just like all other forms of transport) are to be seen within a sustainable transport paradigm. Furthermore, in the interests of developing an integrative and inclusive transport system, we need to be aware that delivery drones and air taxis cannot be allowed to aid the development of a new and exclusive elite mobility system. Instead, the drone fleet as a whole should follow the conceptual guiding principle of developing drones into a form of transport that is *a priori* sustainable and socially inclusive. This will make it possible to avoid creating a new form of transport that later has to be altered to fit in with changing social conditions.

10

Policy-making must be proactive and promote the development of clear air traffic management rules *before* drone technology is introduced.

The results of our attitude research show that the public sees policy-makers as having a duty to take action and develop clear regulations for potential air traffic in lower airspace so that the negative consequences of the technology, such as noise, stress and a limited view, are prevented as effectively as possible. The necessity for clear regulation is perceived not only by the public but also, as our literature and stakeholder analyses made plain, by commercial players. On the basis of these commonly held expectations, it is clear that the central players in the development of airspace into a third traffic level are not the companies developing the technology but rather the protagonists responsible for shaping policy. Policy-makers bear the crucial responsibility for controlling the process and must reconcile all the different conflicting, diverging and decentralised social interests in any potential development of airspace while proactively promoting air traffic management. Although delivery drones and air taxis appear primarily as technical objects, establishing the framework for their use is first and foremost a domain for governmental and political activity.

11

Local authorities must be alerted to the issue and equipped with greater structuring and management abilities for the potential introduction of delivery drones and air taxis

If lower airspace is used as a new traffic level, local authorities will become key players. As is apparent from our stakeholder analysis and participatory events, however, awareness of the issues and implications at a local level is at present only patchy. Furthermore, the legal assessment commissioned as part of this project shows that there is currently almost no latitude for local authorities to influence development and ensure that new drone-based transport services are integrated into urban space. This also makes it more difficult to reconcile commercial, ecological and social interests when implementing the technology. In a future-oriented planning process, therefore, a framework needs to be created to encourage communication between federal, state and local authorities. This will enable them to discuss the potential responsibilities with regard to lower airspace use and establish practical ways in which local communities can take part.

12

A German drone charter must be drafted to ensure that the use of airspace by delivery drones and air taxis is guided by the common good.

With the federal government's action plan for "Unpiloted aircraft systems and innovative air transport concepts", Germany declares its intention to develop delivery drones and air taxis into regular forms of transport. Looking at all the phases of our project, it is apparent that many groups of players are working with different visions and different knowledge bases towards the fulfilment of different goals. At the same time, however, little attention is given to evaluating the technology as a whole with regard to its central aspects and long-term outlook. On the basis of the recommendations listed above, and taking into consideration the political developments during the project, there is therefore a need for further work to elaborate on the existing action plan. It should offer clear guidance, defining the long-term framework for the use of these technologies in more precise terms and including definite agreements and control mechanisms. Goals should be established in binding statements and actual measures should be formulated. A *Charter for airspace usage by delivery drones and air taxis for the common good* should be drawn up in Germany with the participation of all the political institutions and stakeholders involved and also the general public. This process must focus on finding out how the use of airspace by delivery drones and air taxis can support the development of sustainable city communities for the common good.

3. Summary and outlook

Drone technology has made immense progress. In combination with the current efforts being made by manufacturers and politicians, this progress now holds out the prospect that lower airspace could develop into a third traffic level in just a few years. This would represent a historic turning point in the use of public space. The use of lower airspace promises the realisation of a great deal of commercial and social potential; it also plays into humanity's ancient dream of flying, bringing this dream within reach once again.

At the same time, however, technological progress and implementation plans confront society with problems. Because of its lack of prior experience, society risks being unable to fully gauge the possible social, economic and ecological consequences of the widespread use of delivery drones and air taxis. It is therefore all the more necessary to place the commercially and politically desired use of airspace at the service of forward-looking and responsible action on technology and transport policy. The urgency is increased by the fact that delivery drones and air taxis, unlike other technological innovations, operate primarily in public and are thus highly visible and particularly intrusive.

Against this background, the task of the ministry-funded *Sky Limits* research project was to gather information by means of (social science) research and, on the basis of this information, to make recommendations for action to develop the use of airspace for the common good. These recommendations are intended to offer guidance in debates and decisions on this subject. In terms of their content, the twelve recommendations listed here call for a more fact-related and objective debate. In *practical* terms, they call for drone use to be limited to medical emergencies. And in *political* terms, they call for political responsibility

for overall control to be tackled centrally. The political dimension must take the form of greater involvement of the general public and local players in the evaluation of the technology, which should itself be carried out with respect to social and ecological sustainability goals.

Drones as a topic are characterised – quite rightly – as being highly dynamic and innovative; the speed of progress makes it difficult to develop a basis for political decision-making. The recommendations listed here are therefore intended to provide a framework that will allow the potential of the technology to be made usable. This framework should also enable the use of drones to be made acceptable and to be developed with attention to wide-reaching social policy goals. Irrespective of these considerations, a further option still remains – that of simply denying access to airspace for delivery drones and air taxis. Because drones fly in low-altitude urban airspace, and thus always in public space, their use must be clarified in public debate. The population must be guaranteed a say in structuring the technology and making it usable – even if its use is then limited as a result.

The recommendations formulated here are intended to open up and encourage discussions on the usage of lower airspace as a traffic level in ways that serve the common good. In this context, there is a need for binding general principles (a charter) regarding airspace usage in Germany. The *Sky Limits* project has identified numerous different guiding principles, players, potential measures and gaps in the research and has found viewpoints that have not yet been considered. All these strands must now be actively brought together and developed further. This is the only way to ensure that drones – a new, disruptive technology – will be used for the common good.

Project publications available in English

Traffic solution or technical hype? Representative population survey on delivery drones and air taxis in Germany
Dannenberger, Schmid-Loertzer, Fischer, Schwarzbach, Kellermann, Biehle
(https://skylimits.info/ergebnisbericht-umfrage/).

Drones for parcel and passenger transportation: A literature review. In Transportation Research Interdisciplinary Perspectives (TRIP) (4/2020).
Kellermann, Biehle, Fischer
(https://doi.org/10.1016/j.trip.2019.100088).

Drones for parcel and passenger transport: A qualitative exploration of public acceptance. (Sociology & Technoscience) (Vol 10 No 2).
Kellermann, Fischer
(http://uvadoc.uva.es/handle/10324/44871).