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New Horizons in Emergency Medicine

Taking off with drone-driven infrastructure 2.0 for modern healthcare

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Abbreviations	
AED	Automated external defibrillator
CPR	Cardiopulmonary resuscitation
eVTOL	Electric vertical take-off and landing (vehicle)
HEMS	Helicopter emergency medical service
KPI	Key performance indicator
NEF	"Notarzteinsatzfahrzeug" (emergency medical services vehicle)
OHCA	Out of hospital cardiac arrest
ROSC	Return of spontaneous circulation
UAM	Urban air mobility
UAV	Unmanned aerial vehicle

Abstract

Motivation
Dynamic, revolutionary and innovative – the healthcare sector is constantly evolving, driven by technological advances and innovative business models. In this dynamic environment, unmanned aerial vehicles (UAVs), commonly known as drones, offer huge opportunities for future medical applications. Specifically, in emergency medicine, where every second counts, drones with their unique capabilities such as agility and bypassing traditional transportation impediments, hint at a promising potential to enhance medical efficiency and improve patient outcomes.

Current state
Germany's emergency medical services already face significant challenges, from staff shortages to an overburdened infrastructure. We expect these issues to intensify with the introduction of the "Hospital Structural Reform" (Krankenhausstrukturreform) and the changes it promises to bring in the healthcare sector. The shift towards larger, centralized healthcare facilities as part of the reform will likely impact emergency response times, and drone technology offers potential solutions to mitigate these challenges.

Objective of this paper
This paper examines how drones could improve emergency medical services, analyzing conceptual projects and visionary ideas with the potential to improve treatments as well as patient outcomes. At the same time, we outline the challenges involved in drone-based infrastructure, looking at various solutions and identifying lessons learned in successful drone projects around the world. This analysis provides important insight and a better understanding of how we can incorporate innovative drone technology in current healthcare narratives, both in terms of the economic impact and promising future business models.

Future prospects
As a cutting-edge technology, drones have the potential to fundamentally change the healthcare industry and improve critical medical care. The real promise of this transformation can be seen in key performance indicators (KPIs) from faster response times and better patient outcomes to lower operating costs. If our objective is to transform the healthcare sector for the long term and create truly novel infrastructure, we need all stakeholders involved to bring their expertise to the table. This is the key to a comprehensive and sustainable strategy for innovation and development.

With our unique expertise here at Deloitte, we are well equipped to ensure a smooth transition into this new world of technology and to build – working closely with all stakeholders – infrastructure 2.0 for our healthcare ecosystem.

1. Introduction

The digital revolution in healthcare has brought dynamic, innovative and pioneering changes to the sector. Drones and other emerging technologies could play an important role of this transformation, offering agility, sustainability, and the ability to transcend traditional transportation obstacles.

Emergency medicine in Germany is facing a series of complex challenges, ranging from inadequate staffing and overloaded infrastructure to the broader implications of the "Hospital Structural Reform" (Krankenhausstrukturreform). As this reform further drives the trend toward larger healthcare institutions, having a much larger catchment area could inadvertently increase emergency response times. Drones not only offer compelling solutions in a very complex scenario, but also represent an emerging market full of future-oriented business opportunities. Adding drones into the service mix is more than just a strategic move; it offers huge potential to streamline response mechanisms and position enterprising players at the leading edge of this dynamic segment in emergency medicine.

To obtain widespread buy-in for these technological advances, we need to analyze and develop viable business cases that demonstrate the potential and the challenges of incorporating drones in the existing healthcare system. This paper looks at opportunities for drone adoption in modern emergency medical services as well as conceptual projects and successful use cases from around the world that demonstrate its key features and transformative vision. We hope to provide valuable insight focused on the economic impact, key performance indicators and future potential of this innovative technology in our healthcare infrastructure.

2. Emergency medicine

Introduction

Emergency medicine covers everything from pre-clinical emergency care by first responders to inpatient emergency interventions. This creates a complex web of stakeholders involved in both patient care and management of that care in critical situations, and a number of key entities directly involved in providing these urgent medical services.

Rescue services, including fire departments and ambulance services, are often the first responders on the scene, and they are responsible for stabilizing the patient, performing basic life support (BLS) and perhaps even transporting them to a medical facility. Helicopter emergency medical services (HEMS) providers will either bring emergency professionals quickly to the scene or take patients to a medical facility, especially if the event occurs in a remote location. Hospitals then provide further acute and ongoing care. Health insurance companies and other institutions provide the funding needed for patient care, while it is, of course, the patients who receive the emergency medical care. Various companies are involved in this process, whether it is medical equipment manufacturers, transport solution providers or software companies that provide the IT architecture.

German emergency medical services

In Germany, emergency medical services follow the 'rescue chain', a structured system detailing patient care from alerting services to hospital arrival. This model is particularly notable for its distinct approach to immediate on-site medical treatments.

To understand what makes Germany's system so unique, we must compare the "scoop and run" approach seen in many other global emergency systems with the "stay and play" or "stay and stabilize" model common in Germany. The former involves taking patients to the hospital right away, often without providing extensive treatment at the scene. In Germany, however, the emphasis is on administering thorough medical care at the scene of an emergency. While paramedics are typically the first to respond, an emergency doctor might be dispatched to the scene in more complex or severe cases. Together, they perform comprehensive medical procedures to ensure the patient is stabilized before being taken to the hospital. This approach is based on the belief that immediate advanced medical care at the scene can significantly improve patient outcomes, possibly even before they arrive at the hospital.[1, 2]

Germany's emergency and rescue services, which are so integral to the broader healthcare framework, are facing a complex array of challenges: the rising number of emergencies, the geodemographic shift in society and the severe shortage of skilled personnel, particularly emergency physicians. This is placing immense pressure on the healthcare system and could potentially jeopardize the timely delivery of critical care as well as patient outcomes.[3] At the same time, more and more non-urgent calls and repeat callers to emergency dispatchers are not only a drain on essential resources but also a distraction from genuine emergencies.[4, 5] The evolving regulatory and economic environment presents challenges as well, often stretching the system to its limits. And now the sector is facing the "Hospital Structural Reform", which raises serious questions about the future of the emergency system – above all due to its shift toward centralized emergency care facilities that may unintentionally increase response times and add another layer of complexity to an already complicated system.

Emergency medicine encompasses the diagnosis and appropriate treatment of imminent or acute medical emergencies by restoring and stabilizing the patient's vital functions and ensuring they are able to be transported safely.[6]

[1] Hintzenstern, U., 2023. Notarzt-Leitfaden. 10. ed. München: Elsevier, Urban & Fischer.
[2] Knapp, J. et al., 2019. Influence of prehospital physician presence on survival after severe trauma: Systematic review and meta-analysis. The journal of trauma and acute care surgery
[3] Baumgarten, M., Hahnenkamp, K. & Fleßa, S., 2022. Strategien zur Überwindung von Innovationsbarrieren. In: Unbemannte Flugsysteme in der medizinischen Versorgung. s.l.: Springer Gabler Wiesbaden.
[4] Schodlok, M., Langeloh, J., Kreinfeldt, H. & et al., 2023. Der Einfluss von Frequent Usern auf das Rettungsfachpersonal: Ergebnisse einer Umfrage. Notfall Rettungsmed.
[5] Dahmen, J., Brettschneider, P., Poloczek, S. & et al., 2021. „Warum wird der Notruf 112 gewählt?" – Befragung zum Notrufverhalten der Berliner Bevölkerung. Notfall Rettungsmed.
[6] Scholz, J. et al., 2013. Teil 2: Notfallmedizinische Begriffsdefinitionen. In: Notfallmedizin.

3. Drone Technology

Overview

Drones, more formally known as unmanned aerial vehicles (UAVs), are either remotely controlled or autonomous aircraft that can operate without a human pilot on board. They range in design from small, compact devices for personal use to larger, more complex commercial systems. Among these, multicopters, characterized by their multiple rotors like quadcopters with four rotors, are renowned for their precision and ability to hover. Their vast applications encompass everything from recreation, agriculture, research, and logistics to disaster response, military operations, and other domains. Electric vertical take-off and landing vehicles (eVTOLs) are a special subcategory of UAVs. These electric aircraft are specifically engineered to take-off, fly and land vertically, distinguishing eVTOLs from other types of drones that, much like conventional planes, require a runway. Although the term eVTOL applies to any drone with vertical take-off and landing capabilities, the segment's focus has recently been on larger aircraft designed to transport passengers, a huge step forward for future urban air mobility (UAM) models.

Drones in healthcare

In terms of healthcare, drone technology offers new prospects with the potential to transform the healthcare infrastructure. These autonomous technologies, which range from delivering medical supplies to monitoring patients remotely and responding to emergencies, may offer a new vision for healthcare.

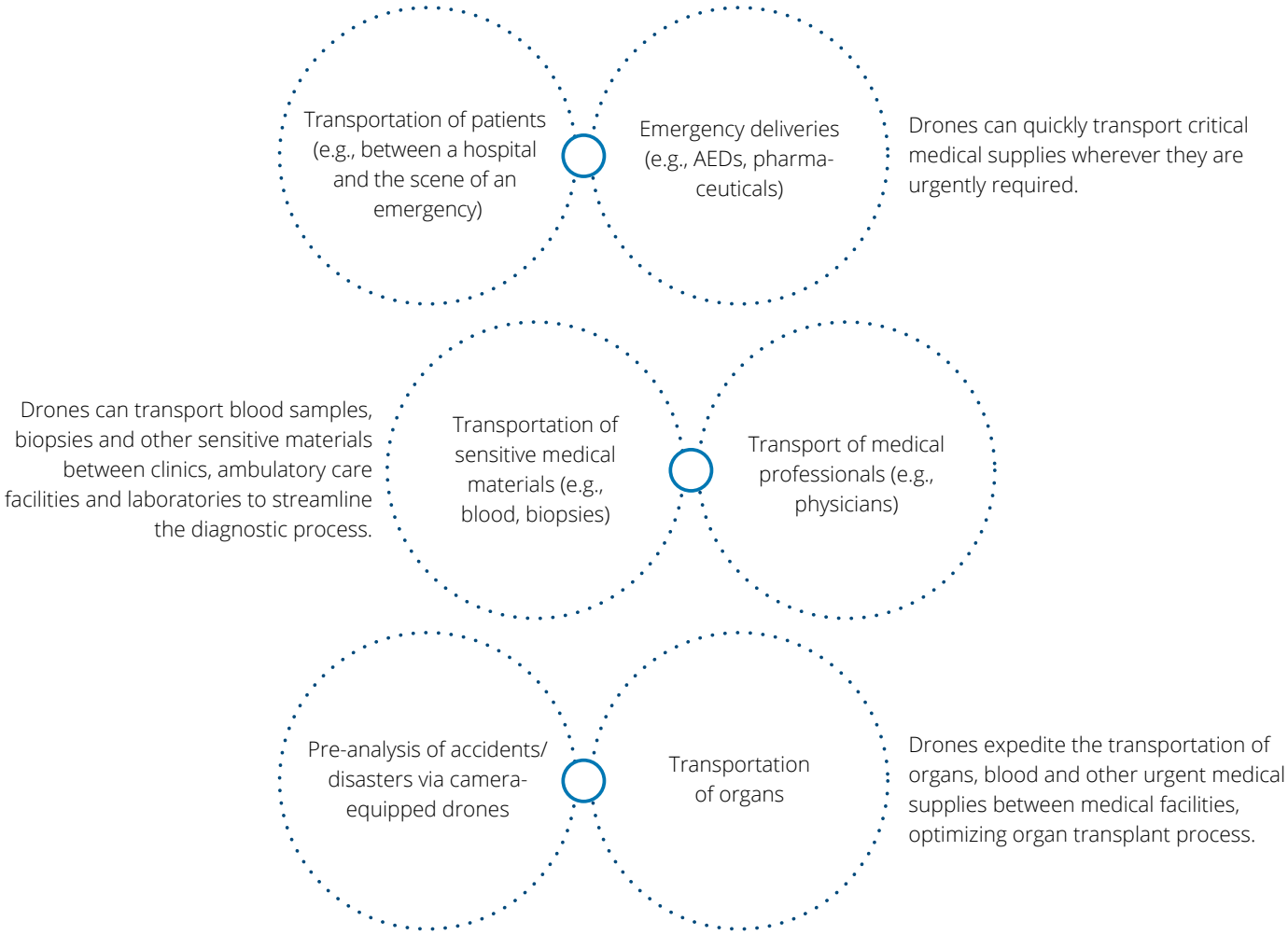
Medical logistics is an area where UAVs could play an outsized role with real benefits for patient care. The ability to quickly deliver specialist medical equipment, essential medicine or other critical medical supplies to both healthcare facilities and emergency sites would provide huge benefits. This is particularly vital in remote rural areas or any region with limited transportation or infrastructure, where timely access to medical supplies makes a significant difference in patient outcomes. Beyond emergency response, drones offer an interesting alternative to traditional courier services, especially when it comes to transporting pharmaceuticals, blood samples and other sensitive or specialized medical materials between laboratories, clinics and other facilities. This has the potential to improve both transportation time and cost-effectiveness, to ensure patients receive timely diagnoses as well as prompt treatment, and to optimize operational efficiencies for healthcare providers.[3]

Organ transplantation is another area with incredibly tight timelines where drone technology could provide significant benefits, particularly where traffic congestion, lack of transportation options and other logistic hurdles may obstruct this critical process. There is huge potential here not only to improve the efficiency of organ transfers but also to expand access to donors for hospitals.

We have seen a number of interesting projects with larger eVTOLs in the area of UAM, which could also play an important role in the rescue services of the future. For example, if eVTOLs were able to carry passengers, in addition to the vertical take-off and landing features, we could bring emergency doctors and other medical professionals directly to patients and ensure quick medical treatment at the scene in line with the "stay and play" or "stay and stabilize" model. As the technology evolves, we may also find better ways to transport patients from one hospital to another, if for example they require a transfer from a smaller clinic or ambulance to a specialist facility.

[3] Baumgarten, M., Hahnenkamp, K. & Fleßa, S., 2022. Strategien zur Überwindung von Innovationsbarrieren. In: Unbemannte Flugsysteme in der medizinischen Versorgung. s.l.: Springer Gabler Wiesbaden.

Fig. 1 – Drone technology applications



Incorporating drone technology into the healthcare system offers various interesting opportunities, particularly when it comes to the issues of place and time.[3] As seen in the applications above, UAVs have the potential to redefine medical logistics by ensuring essential supplies can be delivered when and where they are needed, especially in rural areas or places without well-established infrastructure. Using eVTOLs to transport medical staff and even patients is also a very promising prospect, which could redefine emergency response strategies and the HEMS market.

We are still in the early stages of the broader transformation of our healthcare infrastructure, and it makes sense to delve deeper into the potential benefits of drone technology and analyze concrete business cases to help stakeholders make informed decisions about their potential in the future of healthcare.

[3] Baumgarten, M., Hahnenkamp, K. & Fleßa, S., 2022. Strategien zur Überwindung von Innovationsbarrieren. In: Unbemannte Flugsysteme in der medizinischen Versorgung. s.l.: Springer Gabler Wiesbaden.

4. Business cases

Introduction

When adding new technologies into healthcare sector, the main goal is to find solutions that outperform current technology in terms of process quality and keep costs competitive or even lower.[5] Measuring and tracking key performance indicators (KPIs) is critical in this context, as it allows for a rigorous assessment in real-world applications.

KPI 1: Patient outcomes

A fundamental KPI in emergency medical services is patient outcome. The survival rate of an out-of-hospital cardiac arrest (OHCA) or the disability-free survival rate in trauma patients are important indicators to measure the quality of the provided care. Numerous studies have highlighted the critical importance of time in determining patient outcomes, especially in life-threatening situations. Time has therefore become an indispensable KPI in emergency medicine.[7] Art. 7 of the Bavarian Act to Regulate Emergency Rescue (BayRDG) addresses this by specifying an optimal response time known as the Hilfsfrist.[8] Other important time-related KPIs include the time until the emergency physician arrives, the time to treatment and the time until the patient is transferred to a hospital. In OHCA events, every passing minute without treatment can significantly influence the patient's chances of survival and recovery. Time to treatment is therefore a vital KPI in these critical situations, where rapid response and intervention can drastically increase the likelihood of favorable patient outcomes.[9, 10, 7]

KPI 2: Cost efficiency

As a KPI in emergency medical services, cost efficiency involves analyzing the overall expenses associated with providing care while simultaneously gauging the efficacy and improvement in patient outcomes. Striking the right balance here is the key to financial sustainability and the highest standards of care. When you introduce drones or any new technology, the costs should ideally be equal to or lower than those of existing solutions without compromising the quality of patient care or response times.[3]

The following business cases provide insight into the potential for drone technology to excel in these established KPIs. These projects focus on transporting medical equipment and medical professionals, highlighting representative business cases from a very broad and innovative field. It is important to note, however, that these initiatives are mostly currently in the conceptual phase, which means there are only limited real-world assessments of their practical and economic implications as of yet.

[3] Baumgarten, M., Hahnenkamp, K. & Fleßa, S., 2022. Strategien zur Überwindung von Innovationsbarrieren. In: Unbemannte Flugsysteme in der medizinischen Versorgung. s.l.: Springer Gabler Wiesbaden.
[5] Dahmen, J., Brettschneider, P., Poloczek, S. & et al., 2021. „Warum wird der Notruf 112 gewählt?" – Befragung zum Notrufverhalten der Berliner Bevölkerung. Notfall Rettungsmed.
[7] Röper, J. et al., 2023. Can drones save lives and money? An economic evaluation of airborne delivery of automated external defibrillators. The European Journal of Health Economics, pp. 24(7): 1141-1150.
[8] Institut für Notfallmedizin und Medizinmanagement, 2022. Rettungsdienstbericht Bayern 2022, s.l.: LMU Klinikum.
[9] Holmén, J., Herlitz, J., Ricksten, S. & et al., 2020. Shortening Ambulance Response Time Increases Survival in Out-of-Hospital Cardiac Arrest. J Am Heart Assoc.
[10] Bürger, A. et al., 2018. The Effect of Ambulance Response Time on Survival Following Out-of-Hospital Cardiac Arrest. Dtsch Arztebl Int. 15(33-34): 541-548., pp. 20;115(33-34): 541-548.

Business Case 1: Transportation of emergency equipment

Our first business case involves using drones to transport AEDs (automated external defibrillators) during an emergency. As mentioned in the chapter above, time is a critical KPI in OHCA scenarios, as each passing minute without defibrillation significantly impacts the patient's prognosis (-7%): The overall survival rate is greater than 50% with an AED compared to around 8% without.[7, 11, 12] Although the German government has installed a large number of AEDs in public places to reduce the Time to 1st defibrillation, there is still one major challenge: less than 5% of OHCA patients are defibrillated before the rescue services arrive, largely due to the time it takes to find and deploy these stationary devices.[7] A study conducted by the ADAC Stiftung also showed that most people do not know where to find the nearest AED, even if it is in the direct vicinity of their home.[13] In response to this challenge, initiatives like Horyzn or the Swedish company Everdrone AB are exploring the potential of UAV technology to expedite AED delivery. We outline the key concepts of these projects in the following use case, highlighting the proposed solution to improve response time, its impact on patient outcomes and its cost efficiency relative to the current system.

Case scenario

1. Emergency call:

- Conventional rescue chain: A bystander sees a person collapse and is unable to detect vital signs. The bystander calls the emergency services to report the OHCA.
- With UAV-AED assistance: As soon as the call comes in, the UAV provider's application embedded within the emergency dispatch system sends an AED-equipped drone to the reported location.

2. Initial response:

- Conventional rescue chain: The dispatcher instructs the bystander to begin CPR.
- With UAV-AED assistance: While the bystander starts CPR, the drone is already en route, potentially reaching the location faster than an emergency services vehicle due to the direct flight path and lack of road traffic.

3. AED deployment:

- Conventional rescue chain: Bystanders would have to locate the nearest stationary AED, which can be time-consuming and, in many cases, impractical if bystanders are not aware of or able to access the nearest AED.
- With UAV-AED assistance: The drone arrives promptly, and the AED is immediately accessible to bystanders or first responders on the scene. Provided they can detect a so-called "shockable rhythm", they can attach the AED and administer the first electric shock » Time to 1st defibrillation.

4. Medical intervention:

- Conventional rescue chain: Paramedics and possibly an emergency physician arrive and deploy the AED » Time to 1st Defibrillation.
- With UAV-AED assistance: By the time the paramedics arrive, there is a higher probability that bystanders have already deployed the AED and started defibrillation, giving the patient a better chance of survival.

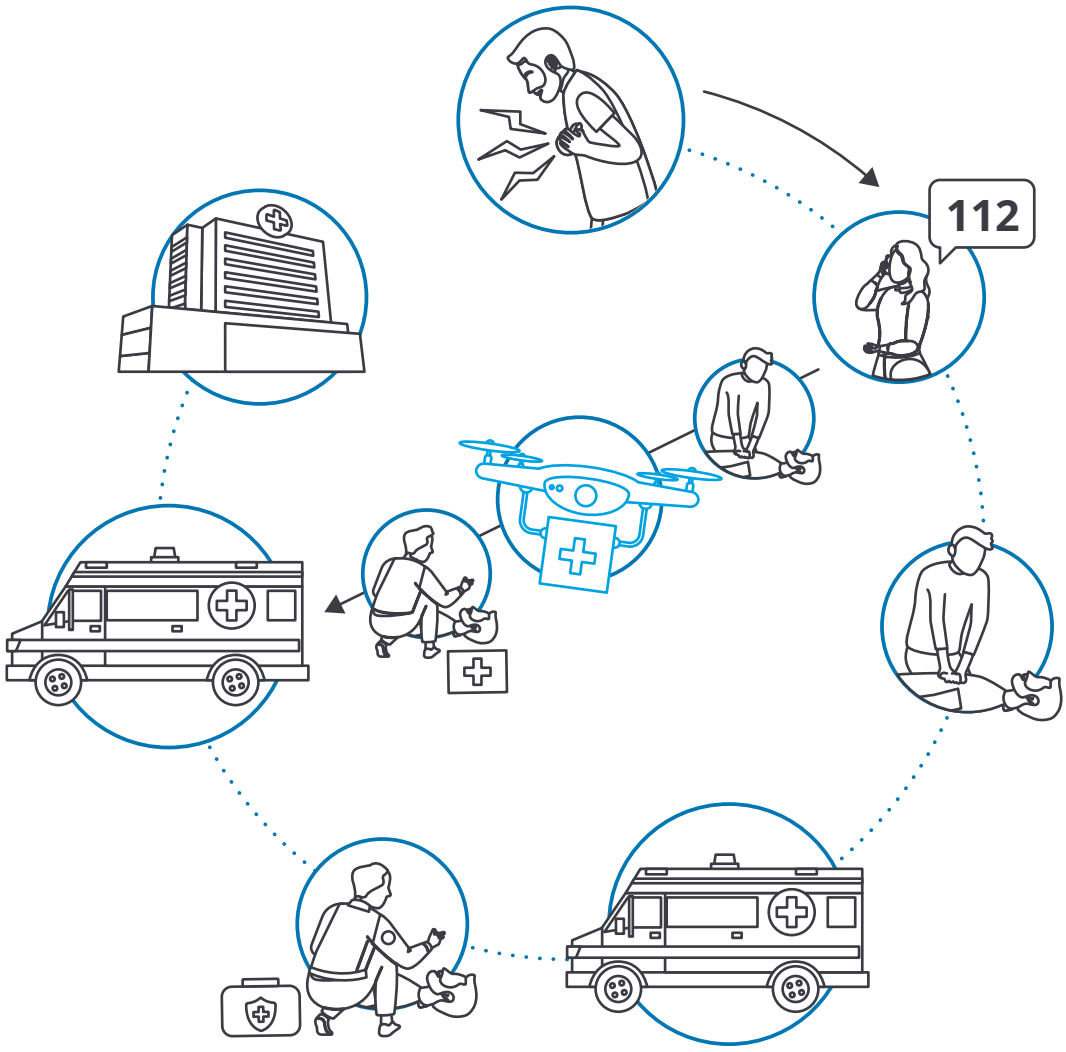
5. Transport and hospital care:

- Conventional rescue chain and UAV-AED assistance: After initial resuscitation attempts and a possible return of spontaneous circulation (ROSC), the patient is transported to a medical facility for further care.

[7] Röper, J. et al., 2023. Can drones save lives and money? An economic evaluation of airborne delivery of automated external defibrillators. The European Journal of Health Economics, pp. 24(7): 1141-1150.
[11] Schierbeck, S. et al., 2022. Automated external defibrillators delivered by drones to patients with suspected out-of-hospital cardiac arrest. European Heart Journal, 43(15), p. 1478–1487.
[12] Süddeutsche Zeitung, 2019. Defibrillatoren in Deutschland werden selten genutzt. [Online] Available at: https://www.sueddeutsche.de/gesundheit/gesundheit-defibrillatoren-in-deutschland-werden-selten-genutzt-dpa.urn-newsml-dpa-com-20090101-190426-99-971052
[13] ADAC Stiftung, 2020. Automatisierte Externe Defibrillatoren - Kennntnisse der Bevölkerung. [Online] Available at: https://stiftung.adac.de/app/uploads/2020/05/AED_Befragung_Ergebnisse_20200120.pdf

Fig. 2 – AED equipped UAV, provided by Everdrone AB

Fig. 3 – UAV-AED assistance



Result

KPI 1: Patient outcomes

In terms of patient outcome, time to 1st defibrillation is faster with a drone-based AED than the conventional rescue chain, offering intriguing insights for stakeholders. Stationary AEDs offer location-based access to a defibrillator, but it is only effective if bystanders are aware of and able to quickly locate the nearest device during an emergency and if they keep hands-off time to a minimum.[14, 13] By contrast, dispatchers can deploy drone-carried AEDs directly to the scene of an emergency extremely quickly, keeping the distance to the stationary AED and hands-off time to an absolute minimum, even if there is only one bystander assisting. Drone-based AED delivery may therefore shorten the time to defibrillation and lead to better patient outcomes.[7, 15]

While Germany has only started considering delivering AED via drones, the Swedish company Everdrone in cooperation with the Karolinska Institute (Solna, Sweden) is already putting this innovative solution into action in their country. Their real-world analysis not only shows that the drones outperform the ambulance service in response time and practical feasibility but also confirmed the life-saving potential of this technology during an acute OHCA event in 2021. Sweden's proactive approach is a compelling example of the transformative power of drones for emergency response on a global scale.[16, 11]

KPI 2: Cost efficiency

In terms of the financial implications, research conducted by the University of Greifswald indicates that the operating costs of stationary AEDs are higher than for drone-based AEDs with the same response time. This in-depth analysis shows that the cost per square kilometer for stationary AEDs is about twice that of the UAV model. The study suggests that, even if costs were the same, drone-based AEDs achieve faster response times and therefore better patient survival rates.[17] This aligns with another German study that describes AED delivery by drone as "cost-effective".[15] Despite potential cost differences between individual drone models and their respective manufacturers, the overall financial trajectory for UAV-based medical interventions is very promising in the near term.

"Imagine a future where everyone experiencing an OHCA has access to an AED within four minutes – that's the healthcare infrastructure we are striving to create."

Balázs Nagy, Founder of "Horyzn"

[7] Röper, J. et al., 2023. Can drones save lives and money? An economic evaluation of airborne delivery of automated external defibrillators. The European Journal of Health Economics, pp. 24(7): 1141-1150.
[11] Schierbeck, S. et al., 2022. Automated external defibrillators delivered by drones to patients with suspected out-of-hospital cardiac arrest. European Heart Journal, 43(15), p. 1478–1487.
[12] Süddeutsche Zeitung, 2019. Defibrillatoren in Deutschland werden selten genutzt. [Online] Available at: https://www.sueddeutsche.de/gesundheit/gesundheit-defibrillatoren-in-deutschland-werden-selten-genutzt-dpa.urn-newsml-dpa-com-20090101-190426-99-971052
[13] ADAC Stiftung, 2020. Automatisierte Externe Defibrillatoren - Kennntnisse der Bevölkerung. [Online] Available at: https://stiftung.adac.de/app/uploads/2020/05/AED_Befragung_Ergebnisse_20200120.pdf
[14] Thies, K., Jansen, G. & Wähnert, D., 2022. Kommt die Defi-Drohne?. Anaesthesiologie 71, pp. 865-871.
[15] Bauer, J., Moormann, D., Strametz, R. & Groneberg, D., 2021. Development of unmanned aerial vehicle (UAV) networks delivering early defibrillation for out-of-hospital cardiac arrests (OHCA) in areas lacking timely access to emergency medical services (EMS) in Germany: a comparative economic study. BMJ Open.
[16] Everdrone, 2022. For the first time in medical history, an autonomous drone helps save the life of a cardiac arrest patient. [Online] Available at: https://everdrone.com/news/2022/01/04/for-the-first-time-in-medical-history-an-autonomous-drone-helps-save-the-life-of-a-cardiac-arrest-patient/

Business Case 2: Transportation of medical professionals

The next business case explores the use of Multicopters to transfer people in an emergency scenario. Collaborations between Airbus Helicopters and the Norwegian Air Ambulance Foundation, for example, or between Volocopter GmbH and ADAC-Luftrettung gGmbH[17, 18] have highlighted this potential. We will analyze the latter partnership in the following section.

As we have established, the German rescue service operates mainly under the "stay and play" or "stay and stabilize" model, in which emergency physicians are dispatched directly to an emergency site. The project proposed by ADAC Luftrettung gGmbH and Volocopter GmbH looks at the potential of Multicopters to transport medical professionals to the scene of an emergency faster than ground transportation. Given the challenges of extended response times and staff as well as resource shortages, this innovation at the intersection of technology and healthcare improve rapid medical intervention and potentially save lives.[18]

Case scenario

1. An emergency call comes in to the emergency dispatch center.

2. The dispatcher assesses the urgency of the situation and determines that rapid medical intervention is required.

3. At the same time, the dispatcher sends a ground ambulance team out and alerts the Multicopter providers.

4. The Multicopter, with the emergency physician on board, takes off immediately and flies directly to the emergency location.

5. The ground ambulance team also heads to the location with all the necessary medical equipment.

6. The Multicopter arrives at the scene, ensuring a rapid response by an emergency physician and works in collaboration with the ground ambulance team to provide comprehensive care.

7. If required, the patient is then transported to the nearest medical facility by the ground ambulance, and the physician can either accompany the patient or return with the Multicopter.

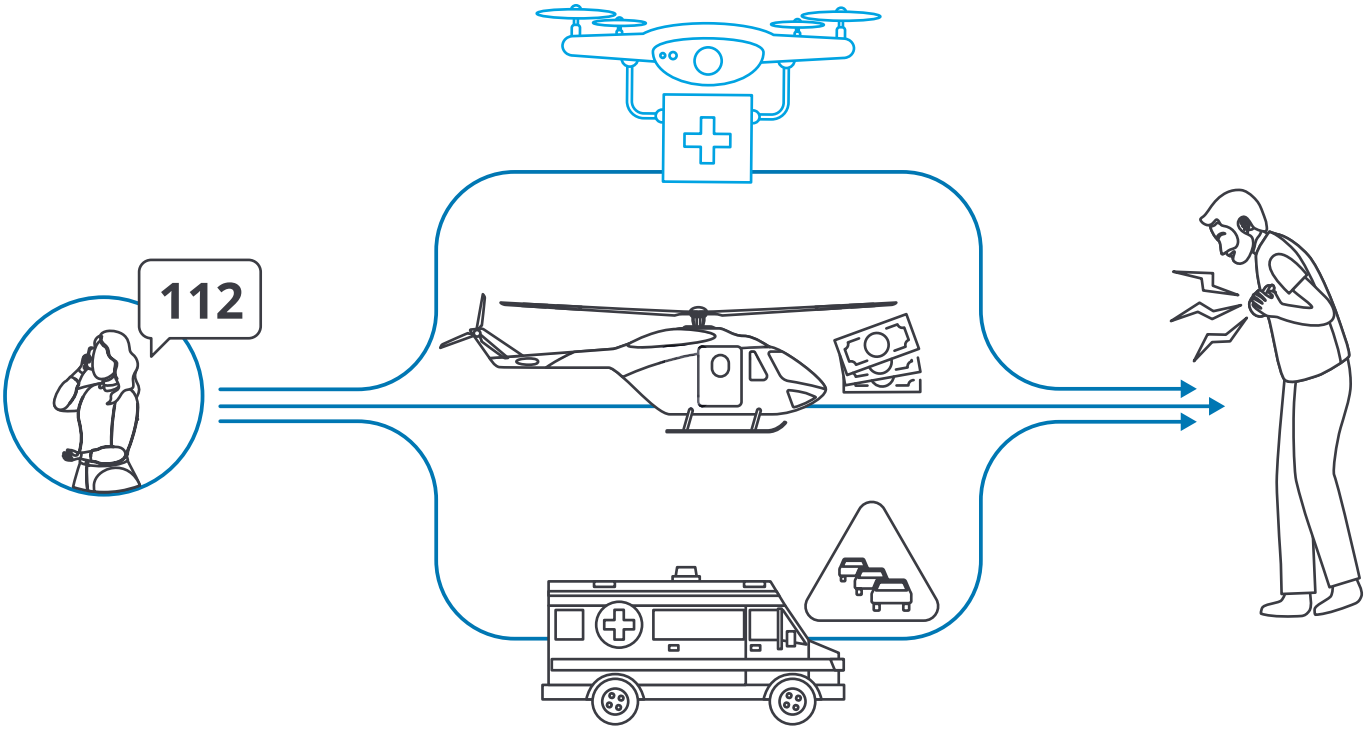
8. If the physician decides to accompany the patient, the Multicopter follows the ambulance, collects them after the patient is safely transferred and flies back to the base to prepare for the next mission.

[17] Airbus, 2023. Airbus and Norwegian Air Ambulance Foundation to develop CityAirbus NextGen's future medical missions in Norway. [Online] Available at: https://www.airbus.com/en/newsroom/press-releases/2023-03-airbus-and-norwegian-air-ambulance-foundation-to-develop-cityairbus

[18] ADAC Luftrettung gGmbH, 2020. Multicopter in the rescue service. [Online] Available at: https://luftrettung.adac.de/app/uploads/2021/02/LRG_Machbarkeitsstudie_engl.pdf

Fig. 4 – Multicopter for the transportation of medical professionals, picture provided by ADAC-Luftrettung gGmbH

Fig. 5 – Multicopter transportation of medical professionals



Result

KPI 1: Patient outcomes

In critical emergencies, early advanced medical intervention by an on-site doctor can improve patient outcomes. While helicopters have been tested for these kind of tasks, Multicopters are generally more flexible, are available faster and offer a wider range of possible landing sites in an emergency scenario. A growing challenge for our rescue services is a lack of or the poor allocation of helicopter resources. With the surge in emergency calls, we're reaching the limits of helicopter availability and some major emergencies may go without airborne assistance as a result. Expanding air infrastructure with Multicopters could alleviate resource bottlenecks and open up opportunities to invest in the specialized helicopters required for winch rescues, critical care transportation and other niche cases. For more routine emergencies that need a physician on site, Multicopters could potentially provide a fast, efficient solution.[18]

KPI 2: Cost efficiency

Compared to traditional helicopters, the use of Multicopters for transporting medical professionals could mean significant cost savings for emergency services. Maintenance costs for Multicopters are expected to be much lower due to the multi-rotor design and simpler technology.[18] Additionally, the shift from kerosene-fueled to electric engines not only results in lower fuel costs but is also a more sustainable solution with lower carbon emissions. And thanks to the much simpler design, production of Multicopters could potentially be more cost-effective on a larger scale.

Current Multicopters are designed as single-pilot solutions, but they could potentially be used for autonomous flight in the future with the associated decrease in personnel costs. Studies also show that the rapid response and extended operational range of Multicopters reduce the demand for ground transportation of medical professionals, which not only addresses the shortage of emergency physicians but also contributes to overall cost efficiency.[18]

"Multicopters with their unique advantages, may represent the next significant enhancement to our land-based and helicopter rescue systems, paving the way for a new era of swift and efficient emergency response."

Aaron Erd, ADAC- Luftrettung

[18] ADAC Luftrettung gGmbH, 2020. Multicopter in the rescue service. [Online] Available at: https://luftrettung.adac.de/app/uploads/2021/02/LRG_Machbarkeitsstudie_engl.pdf

Further considerations

In addition to transporting emergency physicians, Multicopters offer an interesting alternative to traditional means of transporting other medical specialists. Consider the example of a smaller hospital that urgently requires a neuroradiologist to operate on a stroke patient. Traditionally, the solution might be to send the specialist by helicopter, (e.g., the FIT-TEMPIS stroke network).[19] Deploying Multicopters rather than helicopters offers significant cost and resource savings. If we can get the neuroradiologist to the patient quickly, we can expedite care and reduce costs while making the best use of available medical resources and infrastructure.

"With the upcoming structural reform in our healthcare system, change is inevitable. While the specifics remain uncertain, everyone agrees that smaller hospitals will be reduced in number, leading to fewer facilities providing emergency care at a crucial level. This makes it evident that the demand for aerial transport capacity will increase significantly. Relying solely on helicopter technology isn't sustainable, the costs would become prohibitively high."

Prof. Dr. med. Peter Biberthaler, Direktor/Chair der Klinik und Poliklinik für Unfallchirurgie am Klinikum rechts der Isar

[19] TEMPiS Schlaganfallnetzwerk, n.d. TEMPIS - Flying Intervention Team. [Online] Available at: https://tempis.de/flying-intervention-team/

Forward-looking Business Case 3: Secondary patient transport

In this next business case, we turn our attention to the potential of drones for transporting not only emergency physicians, but the patients themselves. As its technology continues to evolve, we can expect future projects to carry larger payloads, which could potentially include patient transfers. This would be a profound transformation of our healthcare infrastructure. Imagine a world where we not only transport emergency casualties by air, but we can also expand the market to include secondary transportation for a wide range of medical needs. Rapid patient transfer could become the norm rather than the exception and revolutionize our understanding of medical transportation.

Potential case scenario

1. Specialized care requirement: A physician at a local hospital determines there is a critical need for specialized care that is not available at this specific facility.

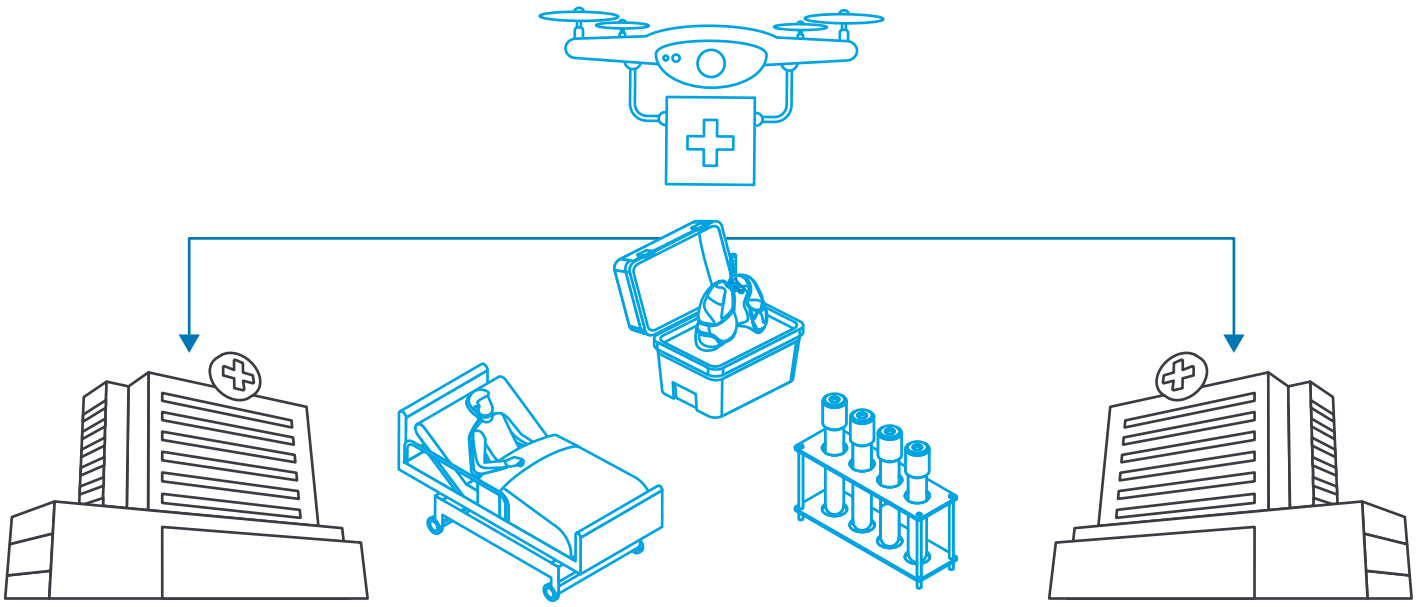
2. Coordination & mobilization: Once the decision has been made, the hospital's coordination team liaises with the relevant drone service provider.

- Alternative: The hospital or the specialized care center has its own drone fleet.

3. Drone activation: Rather than sending a ground ambulance or helicopter, the patient is quickly transported by a drone.

4. Completion of transfer: The patient lands at the designated medical facility and receives the necessary care. The drone then returns to its base and prepares for further emergencies.

Fig. 6 – Transfers between hospitals



Result

KPI 1: Patient outcomes

When assessing patient outcomes, as mentioned earlier, time is often the most critical factor, especially for events like strokes or severe trauma. The rapid response capabilities of drones mean that patients not only receive immediate specialist care on-site from emergency physicians as described in Business case 2; they can also be transferred quickly to a specialist facility for further treatment. Time to treatment is much lower than with ground transportation, which could improve recovery rates and reduce mortality.

KPI 2: Cost efficiency

The use of drones rather than helicopters for patient transfers makes a compelling case from a cost perspective. As already described in Business case 2, operating costs are often lower than traditional helicopters thanks to lower maintenance costs and the differential between charging fees and kerosene prices. The reduced reliance on helicopters, which is a very limited resource, makes for a leaner and more efficient system. It is conceivable that specialized hospitals could even have their own fleet for secondary transportation, which would streamline the process and possibly even eliminate the need for an external dispatch center. Such a direct approach could further expedite patient transportation and improve the overall efficiency of inter-hospital transfers.

"Drones are set to redefine the market of secondary patient transport in the future."

Prof. Dr. med. Peter Biberthaler, Direktor/Chair der Klinik und Poliklinik für Unfallchirurgie am Klinikum rechts der Isar

5. Infrastructure 2.0 for the healthcare system – What challenges can we overcome in the near term?

Through research and insightful interviews with all stakeholders, we have analyzed the complexities and challenges presented by drone technology and identified the most critical pain points. This gives us profound insights into the intricacies of the technology in emergency medical services from regulatory and logistical hurdles to technical and operational constraints. Our goal is not only to highlight these challenges, but also to develop effective strategies to overcome them and promote the development of advanced healthcare solutions.

Technical obstacles
In terms of the technical requirements, drone-based medical applications must be reliable and adaptable in a variety of scenarios. It is vital for every flight, whether it is to transport AEDs and other critical medical cargo or medical professionals and patients, to be perfectly safe.

This necessitates having high technical standards and capabilities such as payload capacity, advanced battery efficiency, landing accuracy, and more. In this intricate balance, the challenge for manufacturers is to combine multiple features into a single, seamless airborne solution.[3]

To realize the full potential of drone technology, we are calling on policymakers to provide proactive support, from direct investments to grants for startup ecosystems and student initiatives. We also recommend a robust knowledge sharing initiatives bringing experts from the drone industry, drone vendors as well as other stakeholders to the table. Through these strategic initiatives, we can address potential technical obstacles in a proactive way and potentially accelerate the adoption of drones in the healthcare landscape.

Regulatory
Companies interested in adding drones to the infrastructure mix must comply with a multifaceted set of regulatory standards. These encompass overarching European safety and operational frameworks, such as the guidelines set by EASA (European Aviation Safety Agency) and SERA (Standardized European Rules of Air), in addition to specific national requirements.[20, 21] This complex regulatory framework is constantly evolving with technological advances and new use cases, while there is still some legal uncertainty regarding their application.[3] To ensure compliance and operational continuity, all stakeholders have to stay up to date with the evolving regulatory landscape so that they are flexible enough to adapt quickly to any changes in the overall framework.

Public awareness and acceptance
Public awareness and acceptance of drones are vital if we want widespread use this technology in the healthcare sector. Concerns ranging from potential invasions of privacy, misuse or safety concerns may generate resistance within the community. The best way to address these concerns is to meet the highest possible security standards while also raising awareness of the potential benefits of drone-based healthcare applications. In the last couple of years, we have seen a noticeable increase in the acceptance of civilian drones, particularly in medical applications.[22] To cultivate this growing sense of trust, we have to provide transparent communications about the benefits and the safety precautions associated with the use of drones in healthcare scenarios.

Integration into the existing healthcare infrastructure
If we want the integration of drone technology into the healthcare system to succeed, end users (e.g., physicians, first responders) must see the real-world benefits of this innovation. We need to raise awareness of drone applications to create demand that will set the stage for broader acceptance and willingness to use the technology in the future.[3] Moreover, as we move towards integration, stakeholders will have to find the right strategy to adapt existing processes and to train of healthcare practitioners to maximize the benefits of drone technology.

Incorporating drone technology into healthcare settings demands careful consideration of the spatial constraints of hospitals. This means planning and developing special areas for vertiports and dedicated drone landing zones. Hospitals have

[3] Baumgarten, M., Hahnenkamp, K. & Fleßa, S., 2022. Strategien zur Überwindung von Innovationsbarrieren. In: Unbemannte Flugsysteme in der medizinischen Versorgung. s.l.: Springer Gabler Wiesbaden.
[20] European-Comission, 2021. Drones: Commission adopts new rules and conditions for safe, secure and green drone operations. [Online] Available at: https://transport.ec.europa.eu/news-events/news/drones-commission-adopts-new-rules-and-conditions-safe-secure-and-green-drone-operations-2021-04-22_en
[21] European-Comission, 2023. New EU rules on dedicated airspace for drones enter into force. [Online] Available at: https://transport.ec.europa.eu/news-events/news/new-eu-rules-dedicated-airspace-drones-enter-force-2023-01-26_en
[22] Bundesverband der Deutschen Luft- und Raumfahrtindustrie, 2022. AKZEPTANZ GEGENÜBER DROHNEN UND FLUGTAXIS IN DEUTSCHLAND STEIGT. [Online] Available at: https://www.bdli.de/meldungen/akzeptanz-gegenueber-drohnen-und-flugtaxis-deutschland-steigt

to strategically place these areas to ensure no existing hospital operations or patient care are disrupted. Supplemental infrastructure from charging stations to secure storage facilities will also be required. All these adjustments should be designed to seamlessly embed drone operations into the dynamic hospital environment while also prioritizing safety and efficiency.

Beyond adapting the physical infrastructure, it is important to ensure the drone technology is aligned with the existing IT systems of the various stakeholders. Making these systems interoperable will be critical for smooth operations and comprehensive integration into the broader structure of the healthcare system. Proper alignment is a key factor in the effective implementation of drones in healthcare.

Conclusion

Incorporating drone technology into the healthcare landscape is a multifaceted endeavor that encompasses technical and regulatory factors as well as public perception. Navigating these complexities requires us not only to understand the challenges but also to address them strategically with a considered action plan. Central to successful integration is a shared vision among all stakeholders including manufacturers, regulators, HEM providers, medical professionals and the public.

Only through a collective, cohesive effort encompassing all perspectives and expertise can we unlock the truly transformative potential of drones in the healthcare setting and ensure seamless and mutually beneficial integration for everyone involved. In light of the recent proposal to overhaul Germany's emergency response system, we are at a pivotal point in the evolution of airborne medical rescue.[16] This transformation invites us to think about the right strategies to incorporate UAVs and open new horizons in emergency medicine.

"You should consider drone technology as one piece of a much larger puzzle when it comes to healthcare logistics and emergency response. To unlock the potential that drones can bring to these sectors, changes also need to be made to the organization and the internal processes."

Mats Sällström, CEO Everdrone AB

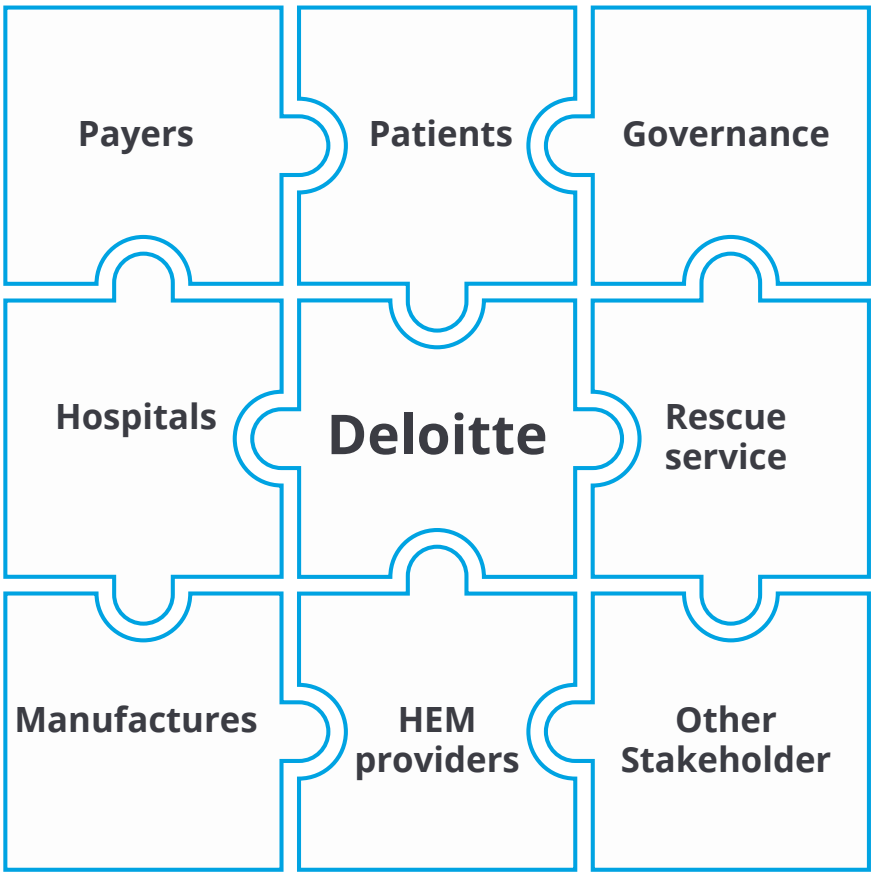
[16] Everdrone, 2022. For the first time in medical history, an autonomous drone helps save the life of a cardiac arrest patient. [Online] Available at: https://everdrone.com/news/2022/01/04/for-the-first-time-in-medical-history-an-autonomous-drone-helps-save-the-life-of-a-cardiac-arrest-patient/

6. Deloitte – Making an impact for the successful launch of healthcare infrastructure 2.0

Based on the use cases presented in this paper, drones clearly offer intriguing possibilities for the future of our healthcare system, particularly in the light of the upcoming reform of the emergency response system and the plans to expand the airborne rescue service.[23] Many projects may still be in the conceptual phase, but it is certainly worth exploring the potential benefits for emergency medicine. We still have a number of challenges to consider and overcome. It is important to understand that drones, while promising, will never be a standalone solution. Instead, they represent a single, albeit significant piece in the intricate puzzle of our broader health care infrastructure.

At Deloitte, we recognize the transformative potential of drones within the continuously evolving healthcare system. We understand the complex changes resulting from the "Hospital structural reform", and we have identified potential challenges and pain points involved in the gradual integration of this disruptive technology into our healthcare system. Our ability to bring all stakeholders together to create synergies and help shape the future of healthcare will determine whether we succeed in leveraging the full potential of this technology.

Fig. 7 – Infrastructure 2.0



[23] Regierungskomission, 2023. Reform der Notfall- und Akutmedizin. [Online] Available at: https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/K/Krankenhausreform/BMG_Stellungnahme_9_Rettungsdienst_bf.pdf

With our deep, cross-sector expertise and successful track record in drone-related projects in various fields as well as our extensive relationships with a wide variety of stakeholders, we are in the ideal position to connect the disparate elements of this intricate puzzle. Our aim? To create a robust, patient-centric and benefit-driven drone infrastructure that takes the healthcare ecosystem to unparalleled heights.

This journey to drone-enabled emergency medicine has just begun, and the sky is not the limit, but rather our launchpad. With Deloitte as your strategic partner, we can help you strike the right balance between managing the turbulence ahead and charting the course for an exciting, transformative future in healthcare.

"As we proceed to explore these high-flying innovations, the horizon of emergency medicine looks brighter and undeniably offers a broader range of care where it really matters! This is the starting point in a fast moving journey to redefine healthcare and actually save lives."

Ibo Teuber, Partner Deloitte

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