Aerial Allies on Asphalt

Examining Decision-Making for Drone Implementation at Rijkswaterstaat

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by

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Preface

This thesis marks the end of an intense yet rewarding journey, representing the result of months of research, analysis, and reflection. Undertaking this master's thesis provided me with an opportunity to delve deep into a subject that has captivated my interest. Additionally, it was a great opportunity to combine it with an internship at Rijkswaterstaat, allowing me to immerse myself in the integration of drone technology within their operations.

My internship started off smoothly but became quite challenging towards the end. I want to thank my supervisors, friends, and family for their unwavering support throughout this process. Their encouragement kept me motivated and inspired me to push through.

I would like to express my heartfelt gratitude to my first supervisor and chair for their guidance and trust. After every conversation with them, I felt renewed and ready to tackle the next phase of my research.

I also extend my thanks to my second supervisor, whose expertise and constructive feedback shaped this thesis and kept me focused.

Furthermore, I am deeply thankful to my mentor at Rijkswaterstaat who introduced me to the realm of aerial machines and provided invaluable insights into innovation decision-making within the organisation of Rijkswaterstaat. I have learned immensely from their mentorship.

I am also grateful to the participants of the interviews, whose time and insights made this research possible. Their willingness to share their experiences enriched the findings of this study. After each interview, my passion for the subject soared to new heights, making the research incredibly enjoyable.

Lastly, I want to acknowledge the support of my friends and family whose understanding and encouragement have been instrumental in my progress.

As I present this work, I hope it serves as a meaningful contribution to the growing body of literature on innovation implementation, specifically focusing on drone technology within road authority organisations such as Rijkswaterstaat. May it inspire further exploration and dialogue in this field.

Thank you to everyone who supported me on this journey. Your encouragement and belief in me has been crucial in reaching this milestone.

Fenna Cleuren
Rotterdam, June 2024

Summary

Traffic congestion and accidents is a growing problem in the Netherlands. The high population density and many urban and industrial areas create complex traffic conditions that require increased supervision. The use of drones offers an innovative solution to these challenges. The Dutch government, through the Ministry of Infrastructure and Water Management, is actively investigating the possibilities for using drones safely and effectively in aviation. Drones can not only contribute to faster incident management on the water, but also have the potential for revolutionary improvements in road management, traffic management and incident management. This research focuses on the possibilities and challenges of using drones by Rijkswaterstaat for road traffic management, including policy and technological aspects.

Not only the innovation process itself, but also the multi-actor environment in which that process takes place and which plays out over time, are important aspects of the problem. Therefore, the research will conduct this analysis using Kingdon's Multiple Streams framework. This framework has been adapted to be applied to the innovation drones within the RWS organisation. The adapted framework includes three flows that influence the dynamics of innovation: the problem flow, the technological flow and the regulatory and policy flow. This approach provides a more holistic view of how different factors and actors come together in decision-making over time, which is crucial for a successful implementation process. The study aims to gain a deeper understanding of the effective application of drone technology by RWS and the necessary policy measures to support it. The central research question to be answered is: How can innovative drone technology be implemented by an organisation like Rijkswaterstaat?

To answer this question, specific sub-questions have been formulated: (1) What are the challenges RWS has faced in regard to road traffic management over time? (2) What are the opportunities and challenges of drone technology in relation to RWS road traffic management, both historically and currently? (3) What are the challenges of laws, regulations and RWS policies related to drones for RWS road traffic management over time? (4) In what way have the findings from the problem stream, technology stream and regulatory and policy stream converged over time to create a window of innovation opportunity for the effective implementation of drones for RWS road traffic management?

The research uses a qualitative approach to thoroughly examine the dynamics surrounding drone implementation within RWS. First, the theoretical framework will be explained. Next, a literature review on drone technology will discuss the current applications and potential challenges of this innovation. Following that, an actor analysis will map out the various stakeholders in the drone ecosystem. Insights into current problems regarding drone innovation implementation are then gained through semi-structured interviews with experts and stakeholders. This method is used to find a way to integrate drones into RWS Road Traffic Management. Informal communication, such as meetings and expert sessions, is also utilised for valuable insights. The research focuses on an adapted theoretical framework that combines elements of Kingdon's Multiple Streams Approach with insights from innovation and implementation theories. This revised framework includes three streams that influence innovation dynamics: the problem stream, the technology stream, and the regulation and policy stream.

The answer to the first sub-question encompasses the current challenges for RWS in road traffic management. These are complex issues such as efficient incident management, monitoring traffic flows, and managing infrastructure, while also ensuring citizens' privacy. Budgetary constraints and staff shortages force RWS Road Traffic Management to make strategic choices, while the ongoing pressure to innovate increases the complexity of their tasks by requiring them to embrace new technologies and work methods.

Regarding the second sub-question, drones can offer numerous opportunities to improve road traffic management, such as incident management, traffic monitoring, and infrastructure inspections. However, challenges such as manual control, limited autonomy, and legal restrictions persist.

As for the third sub-question, there are several challenges related to laws, regulations, and RWS policy detected. The lack of clear guidelines for Beyond Visual Line of Sight (BVLOS) operations complicates licensing procedures. The need for a clear legal framework for BVLOS operations is emphasised to enable smooth integration of drones into operational workflows. There is a lack of awareness within the management team of RWS Road Traffic Management about the benefits of drones, as well as the absence of explicit strategic plans for drone use. This lack of specific guidelines may hinder the integration of drone initiatives and influence the prioritisation of innovation within the organisation. The transition from an intrapreneurship mindset, characterised by a more organic and opportunistic approach, to a structured process like the IUP process may also pose challenges due to its influence on innovation prioritisation. It is crucial to collaborate closely between policymakers, legislators, internal RWS departments, and external stakeholders to create a framework for innovation that enables the effective integration of drones.

The fourth sub-question requires an integration of findings from the problem, technology, and regulation and policy streams. This provides a roadmap for creating an 'window of innovation opportunity'. Recognising inefficiencies in incident management and mirroring successful drone applications in other sectors, such as the maritime industry, illustrates potential solutions. This includes experimenting with BVLOS flights to be present within the 'golden hour' after an incident, allocating sufficient manpower and resources, and collaborating with regulatory agencies are just some steps to create a framework for innovation that supports the effective implementation of drones in RWS road traffic management.

The use of Kingdon's model offers a new perspective on this theory, as the model is usually applied at the national policy level and in broader policy contexts. Nonetheless, applying this model in the RWS case study research provides insight into how this model can be adapted and applied to specific organisational contexts and policy areas. Although the model is inherently descriptive, concrete steps based on the RWS principles can help identify and create 'window of innovation opportunity' for innovation.

To achieve an 'window of innovation opportunity' for the effective implementation of drones, changes are necessary at various levels. Internally, Rijkswaterstaat (RWS) must prepare by identifying operational challenges, recognising the benefits of drones, and fostering a culture of innovation. This requires investment in resources, communication, and policy adjustments. Externally, laws and regulations must be adjusted to enable BVLOS operations, and partnerships with other Drone2Go partners must be established to share knowledge and resources. It is essential to realise that RWS's internal 'window of innovation opportunity', where the problem is recognised, and investments are made in drone solutions, does not necessarily coincide with the external 'window of innovation opportunity' regarding legislation or willingness to cooperate with other partners. RWS faces a strategic choice: strictly following Kingdon's model and waiting for an external 'window of innovation opportunity', or conducting further research into the value of automated drones for incident management in a Proof of Concept (POC) to create an internal 'window of innovation opportunity'. The POC is essential to assess the potential value of drones for road traffic management and convince the sector of this value. Additionally, RWS policymakers are advised to make a balanced choice for allocating existing resources and budgets to support drone projects, increase internal awareness of the benefits of drones through campaigns and sharing success stories with both operations and management. It is important to collaborate with regional teams to identify specific problems that drones can solve and promote dialogue between departments and management teams. Policymakers should collaborate with ILT and other entities to adjust regulations for BVLOS operations and actively participate in the BVLOS Roadmap.

Samenvatting

Verkeerscongestie en ongevallen is een groeiend probleem in Nederland. De hoge bevolkingsdichtheid en vele stedelijke en industriële gebieden zorgen voor complexe verkeersomstandigheden die om meer toezicht vragen. Het gebruik van drones biedt een innovatieve oplossing voor deze uitdagingen. De Nederlandse overheid, via het Ministerie van Infrastructuur en Waterstaat, onderzoekt actief de mogelijkheden om drones veilig en effectief in te zetten binnen de luchtvaart. Drones kunnen niet alleen bijdragen aan sneller incidentbeheer op het water, maar hebben ook potentieel voor revolutionaire verbeteringen in wegbeheer, verkeersmanagement en incident magement. Dit onderzoek richt zich op de mogelijkheden en uitdagingen van het inzetten van drones door Rijkswaterstaat voor wegverkeersmanagement, inclusief beleidsmatige en technologische aspecten.

Niet alleen het innovatieproces zelf, maar ook de multi-actoromgeving waarin dat proces plaatsvindt en die zich in de loop van de tijd afspeelt, zijn belangrijke aspecten van het probleem. Daarom dat het onderzoek zal deze analyse zal doen met behulp van het Multiple Streams framework van Kingdon. Dit framework is aangepast om dat het wordt toegepast op de innovatie drones binnen de organisatie RWS. Het aangepaste framework omvat drie stromen die de dynamiek van innovatie beïnvloeden: de probleemstroom, de technologische stroom en de regelgevings- en beleidsstroom. Deze aanpak biedt een meer holistisch beeld van de manier waarop verschillende factoren en actoren werken komen samen in de besluitvorming in de loop van de tijd, wat cruciaal is voor een succesvol implementatieproces. De studie streeft ernaar om een diepgaander begrip te krijgen van de effectieve toepassing van dronetechnologie door RWS, en de benodigde beleidsmaatregelen om dit te ondersteunen. De centrale onderzoeksvraag die hierbij beantwoord moet worden is: Hoe kan de innovatieve drone-technologie worden geïmplementeerd door een organisatie zoals Rijkswaterstaat?

Om deze vraag te beantwoorden, zijn er specifieke subvragen geformuleerd: (1) Met welke uitdagingen heeft RWS in de loop der tijd te maken gehad op het gebied van wegverkeersmanagement? (2) Wat zijn de kansen en uitdagingen van dronetechnologie in relatie tot het wegverkeersmanagement van RWS, zowel historisch als actueel? (3) Wat zijn de uitdagingen van wet-, regelgeving en RWS-beleid met betrekking tot drones voor RWS-wegverkeersbeheer in de loop van de tijd? (4) Op welke manier zijn de bevindingen uit de probleemstroom, technologiestroom en regelgevings- en beleidsstroom in de loop van de tijd samengekomen om een 'window of innovation opportunity' te creëren voor de effectieve implementatie van drones voor RWS-wegverkeersbeheer?

Het onderzoek maakt gebruik van een kwalitatieve benadering om de dynamiek rondom droneimplementatie binnen RWS grondig te onderzoeken. Eerst zal een het theoretisch framework worden uitgeled. Vervolgens vertelt een literatuurstudie over dronetechnologie wat de huidige toepassingen en uitdagingen kunnen zijn van deze innovatie. Daarna, een actorenanalyse om de verschillende belanghebbenden in het drone-ecosysteem in kaart te brengen. Vervolgens wordt er inzicht verkegen in de huidige problemen met betrekking tot de implementatie van drone-innovatie aan de hand van semi-gestructureerde interviews met experts en betrokkenen. Deze methode wordt gebruikt om een manier te vinden om drones te integreren in het verkeersmanagement van RWS. Informele communicatie, zoals bijeenkomsten en expertsessies, wordt ook benut voor waardevolle inzichten.

Het antwoord op de eerste deelvraag omvat de huidige uitdagingen voor RWS in het beheer van wegverkeer. Dat zijn complexe vraagstukken zoals efficiënt incidentmanagement, verkeersstromen monitoren en infrastructuur beheren, terwijl ook de privacy van burgers gewaarborgd moet blijven. Budgettaire beperkingen en personeelstekorten dwingen RWS Wegverkeermanagement tot strategische keuzes, terwijl de voortdurende druk om te innoveren de complexiteit van hun taken verhoogt door de noodzaak om nieuwe technologieën en werkmethoden te omarmen.

In het kader van de tweede deelvraag kunnen drones tal van kansen bieden om het beheer van wegverkeer te verbeteren, zoals bij incidentmanagement, verkeersmonitoring, en infrastructuurinspec-

ties. Echter, uitdagingen zoals handmatige besturing, beperkte autonomie en wettelijke beperkingen blijven voorlopig bestaan.

Zoals de derde deelvraag vereist zijn er een aantal uitdagingen betrekking tot wet- en regelgeving en RWS-beleid gedetecteerd. Het ontbreken van duidelijke richtlijnen voor operaties buiten het zichtbereik (BVLOS) compliceert de vergunningsprocedures. De noodzaak van een helder wettelijk kader voor BVLOS-operaties wordt benadrukt om een soepele integratie van drones in operationele werkprocessen mogelijk te maken. Er is een gebrek aan bewustzijn binnen de RWS Wegverkeermanagement directie over de voordelen van drones, evenals het ontbreken van expliciete strategische plannen voor het gebruik van drones. Dit gebrek aan specifieke richtlijnen kan de integratie van drone-initiatieven bemoeilijken en de prioritering van innovatie binnen de organisatie beïnvloeden. De overgang van een intrapreneurship mindset, die wordt gekenmerkt door een meer organische en opportunistische aanpak naar een gestructureerd proces zoals het Innoveren Uniformeren en Produceren proces, kan ook uitdagingen met zich meebrengen vanwege de invloed ervan op de prioritering van innovatie. Het is van cruciaal belang om nauw samen te werken tussen beleidsmakers, wetgevers, interne RWS-afdelingen en externe belanghebbenden om een raamwerk voor innovatie te creëren dat de effectieve integratie van drones mogelijk maakt.

De vierde deelvraag vraagt om een integratie van bevindingen uit de probleem-, technologie- en regulerings- en beleidsstromen. Dit biedt een routekaart voor de creatie van een 'window of innovation opportunity'. Het herkennen van inefficiënties in incidentbeheer en het spiegelen van succesvolle drone-toepassingen in andere sectoren, zoals de maritieme industrie, illustreert potentiële oplossingen. Dit omvat het experimenteren met BVLOS-vluchten om binnen het 'gouden kwartier' na een incident aanwezig te zijn, het toewijzen van voldoende mensen en middelen en het samenwerken met regelgevende instanties zijn slechts enkele stappen om een raamwerk voor innovatie te creëren dat de effectieve implementatie van drones in RWS-wegverkeersbeheer ondersteunt.

Het gebruik van Kingdons model biedt een nieuwe kijk op deze theorie, aangezien het model meestal wordt toegepast op nationaal beleidsniveau en in bredere beleidscontexten. Desalniettemin biedt de toepassing van dit model in het RWS-caseonderzoek inzicht in hoe dit model kan worden aangepast en toegepast op specifieke organisatorische contexten en beleidsterreinen. Hoewel het model inherent beschrijvend is, kunnen concrete stappen op basis van de principes RWS helpen bij het identificeren en creëren van 'windows of innovation opportunity'.

Om een 'window of innovation opportunity' te verkrijgen voor de effectieve implementatie van drones, zijn veranderingen op verschillende niveaus noodzakelijk. Intern moet Rijkswaterstaat (RWS) zich voorbereiden door operationele uitdagingen te identificeren, de voordelen van drones te erkennen en een cultuur van innovatie te bevorderen. Dit vereist investeringen in middelen, communicatie en beleidsaanpassingen. Extern moeten de wet- en regelgeving worden aangepast om BVLOS-operaties mogelijk te maken en moeten samenwerkingsverbanden met andere Drone2Go-partners worden opgezet om kennis en middelen te delen. Het is essentieel te beseffen dat het interne 'window of innovation opportunity' van RWS, waarbij het probleem wordt erkend en investeringen in drone-oplossingen worden gedaan, niet noodzakelijkerwijs samenvalt met het externe 'window of innovation opportunity' wat betreft wetgeving of bereidheid tot samenwerking met andere partners. RWS staat voor een strategische keuze: strikt het model van Kingdon volgen en wachten op een extern 'window of innovation opportunity', of nu verder onderzoek uitvoeren naar de waarde van geautomatiseerde drones voor incidentmanagement in een Proof of Concept, om een intern 'window of innovation opportunity' te creëren. De POC is essentieel om de potentiële waarde van drones voor wegverkeersmanagement te beoordelen en de sector te overtuigen van deze waarde. Daarnaast worden beleidsmakers van RWS aangeraden om een afgewogen keuze te maken voor het toewijzen van bestaande middelen en budgetten ter ondersteuning van droneprojecten, de interne bewustwording van de voordelen van drones te verhogen door campagnes en het delen van succesverhalen bij zowel de operatie als het management. Het is belangrijk om samen te werken met regionale organisatieonderdelen om specifieke problemen te identificeren die drones kunnen oplossen en de dialoog tussen afdelingen en managementteams te bevorderen. Beleidsmakers dienen samen te werken met ILT en andere instanties om regelgeving aan te passen voor BVLOS-operaties en actief deel te nemen aan de BVLOS Roadmap.

Contents

1 Introduction

Traffic congestion is a constant source of annoyance to motorists. The number of traffic jams in the Netherlands is increasing. In 2022 the traffic jams will have doubled compared to the previous year (Rijkswaterstaat, 2023d). This results in roads that are heavily used and incidents occur which create traffic jams. Therefore, more supervision is needed. Drones can be useful for that.

They offer promising capabilities for various applications such as traffic monitoring, infrastructure management, and incidents response. They can perform operations that are challenging for manned aircraft, such as real-time traffic data collection and supporting emergency services by responding quickly and cost-efficiently to emergencies (Chowdhury et al., 2023; Outay et al., 2020). Additionally, drones can be used for reconstructing accident scenes, providing more efficient and precise data compared to traditional methods (Iman Norahim et al., 2023). In disaster management, drones play a crucial role in damage inspections and optimising rescue logistics through advanced techniques like deep learning (Hu et al., 2023; Wang et al., 2021). Furthermore, drones contribute to traffic safety by detecting vehicles and analysing traffic flows (Bisio et al., 2022; J. Li et al., 2019), and they are valuable for infrastructure monitoring by swiftly and accurately collecting data, even under challenging conditions (Casierra et al., 2022; Outay et al., 2020).

The Ministry of Infrastructure and Water Management aims to facilitate the use of unmanned aerial vehicles (drones) for various societal applications and innovations, such as accident response and building inspections. They are focused on developing policies and collaborating with relevant stakeholders to promote the integration and safe deployment of drones (Ministry of Infrastructure and Water Management, 2023a).

1.1. Problem statement

On waterways, drones offer clear benefits, enabling incidents to be handled 15 to 30 percent faster (“Drones nemen bij Rijkswaterstaat een hoge vlucht”, n.d.). By providing aerial perspectives, they facilitate quicker decision-making and faster emergency response times. Moreover, contractors tasked with pollution cleanup can promptly initiate their work, as drones efficiently identify necessary resources and deployment areas (“Drones nemen bij Rijkswaterstaat een hoge vlucht”, n.d.). Rijkswaterstaat (RWS) strategically employs drones for maritime and water management.

Drones have the potential to revolutionise road incident management, traffic monitoring, and infrastructure inspection (Rijkswaterstaat, n.d.-a). Their capability to swiftly and accurately gather aerial data can enhance operational efficiency and introduce new opportunities for data-driven decision-making. However, their utilisation in road traffic management by RWS is not yet optimised. Moreover, the implementation of this innovation in RWS’s road traffic management remains unclear.

The fact that drones are already used within RWS but are not yet optimally deployed in road traffic, despite literature demonstrating numerous potential applications, calls for further investigation. Also, this illustrates that within an organisation, there exist various dynamics with divergent opinions and priorities. The maritime and water management dossier differs from the road traffic management dossier. Development departments often seek to push innovations, while operational departments prioritise stability, and directors must balance these with constraints such as capacity and budget. This results in a complex layering and contributes to a non-linear implementation process.

Therefore, it is crucial to investigate not only the innovation itself but also the environment in which the innovation process takes place. Traditional innovation theories such as Rogers’ Diffusion of Innovations and the Davis’ Technology Acceptance Model are less suitable for this study. These theories primarily focus on the diffusion and acceptance of innovations among individuals and do not adequately consider the organisational, social, and political context (Davis, 1989; Rogers, 1995).

A decision-making approach, on the other hand, is more suitable as it accommodates the complex and dynamic nature of policy-making surrounding innovation within a multi-actor environment like the

RWS organisation. This approach provides a more holistic view of how different factors and actors come together in decision-making over time, which is crucial for a successful implementation process.

1.2. Knowlegde gap and Research question

The knowledge gap in this context is understanding why drones, despite literature on their proven benefits and their existing use within RWS for maritime purposes, are not optimally integrated into road traffic management of RWS. This gap necessitates exploring the decision-making processes, stakeholder dynamics, and organisational factors that hinder or facilitate the implementation of drone technology in this specific domain. Therefore, the following research question has been formulated:

How can an innovative technology, such as drones, be implemented by a road management organisation, like Rijkswaterstaat?

This research question will be answered with a decision-making approach using Kingdon's multiple stream theory (Kingdon, 1984). Alleviating the problem requires an interdisciplinary approach, involving empirical research on policy agenda-setting and implementation processes. This research will therefore contribute to policy sciences, with a focus on Kingdon's policy-making theory. It provides an empirical application of Kingdon's theory to the integration of drones in road traffic management within an organisation and exploits a multi-actor approach. This will contribute to advancing the scientific field of policy analysis and will be relevant to researchers, policymakers and practitioners involved in policy concerning the use of drones in road traffic management.

1.3. EPA Relevance

Answering the research question relates to the master's program of Engineering and Policy Analysis due to the complexity of the problem. The implementation of drones for road traffic management intersects with several grand challenges, particularly in the realm of transportation and infrastructure. Efficient traffic management is essential for economic growth, social well-being, and environmental sustainability. By leveraging drone technology, road authorities like RWS can address critical issues such as congestion, incident management, and infrastructure maintenance, contributing to the broader goal of creating smarter and more sustainable transportation systems. The research acknowledges the systemic nature of road traffic management challenges faced by RWS. It encompasses various aspects, including incident management, traffic monitoring, infrastructure inspection, and regulatory considerations. By taking a holistic view of the challenges and opportunities, RWS can better understand the interrelation of different factors and develop comprehensive strategies for integrating drone technology into their operations effectively. The topic is considered from a multi-actor perspective, since it encompasses various stakeholders who play crucial roles in the implementation and regulation of drone technology within the transportation sector. Furthermore, it addresses pressing issues faced by RWS in road traffic management, such as budget constraints, personnel shortages, and the need for innovative solutions to enhance operational efficiency. By identifying key challenges, opportunities, and regulatory considerations, stakeholders can develop evidence-based policies and strategies to facilitate the effective implementation of drone technology. Additionally, the proposed solutions and recommendations offer actionable insights that can inform policy decisions at both the organisational and governmental levels, ultimately shaping the future direction of road traffic management practices.

1.4. Societal relevance

The social relevance of this research is significant as it has the potential to improve various aspects of everyday life. The use of drones in road traffic management can increase road safety, manage traffic flows more efficiently and improve environmental protection measures. This can lead to cost savings for the government and individuals, as well as economic growth through reduced traffic congestion. Moreover, the use of drones promotes innovation in transport technology and creates new job opportunities in the emerging drone industry. By encouraging collaboration among stakeholders and pursuing shared goals, the research also contributes to building resilient communities and strengthening social cohesion.

1.5. Outline

The upcoming chapter will provide a detailed explanation of the theory framework. The subsequent chapter will delve into the current literature on the possibilities and challenges of drone technology. The research approach will then be described, after which an actor analysis will be carried out. Following that, there will be four chapters where the analysis of drone implementation in RWS according the Kingdon's framework will be conducted. In which the streams and their possible convergence will be discussed. The chapters will address the bottlenecks and opportunities of the decision-making process regarding drone implementation. Afterwards, a thorough discussion of the results and their limitations will be presented. Subsequently, a conclusion with the answer on the main research question will be provided, accompanied by recommendations based on the findings and for future research.

2
Theory framework

This theoretical chapter explores the framework for implementing innovation. Innovation has become crucial for organisational growth and competitiveness, but its success depends heavily on how effectively it is implemented within an organisation. The focus is not only on the decision-making process around innovation, but also on the broader context in which this implementation takes place, with special attention to policy and organisational aspects.

2.1. Innovation theories

Implementing an innovation necessitates a process where decisions are made to address complex problems with creativity (Pietronudo et al., 2022). The successful implementation of a new innovation, such as drones, within an organisation, such as Rijkswaterstaat, requires a comprehensive understanding of the complexities involved in integrating new technologies into existing operational frameworks. The scientific literature offers a wide range of tools and methods for analysing innovation within an organisation. Rogers' Diffusion of Innovations (DOI) Theory focuses on how new ideas and technologies spread within a social system. This theory identifies five factors that influence the speed and degree of adoption: comparative advantage, compatibility, complexity, testability and observability (Rogers, 1995). Rogers' theory could be valuable for understanding the diffusion of innovation within RWS across different segments and among its stakeholders. However, Rogers focuses primarily on the diffusion of innovation among individuals, with less attention to the specific dynamics within organisations. It also presents the adoption of innovations in a linear fashion, starting with creating an awareness about an innovation to making the decision on implementation (Lundblad, 2003). The Technology Acceptance Model (TAM) focuses on users' acceptance of technology and identifies two main factors: perceived usefulness and perceived ease of use (Davis, 1989). This model aims to understand individual users' attitudes towards new technologies and their willingness to use them. Although TAM provides a framework for RWS to comprehend individual perceptions of drone technology for its usage in road traffic, it overlooks social and organisational factors that can influence technology acceptance (Ajibade PhD, 2018). Therefore, it is lacking insight into the broader context of technology implementation within an organisation like RWS. Evolutionary Game Theory (EGT), on the other hand, models the interactions between different actors as strategic games in which success depends on the choices made by others (Weibull, 1997). This theory could help analysing how different stakeholders inside and outside RWS cooperate and compete in the implementation of an innovation. In the case of the use of drones in road transport, EGT would focus on understanding the factors that influence the acceptance or rejection of drones over time, such as competition between different stakeholders, social behaviour and economic incentives (Ozkan-Canbolat et al., 2016). However, its use for analysis on the implementation of innovations in an organisation may be limited by a lack of attention to the dynamic environment where external factors, such as regulations regarding the technology or organisational processes, can affect the outcome of the predictions made by the theory.

2.2. Decision-making in innovation

EGT, DOI, and TAM could all provide suitable theoretical frameworks for RWS's case study on road traffic and the use of drones. However, they lack a comprehensive decision-making approach that incorporates stakeholder involvement, financial analysis, and process optimisation, essential for RWS to effectively implement innovations like drone use in road traffic management. It is crucial to investigate not only the innovation itself but also the multi-actor environment in which the innovation process takes place over time.

Yildirim et al. (2022) and Bartoli et al. (2008) highlight critical aspects of decision-making in innovation processes. Yildirim et al. emphasises collaboration and open innovation, underscoring the importance of stakeholder engagement in selecting suitable technological innovations. This approach not

only optimises the selection of innovative projects but also enhances their performance within organisational settings. Bartoli et al. (2008), on the other hand, examines the economic viability of innovative procedures in healthcare, using financial analysis to assess cost-effectiveness and sustainability.

For RWS, exploring frameworks such as EGT, DOI, and TAM could provide theoretical guidance for studying drone use in road traffic management. However, adopting an interdisciplinary decision-making approach allows RWS to systematically evaluate the impact of innovations on both technological potential and organisational dynamics in a multi-stakeholder environment. This approach facilitates better financial management, stakeholder engagement, and continuous improvement in innovation processes.

2.3. Decision-making in a Public Context

RWS's implementation of drone technology in traffic management requires not only a thorough understanding of innovative decision-making processes, but also of the broader policy context in which RWS operates. As a public organisation, RWS is influenced by laws and regulations, public expectations and policy frameworks. RWS contributes to the public interest by ensuring the safety, accessibility and sustainability of infrastructure (Ministry of Infrastructure and Water Management, 2023b). Engaging stakeholders and building consensus are therefore essential aspects in shaping effective policy (Lemke & Harris-Wai, 2015).

Several models of policy-making, such as the phase model and Kingdon's flow model, offer insight into how policy decisions are made and implemented. The phase model offers a structured approach by dividing the process into phases such as problem definition, policy formulation and implementation (Teisman, 2000). Kingdon's multiple streams model, on the other hand, emphasises the role of timing and the convergence of different policy streams that together enable policy change (Kingdon, 1984).

It asserts that policy changes occur when three "streams" come together over time and align with each other (Kingdon, 1984). Understanding the temporal dynamics of these streams is crucial for comprehending how policy agendas evolve and how windows of opportunity for policy change emerge and close. Therefore, it is not only important to understand how the policy making process is, but also to delve into when these policy making events occur. The timing and reasons behind policy making decisions are essential as they can significantly influence the effectiveness of implementation strategies and outcomes.

2.4. Decision-making in an organisation

Although Kingdon's streams model is commonly applied to analyse policy making in the public sector, its use to examine decision-making processes within organisations is less common.

Some have applied an interorganisational adaptation of Kingdon, as described by van Meer and Noordegraaf (2005), to analyse decision-making processes surrounding innovative workplaces, emphasising the influence of various actors. However, this research does not provide deeper insights into how the use of Kingdon varies within an organisation. Additionally, Timmermans (2013) discusses the unique dynamics and factors influencing decision-making in urban development using Kingdon's framework. He adapts Kingdon's Policy stream to a political-governance stream focusing on dynamics and interactions among actors in urban development, highlighting the role of timing and local government willingness. This differs from Kingdon's original focus on national policy and the role of political and administrative processes at that level.

There is therefore a clear gap in the literature regarding the application of Kingdon within intraorganisational contexts. Despite the rarity of such applications, there is a noticeable gap between Kingdon's original focus on national policy and the interorganisational application mentioned in previous studies, and the intraorganisational application proposed in this research. Interorganisational applications focus on interaction and collaboration between multiple organisations, with timing playing a crucial role. In contrast, intraorganisational applications deal with organisation-specific issues and policy solutions, such as operational inefficiencies or internal policy matters. The political-governance stream encompasses power dynamics, including the influence of different departments and leaders.

2.5. Choosing Kingdon's framework

There is a gap in the literature regarding the application of Kingdon's framework for intraorganisational analysis within a public context. However, in the implementation of drones into road traffic management, there exists a multi-actor environment where issues, drone solutions, and regulations evolve over time. Applying the Kingdon framework in this research could offer valuable insights into factors influencing innovation adoption within RWS, thereby contributing academically to Kingdon's theory in an intraorganisational and innovation context.

2.5.1. Kingdon's three streams framework

Kingdon's Multiple Streams Approach (MSA) builds upon Cohen, March and Olsen's (1972) Garbage Can Model by focusing on the understanding of policy formation through emphasising the significance of ideas (Cairney & Jones, 2016). The Garbage Can Model suggests that decision-making in organisations is often characterised by ambiguity, fluidity, and unpredictability. In this model, problems, solutions, participants, and choice opportunities are all seen as randomly coming together in a "garbage can" of possibilities. Decision-makers pick solutions not necessarily because they are the best, but because they are available when decisions need to be made (Cohen et al., 1972). Kingdon's MSA, while sharing some similarities with the Garbage Can Model in recognising the uncertainty and complexity of the policy process, differs in its emphasis on the role of ideas (Cairney & Jones, 2016). Rather than viewing policy decisions as arbitrary outcomes of a messy process, Kingdon's approach highlights the importance of ideas in shaping policy agendas and decision-making. Ideas are seen as central drivers that influence how problems are defined and what solutions are considered feasible. Three major process streams that Kingdon (1984) identified in the American federal government are (1) problem recognition, (2) the formation and defining of policy proposals and (3) politics. In the problem stream, the issue comes to the forefront. This occurs through three mechanisms that attract the attention of policymakers: (1) indicators such as data and reports; (2) focusing events such as disasters and symbols; and (3) other feedback channels such as media and public deliberation (Volles, 2016). Secondly, the policy stream is a collaborative effort involving a community of specialists (researchers, academics, and others) who play a central role. They develop new and existing ideas that could serve as solutions to existing problems. This process is akin to a 'primeval soup' in which ideas float around, merge, split, and rise or fall in popularity. Within this 'soup' are policy entrepreneurs, who are willing to invest various resources in hopes of a future return in the form of favourable policies. They are essential for the survival of an idea and form the basis for groups of supporters of specific policy measures. To survive, an idea must align with dominant values, be technically feasible, and anticipate potential constraints (Kingdon, 1984). Third, the political stream is composed of events such as changes in the national mood, public opinion, or election results. Here, the primary actors, which are the visible government actors, introduce agenda items rather than alternatives and strive to form a consensus (Kingdon, 1984; Volles, 2016).

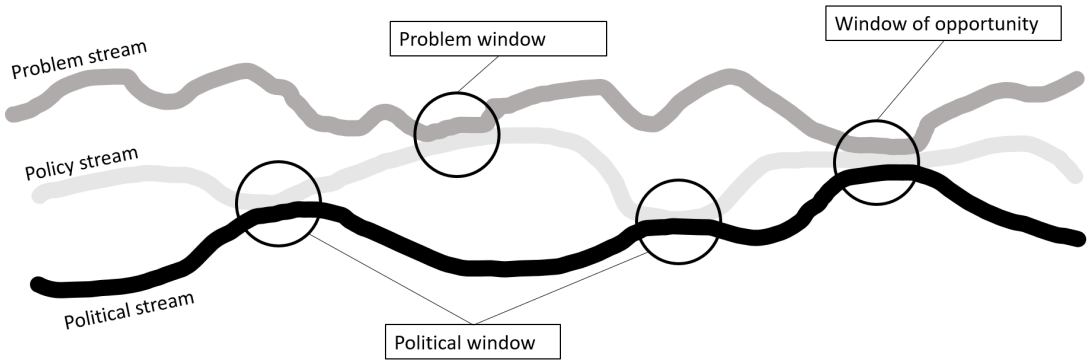


Figure 2.1: Kingdon's multiple streams model (Figure from (Enserink et al., 2013), modified by the author)

An important new element in the model is the metaphor of a 'policy window'. A policy window occurs when there is an opportunity to push the three streams together by advocating attention to their special

problems, or their pet solutions. A problem window often emerges in response to events that bring the problem to the forefront and emphasise the need for policy action. The problem captures the attention of policymakers, and a sense of urgency arises to take action. In contrast, a political window opens in response to political changes, such as elections or shifts in public opinion. It refers to a period when political conditions are favourable for the approval or implementation of specific policies, even though the problems may not have changed at all, nor the solutions (Kingdon, 1984). Kingdon's MSA provides an understanding of policy formation, highlighting the efforts of policymakers, experts, and other actors to frame issues, propose solutions, and shape the policy agenda. This approach emphasises the active role of individuals and organisations in shaping policy outcomes (Kingdon, 1984).

2.5.2. Revised three streams framework

Since this research focuses on the implementation of innovation, we explore whether the Kingdon framework needs to be adapted to understand the complex processes of innovation implementation.

Kroll and Adelle (2022) used the theory of multiple streams and the concept of "policy windows" Kingdon (1984), in conjunction with the theoretical framework on securing vital systems Collier and Lakoff (2014), to demonstrate how the government and civil society collaborated to innovate and mitigate the impacts of the COVID-19 crisis. Furthermore, the study of Huber-Stearns et al. (2019) utilised the framework to analyse the emergence and implementation of Watershed Protection Partnerships (WPPs), with various streams contributing to the formation and execution of this governance innovation. The research of Elzen et al. (2011) investigates how normative concerns, such as sustainability and animal welfare, drive system innovations, particularly focusing on their effectiveness in influencing transitions. By employing insights from social movement theory and political science, it examines the interplay between normative pressures and other streams, such as regulatory, market, and technology factors. Ilieva et al. (2023) employs a similar approach by combining the multiple streams model with the multi-level perspective on socio-technical transitions. They describe innovations as solutions that reside within the policy solution stream, of which some decision-makers may perceive as "fitting well", although they may not be politically or administratively feasible.

In the examination of policy formation and innovation implementation, a revised version of the multiple streams framework is considered. Acknowledging that the focus goes beyond traditional policy considerations to include dynamics of implementing an innovation, inspiration is drawn from the work of Elzen et al. (2011). This framework delineates four distinct streams that influence innovation dynamics: the problem stream, regulatory and political stream, market stream, and technology stream. The problem stream follows from an interest in normative contestation, focusing on societal debates and disagreements regarding perceived problems. The regulatory and political stream is the merged policy and politics stream from Kingdon's model. It is based on institutional environment which contains social groups that affect industries in non-commercial ways, e.g. policy makers, social movements, the wider public, media, public opinion; regulatory legitimacy and cultural-normative legitimacy. The market stream refers to the influence of consumer preferences and market dynamics on shaping transitions within a system and is rooted in the task environment which includes social groups that engage in economic exchanges and transactions with industries. The technology stream generates potential solutions, innovations, through R&D, with mainstream researchers focusing on incremental innovations while others pursue radical changes, often operating within the niche regime. Turning to the current research, which centres on the implementation of innovation, the focus aligns with the framework of Elzen et al. (2011).

Therefore, for this research, the choice is made to examine the problem stream due to an interest in incident management and the potential alternative applications for drones within RWS operations. Since this research focuses on innovation in a public context rather than on policy and politics per se, the other two original streams of Kingdon have been adjusted. The second stream is the technology stream. This stream is based on the flow of new ideas and solutions that can address the problems identified in the problem stream. Since this research focuses on the specific innovation of drones, technological advancements related to drones will be analysed here. The regulatory and policy stream, combining the policy and politics stream from Kingdon's model, has been chosen as third second stream. It is important to note that the term 'policy' in the phrase 'regulatory and policy stream' refers to the policies of RWS. This includes the organisation's guidelines, strategic objectives, project execution procedures, personnel management, and budgeting. The market stream highlighted by Elzen is not included because the influence of market dynamics and consumer preferences is less

relevant in a public, intraorganistional, and non-commercial context. By focusing on these streams, a comprehensive understanding of the multifaceted dynamics shaping innovation implementation within the research context is sought.

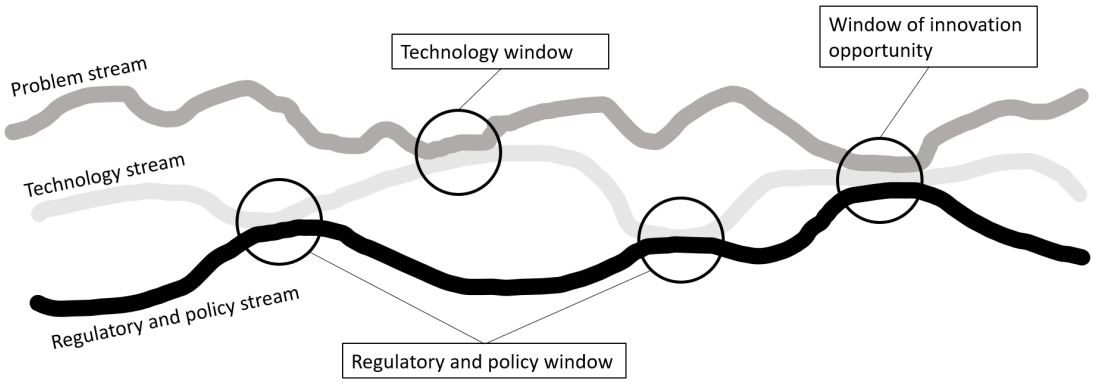


Figure 2.2: Revised multiple streams model (Adapted from (Enserink et al., 2013), and modified by the author)

A linkage between the problem stream and the technology stream is known as a technology window. This window opens when an event brings problems to the forefront and drones, as a technological solution, can address these issues. A linkage between the technology stream and the regulatory and policy stream occurs when there is a change in regulation or policy that aims to promote the use of drones, even if specific applications are not yet defined. However, an 'window of innovation opportunity' will only emerge when all three streams converge.

3
Drone Technology and Applications

In this chapter, the state of the art regarding drone technology will be accessed. Conducting a literature review is necessary to offer an overview of the existing information about why drones are a unique innovation and to define core concepts. Together with the theoretical knowledge gap defined in the previous chapter, the assessment of these core concepts will address the knowledge gap of the research Subsequently, a research question will be formulated based on the identified knowledge gap and the research objective.

3.1. Drones are an innovation

What is an innovation? A distinction is made between invention, improvement and innovation. Invention deals with the initial creation of a product. Invention addresses a specific problem by using technology, where the technical aspects serve a functional purpose (Dieffenbacher, 2024). An improvement aims for better results. It is a transformation by improving something that already exists to a higher level of quality or efficiency ("Improvement vs. Innovation: Defining the Differences", 2023). It focuses on refining and optimising current practices or products rather than introducing something entirely new. The term "innovation" comes from the Latin verb "innovāre," which means to introduce new things, ideas or ways of doing something (Dieffenbacher, 2023). Drones fall into the latter category. Drones combine various existing technologies, such as remote control, GPS, cameras, and sensors, in innovative ways. The development of drones have led to new opportunities and applications across a wide range of industries, making them a prime example of technological innovation in the modern era.

3.2. Literature review

To really understand what the opportunities of drone technology are, a literature search will be performed to understand the current state of knowledge. Drawing inspiration of the 2022 Annual Report of Drones2Go, the literature search will distinguishes two categories, namely technology and implementation process ("Drone2Go jaarverslag 2022", n.d.). For technology, it looks at existing technology and application options. There will also be a literature review of the current process, which will look at the challenges and considerations involved in integrating new technologies such as drones, such as legal challenges and social acceptance. Appendix A provides a detailed description of the strategy used for the literature search. This strategy includes the methods and sources used to find and select relevant literature for analysis in this study. The description of the literature search strategy provides transparency and repeatability of the research procedure, reinforcing the credibility and reliability of the findings.

3.3. Core concepts

The fundamental concepts analysed from the literature are presented. These concepts serve as the foundation for the research and provide a coherent approach to exploring the underlying issues.

3.3.1. Characteristic of drones

Drones bring together several key technological advancements and a distinct innovation, especially in the context of road authorities, waterway authorities and incident management, for several reasons:

1. Unique Perspective: Drones offer a unique "eyes from the sky" perspective (Bisio et al., 2022). They can access hard-to-reach areas where traditional aid workers may not be able to reach (Gupta et al., 2020). This allows road authorities to quickly assess traffic congestion, road closures, and accident scenes.

2. Speed: Drones can reach the scene quickly and provide assistance in emergency situations, reducing the response time of emergency services. This is especially important in traffic accidents, where every second counts to save lives (Gupta et al., 2020). They can rapidly assess situations, helping road authorities allocate resources more efficiently (Outay et al., 2020).
3. On-Demand Deployment: Drones can be deployed when and where road authorities need them, providing flexibility and agility for incident response and traffic management (Gupta et al., 2020).
4. Cost-effective: Drones are more cost-effective and efficient in various operations compared to traditional manned aviation (Outay et al., 2020).
5. Data Collection: Drones gather data that was previously challenging to obtain in the field, such as traffic flow patterns and road condition assessment (Chowdhury et al., 2023). This data aids road authorities in making informed decisions and optimising traffic management. Sharing information about the situation on the ground allows emergency services to better prepare and get a better understanding of the emergency situation before arriving at the scene, so they can act more efficiently upon arrival (Gupta et al., 2020).
6. Regulatory Challenges: The widespread use of drones in traffic management has led to regulatory and privacy challenges that road authorities need to address. Innovations related to airspace management and privacy protection are crucial in this context (Lee et al., 2022).

3.3.2. Technology and applications of drones

The literature review also provides an overview of recent developments regarding the application of unmanned aerial vehicles (UAV), or drones. They can perform airborne operations that are more difficult to carry out by a manned aircraft. The study presents how drones are being used for road safety and disaster response, traffic monitoring and management, and infrastructure management.

Incident management

Drones offer significant potential for incident management and emergency response. They can be equipped with advanced technologies, such as cameras, microphones and mobile internet, allowing them to provide real-time information to emergency services. This information can be invaluable, such as providing professional medical instructions before the arrival of an ambulance (Gupta et al., 2020).

One of the advantages of drones is their ability to optimise the response of emergency vehicles (EVs) to incident locations. They can be used to collect real-time traffic data, such as traffic density and vehicle speeds, allowing them to identify the fastest and most efficient routes for EVs and minimise congestion (Chowdhury et al., 2023; Outay et al., 2020). In addition, drones can serve as lead vehicles for EVs, driving ahead to clear the road and alert other road users. This helps shorten the travel time of EVs and avoid traffic jams at crucial points such as intersections (Chowdhury et al., 2023).

Another important application of drones is in accident investigation, where they are used to reconstruct accident scenes. Traditional methods, such as sketching the accident scene and using photographs, have some drawbacks. They are time-intensive and often result in limited data. The use of drones can provide more efficient and accurate reconstructions, as they collect data faster, and have the ability to produce 3D images and the ability to correct errors in the data (Iman Norahim et al., 2023; Outay et al., 2020).

In the field of relief, drones can be invaluable in delivering medical supplies to remote areas where traditional relief efforts are difficult to reach. This can save lives by bringing supplies during health crises such as the Ebola outbreak and the Covid-19 pandemic as well as transporting antidotes for snakebites or defibrillators for out-of-hospital cardiac arrests (Gupta et al., 2020; Wang et al., 2021).

Disaster response

Drones are of increasing importance in disaster response, where they are used for damage inspections after natural disasters such as earthquakes and typhoons, and for topographic mapping to optimise rescue logistics (Wang et al., 2021). Hu et al. (2023) describes an innovative approach for using drones in automated building damage reconnaissance and mission planning, aimed at improving the efficiency of disaster response. The method uses advanced deep learning techniques to enable drones to accurately detect and classify different categories of damage. This is an improvement over existing methods by being highly accurate in detecting and classifying damage, with fast processing speed.

It also integrates the collected information into a drone mission planning system. This system uses optimisation algorithms to plan drones' routes and tasks, with the aim of maximising response efficiency. It takes into account various operational constraints, such as drone battery life and available resources. This allows emergency responders to react quickly and effectively to emergencies, reducing the impact of natural disasters on communities (Hu et al., 2023).

Traffic and infrastructure monitoring
Drones are increasingly used for traffic monitoring because of their mobility and ability to collect data from different perspectives. Using machine learning and deep learning techniques, drones can perform complex analysis and provide valuable insights for traffic management. They can effectively detect, track and count vehicles, allowing traffic parameters such as vehicle speed and vehicle density to be extracted even with only one camera pointed at the ground surface (Bisio et al., 2022; J. Li et al., 2019; W. Li et al., 2019; Outay et al., 2020). The data obtained on traffic parameters can be used for various analyses of traffic flows. This includes assessing road designs and analysing traffic patterns such as shock waves and waiting times at intersections, as well as observing driving behaviour, such as lane switching and aggressive driving, which can help detect anomalies and address traffic problems (Bisio et al., 2022; Outay et al., 2020). Drones can play a role in road safety risk assessments, for example by measuring collision risks during merging on highways and detecting emergencies using onboard vision processing. Using a network of multiple UAVs, coordinated with decision-making techniques and onboard devices, can improve road safety (Outay et al., 2020). However, it is important to note that further research is needed to improve risk assessment methods, especially given the continuous advances in UAV technology.

Drones are invaluable for monitoring infrastructure projects. They improve efficiency by collecting data quickly and accurately without the need for physical personnel on site. This not only reduces the risk of accidents in hard-to-reach locations, but also enables advanced damage identification, even under different weather and light conditions. In addition, drones can create detailed 3D models of road surfaces, which is crucial for assessing road conditions and planning maintenance works. Moreover, drones offer real-time monitoring and advanced data analysis capabilities, allowing project managers to react quickly to problems and make decisions based on accurate information (Casierra et al., 2022; Outay et al., 2020).

Limitations
Despite the literature illustrating many applications of drones, there are also technology limitations indicated. Outay et al. (2020) notes that battery life is a major limitation for unmanned aerial vehicles, which can typically fly for only 25-30 minutes. Communication between unmanned aerial vehicles and ground stations also consumes energy, requiring efficient routing protocols and optimisation algorithms to balance energy consumption and operational efficiency. In addition, drones may be limited in their ability to operate under extreme weather conditions, such as heavy snowfall or rain. This can reduce their effectiveness and compromise the safety of operations (Gupta et al., 2020).

3.3.3. Implementation process
For large-scale implementation of drones, there are still several challenges to overcome. A major hurdle is airspace regulations, especially in urban areas. The Netherlands has successfully adopted the EU's drone classification according to EU 2019/947. While it uses the EU regulation as the basis for classification, registration, licensing and supervision, it also enforces country-specific rules for drone flights (Lee et al., 2022). Ensuring the physical safety of both drone operators and people on the ground is an important ethical consideration. This includes minimising risks of accidents, collisions and other incidents that could cause injury (Wang et al., 2021). Regarding privacy, the Netherlands recognises the General Data Protection Regulation (AVG), but specific rules for drones are lacking (Lee et al., 2022). Nevertheless, the use of drones with cameras remains a privacy issue, as people are concerned about being filmed without their consent. The lack of specific privacy protection rules beyond the AVG may cause resistance to the use of drones for emergency response (Gupta et al., 2020; Lee et al., 2022).

3.4. Knowledge gap and Research Question
The Core concepts covered several applications of drones, including incident management, traffic safety, traffic monitoring and management, and management of (highway) infrastructure, all of which

are relevant to Rijkswaterstaat's operations. However, implementing drones proves to be challenging due to several factors, including regulatory issues, privacy considerations and safety requirements. Current laws and regulations related to drone use are complex, especially given the crucial role of drone safety. This makes it difficult for organisations to operate drones consistently and effectively. In addition, there are significant privacy concerns, as drones are able to collect and process data from a new aerial perspective, which can raise concerns about surveillance and data privacy.

While much literature exists on both the benefits and challenges of drones, there is a lack of specific studies or documentation on how road authority organisations such as the Rijkswaterstaat can effectively implement this drone technology in their operational processes by dealing with the aforementioned challenges. As concluded in the previous chapter, there is a gap in the literature regarding the application of Kingdon's framework for intraorganisational decision-making analysis within a public context. This exposes an important knowledge gap that forms the basis for the proposed research. This gap covers two essential aspects: first, the organisational need within Rijkswaterstaat for research on the integration of drones, and second, the lack of existing scientific literature on the application of Kingdon's framework on the implementation of innovations within this specific organisational context.

To address this gap as a decision-making process for which Kingdon's framework is applied, the following research question is proposed:

How can innovative drone technology be implemented by an organisation, such as Rijkswaterstaat?

4
Research Approach

This chapter outlines the research approach used to answer the research question: *How can innovative drone-technology be implemented by a road authority organisation, such as Rijkswaterstaat?*

The research builds on the theoretical framework discussed in Chapter 2, using Kingdon's theory of multiple streams as a guide for understanding innovation implementation processes within complex organisational contexts. In Chapter 3, a detailed literature review was carried out to understand the unique characteristics of drones as an innovation, and how these characteristics may affect their implementation in road management organisations such as Rijkswaterstaat (RWS).

This chapter serves as as a roadmap for the research, providing a clear framework for investigation. Beginning with a summary of the theoretical framework which are also be used for gathering data. Thereafter, the current use of drones by RWS is introduced as the case study of this research. Subsequently, specific sub-questions derived from the main research question are presented, explored within the context of the RWS case study. Following this, the methods and techniques for conducting the research are discussed, including the rationale behind choices and procedures for gathering, analysing, and interpreting data.

4.1. Theoretical framework

The revised theoretical framework draws from Kingdon's multiple streams framework for policy formation and the concept of "policy windows," (Kingdon, 1984). The focus is on understanding the complex processes of innovation implementation. The revised framework encompasses three streams that influence innovation dynamics: the problem stream, the regulatory and policy stream, and the technology stream. This framework provides a holistic approach to understanding the various aspects of innovation implementation within the public organisation of RWS, with specific attention to road and incident management and the use of drones within RWS operations. A more detailed explanation can be found in Chapter 2.

4.2. Case study

Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and Water Management. Within RWS, there are several organisational units, national and regional. Traffic and water management (VWM) is a national organisational unit that takes on the tasks of traffic management on the roads and waterways, and water management. Within the Shipping and water management (VWM - SWM) is RWS already looking at opportunities for drones for safety on the water. It takes a long time for ships to arrive on site when incidents happen (for example, due to a relatively small number of patrol boats). Therefore, drones could therefore quickly provide a picture of various events. Think of tracking down refugees or drowning people and helping the coastguard. But also the monitoring of environmental incidents, such as oil spills, or the inspection of offshore structures ("'Toezicht op zee met behulp van drones neemt een vlucht'", 2021). The Smart Patrol program of SWM stimulates innovations in shipping traffic and water management. They are investigating all kinds of techniques that help RWS to work more sustainably, more efficiently, in short, smarter ("Smart Patrol", n.d.). Then there is Road Traffic Management (VWM - WVM) which are about safety on the road network and road traffic management. Drones have the potential to revolutionise the way we manage road incidents, monitor traffic flows and inspect infrastructure assets.

4.2.1. Use of drones at Rijkswaterstaat

Since 2019, RWS has a operational RWS Drone that is deployed ad hoc for both maritime and road-related incidents. With 25 pilots with diverse backgrounds and a focus on both maritime and road traffic, the team is a key player within RWS. Organised under Bureau Incident Management Water and

Shipping, and with close involvement of various regional organisational units, the drone team plays a crucial role in monitoring and managing incidents in the Netherlands.

Drones offer a faster, more frequent and safer way to inspect bridges than traditional methods. Currently, these inspections are carried out by market players on behalf of the Rijkswaterstaat, with drones scanning bridges and using artificial intelligence to detect defects. As autonomous flying is not yet permitted, two people are currently needed to operate the drone and analyse the data manually. The future vision involves a single person remotely controlling a drone and analysing data automatically. Although many inspections have still been pilots, the plan is to fully integrate drones into the inspection process in the next 3 years (Rijkswaterstaat, n.d.-a).

4.2.2. Drone2Go

Drone2Go is a collaboration project has already been started, namely Drones2Go, in which partners work together on automatically flying drones under the leadership of Rijkswaterstaat. ("Drone2Go jaarverslag 2022", n.d.). They encourage the developments of drones and are jointly working toward a nationwide drone network where drones can fly independently to an incident 24 hours a day and share live images with emergency responders. Drone2Go operates as a collaborative program of government agencies with the goal of establishing a nationwide network of automatically flying drones for use in incident response, surveillance and inspection. The parties now affiliated with Drone2Go are RWS, Police, Fire Department, Human Environment and Transport Inspectorate (ILT), Customs, Coast Guard and the Dutch Food and Consumer Product Safety Authority (NVWA).

Deloitte conducted an exploratory study in October 2023 to guide the next steps for Drone2Go, focusing on advancing BVLOS flying and establishing a national network. The study affirmed Drone2Go's eligibility based on public interest, public task, and compliance with European legislation. Challenges in scaling BVLOS flying include legal and regulatory hurdles, necessary IT infrastructure, and drone technology limitations. Potential advancements include automatic and autonomous BVLOS flying. Network development entails organising IT and physical infrastructure and ensuring compliance with evolving regulations like U-space and CIS services. Three organisational forms were assessed: existing organisation with a primary mission, newly created organisation, and existing organisation with a business operation mission. An existing or newly created organisation is deemed suitable, with less favourability toward an existing organisation with a business operation mission. Next steps involve deciding on activities, implementation time frame, and organisational structure, with crucial considerations including stakeholder support, funding, and task allocation. The goal is to offer a mature and cost-effective solution, building upon existing initiatives like the RWS drone team.

Rijkswaterstaat's case study is relevant because their experiences with drone technology in the maritime sector may offer valuable insights for the use of drones in road traffic management. In addition, studying their practical applications of drone technology can help identify best practices, challenges and opportunities for using drones on the road.

4.3. Sub-questions

This study aims to provide an insight into the implementation of the innovation drones within an organisation and contribute insights to both academia and the Rijkswaterstaat organisation. This research examines the possibility of using Kingdon's descriptive theory of policy-making to formulate prescriptive recommendations. Therefore, specific sub questions derived from the main research question within the context of RWS have been drawn up. The first three sub-questions are inspired by the three streams, the problem stream, the technology stream and the regulatory and policy stream. The last sub-question looks at the convergence of these three streams over time. Sub-research questions:

1. What are the challenges RWS has faced in regard to road traffic management over time?

2. What are the opportunities and challenges of drone technology in relation to RWS road traffic management, both historically and currently?

3. What are the challenges of laws, regulations and RWS policies related to drones for RWS road traffic management over time?

4. In what way have the findings from the problem stream, technology stream and regulatory and policy stream converged over time to create a window of innovation opportunity for the effective implementation of drones for RWS road traffic management?

4.4. Research Method

This research uses a multifaceted approach to comprehensively investigate the dynamics surrounding drone implementations in the case study of Rijkswaterstaat. A qualitative research method was chosen for this study. This method is used to produce in-depth and illustrative information in order to understand the various dimensions of the problem under analysis (Almeida et al., 2017). It focuses on the understanding and explanation of the dynamics of social relations (Almeida et al., 2017; Mohajan, 2018).

This qualitative research uses different methods to collect and analyse data. First, a literature review was conducted in the previous chapters. An actor analysis was then be executed to delineate the different stakeholders in the drone ecosystem.

An exploratory study was then conducted to gain an understanding of the current issues related to the implementation of drone innovation. This phase involves a careful exploration of the current landscape that served as a basis for identifying current challenges and opportunities within this domain. The exploratory interviews can be found in Appendix D. In the second phase of the research, the framework was applied to conduct a detailed analysis of the identified opportunities and challenges, providing a thorough understanding of the potential growth opportunities and obstacles within the domain of drone technology for the Rijkswaterstaat organisation. The final interviews can be found in Appendix E.

Literature review

A literature review, also known as a literature search, is a research method that involves systematically collecting and synthesising previous studies. It provides an overview of existing knowledge within a specific field, enabling researchers to understand the current state of affairs, identify gaps in knowledge, and develop new insights. A well-conducted literature review establishes a solid foundation for advancing knowledge and facilitating theory development within a discipline (Snyder, 2019). Through a thorough analysis of existing literature, relevant theories and models applicable to the research area were identified, which facilitated the developing the theoretical framework for this research. Moreover, a literature review was performed to give the state-of-the-art of the innovation of drone technology, which delved into the unique properties of drones as an innovation.

Actor analysis

Actor analysis is a systematic process used to identify and understand the interests, positions, and relationships of various stakeholders involved in a policy-making or decision-making process. The actor analysis typically involves gathering data through various means such as interviews and document analysis to identify key stakeholders, understand their interests, assess their influence, and analyse their relationships with one another (Hermans & Thissen, 2009). Actors have problems and solutions (Teisman, 2000). They will serve as entrepreneurs of the three streams within this multi-actor environment. The actor analysis provides a valuable research method for identifying the entrepreneurs and interview candidates for understanding the complex dynamics of the implementation process of drones.

Interviews

Literature reviews form the basis of the study, specifically for sub-questions one, two and three. The study by Almeida et al presents the advantages and disadvantages of structured interviews and in-depth interviews (Almeida et al., 2017). The advantages of structured interviews are that the interviews are well-structured and easy to compare. Time-wise, these are quick to conduct and easy to replicate. Unfortunately, the predefined questions will make the interview lack flexibility. It is more difficult for the researcher to adapt the interview when intriguing research possibilities emerge. In-dept interviews, on the other hand, are useful for informal settings and you don't need as many participants to get useful information. The interviews can be modified to obtain more detailed information on a particular topic. The disadvantages of this are that it takes a lot of time and the verification process is more complicated when comparing and validating information.

Therefore, semi-structured interviews were conducted with experts and actors to identify a way to work together to implement drones in road traffic. How these actors which are interviewed, are selected can be found in Chapter 5.

The interview process began with exploratory interviews, providing initial insights and helping to identify key themes and areas of interest. The Exploratory interviews (Expl.) can be found in Appendix D. Following this, a second round of interviews was conducted, informed by Kingdon's Multiple Streams Framework. For each of the three streams guideline questions were developed to delve into specific issues and dynamics. These questions aimed to uncover insights into problem identification and framing, drone technology challenges and solution development and selection, and the political and policy processes and contexts that affect decision-making. The detailed interview guideline questions can be found in the appendix C. The Final interviews (Fin.) are summarised in Appendix E. This semi-structured approach ensures that the interviews are systematically aligned with the theoretical framework, providing a robust foundation for analysing the convergence of streams and the resulting window of opportunity for innovation.

Below is a table listing the interviewed actor along with their corresponding interview numbers, all of which can be found in the appendices referenced.

Table 4.1: Interviews with stakeholders

Department	Specific actor	Interview
RWS VWM - SWM	Flight operation manager1 RWS Drone team	Expl. 1, Fin. 5 (Problem & techn. stream)
RWS VWM - SWM	Flight operation manager2 RWS Drone team	Expl. 12
RWS CIV - OSR	Accountable manager RWS Drone team	Fin. 2 (Problem & techn. stream)
RWS CIV - OSR	Technical manager RWS Drone team	Expl. 2
RWS VC ZWN	Traffic traffic controller & RWS Drone team	Expl. 5
RWS VC NWN	Traffic traffic controller & RWS Drone team	Expl. 6, Fin. 9 (Problem & techn. stream)
RWS VC NON	Traffic traffic controller & RWS Drone team	Expl. 7
RWS VWM - SWM	RWS Drone Coordinator	Fin. 10 (Problem & techn. stream)
RWS VWM - SWM	Project Manager Detectie Op Een Brug	Fin. 6 (Reg. & policy stream)
RWS VWM - WVM	Project Manager Smart Mobility	Expl. 3, Fin. 1 (Reg. & policy stream)
RWS VWM - WVM	Implementation plan responsible	Expl. 4, Fin. 4 (Reg. & policy stream)
RWS VWM - WVM	Project manager Slimme Camera's	Fin. 3 (Reg. & policy stream)
RWS VWM-WVM	Network service Ice control	Expl. 9
RWS VWM-WVM	Traffic Information Gathering expert	Expl. 10
RWS VWM-WVM	Network service Incident management	Expl. 11
RWS WVL	RWS Innovation expert	Fin. 7 (Reg. & stream)
DGLM	unmanned aviation regulation expert	Fin. 8 (Reg. & policy stream)

Informal communication
Informal communication, which is conducted through events, meetings and expert sessions within RWS, is a collection method in this study. These informal meetings provide opportunities for spontaneous conversations and exchange of ideas with relevant stakeholders and experts. Active participation in these interactions allows researchers to develop a broader understanding of the issues under study and gain valuable insights for analysis.

Table 4.2: Informal communication gatherings

Gatherings	Date
Sparring sessions Smart Patrol	Every Monday: September 2023 - May 2024
Core team Drones meetings	15 Sep, 24 Oct, 5 Dec 2023, 27 Feb, 9 Apr 2024
Drone2Go compliance	14 September 2023 & 7 March 2024
Event BVLOS Roadmap	19 september & 4 december 2023
Event NGF Groeifonds	19 september 2023
Meetings: POC Automated Drones with NDW&PNH	Every 2 weeks: 26 September 2023 - 22 April 2024
Visit Droneland	4 April 2024
Deloitte research: Drone2Go	Every week: 28 September 2023 - 2 November 2024
Smart Mobility Project Event	9 October 2023
Community of practice Drones	9 November 2023
Expertsession Deloitte	13 November 2023
Directors' meeting Drone2Go	17 January 2024
Presentation Team Smart Mobility	21 February 2024

5
Actor analysis

To understand the implementation of drones as a technological innovation within the organisation of Rijkswaterstaat (RWS) in the field of road traffic and incident management, it is important to understand the actors that influence it. In this chapter an actor analysis is conducted. By identifying and categorising actors, insight is gained into their interests, power and interrelationships. This not only provides a holistic understanding of the context in which decisions are made, but also helps to foresee potential influences and implications of decisions. This analysis is essential because it clarifies the dynamics of actor interactions, which is needed to predict how and why certain policy decisions come about.

5.1. Power Interest Grid

Within the technological innovation of drones for road traffic management, there are numerous actors, including both external stakeholders such as regulators, suppliers, and developers responsible for legislation and drone hardware and software, as well as internal stakeholders within the RWS organisation involved in road traffic operation, management, and those with expertise in drone usage. As shown in figure 7.1, actors display varying levels of power and interest. In this section, the key players (high power/high interest), the context setters, the crowd, and the subjects will be described.

These actors have been identified through interviews conducted specifically for this report, analysis of internal documents from RWS, and a previously mentioned meeting as described in the report. An explanation of each individual actor can be found in the appendix B.

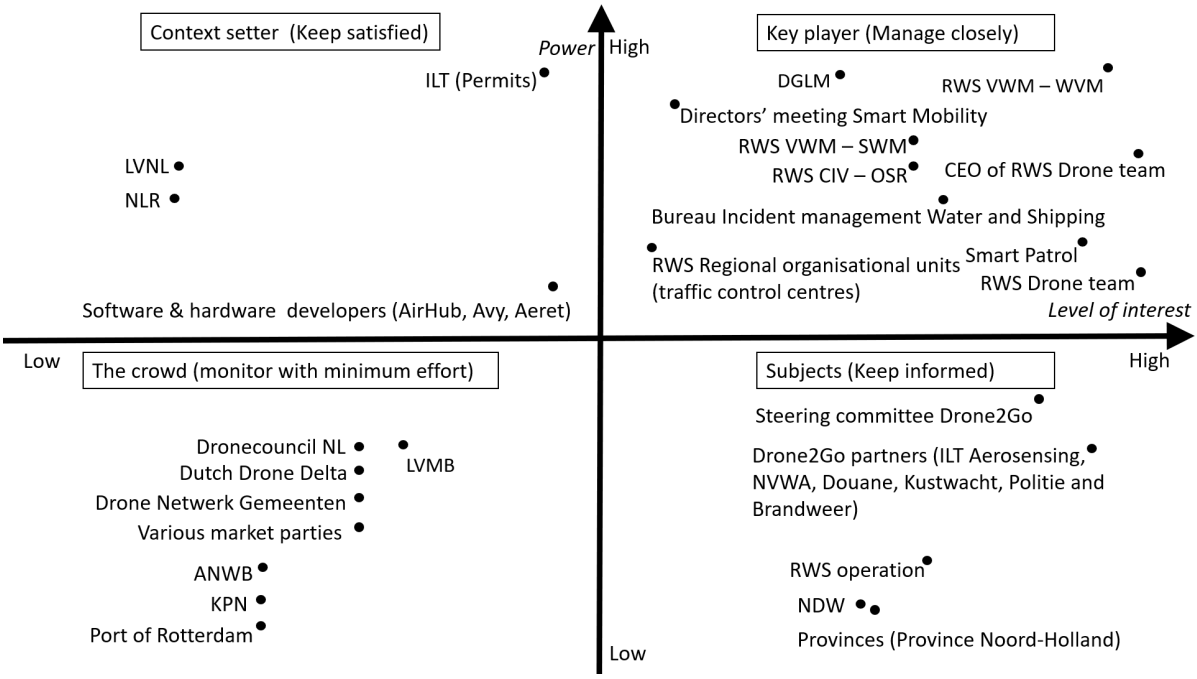


Figure 5.1: Power interest grid of actors

5.2. Key players

Within the context of RWS road traffic, there are multiple actors that are key players. The key players of the RWS case study are structured into five distinct groups to create a generalised framework. This approach ensures that insights drawn from this categorisation can be applicable and beneficial for other studies featuring diverse case studies beyond RWS.

Policy and regulatory authorities:

- *Directorate General of Aviation and Maritime Affairs* (DGLM) is in charge of for developing and implementing aviation policy and regulations, which directly affects the use of drones. A DGLM representative responsible for the drone dossier is a suitable interview candidate.
- The *Directorate of Road Traffic Management* (”Wegverkeermanagement” in Dutch or WVM) is part of the the national organisational unit for *traffic and water management* (RWS VWM). Within this directorate, the person responsible for creating the implementation plan, various network service managers, and a project manager leading another innovation project would be suitable interview candidates because they each bring unique perspectives and expertise within VWM - WVM.

Policy authorities from other domains within RWS utilising drones:

- The *Directorate of Shipping Traffic and Water Management* (”Scheepvaartverkeer en watermanagement” in Dutch or SWM) SWM is part of RWS VWM as well. SWM uses drones for their operations on the water. The RWS Drone Coordinator from the Smart Patrol Team, originating from this directorate, is a suitable interview candidate because they possess specialised knowledge and firsthand experience regarding the implementation and operational use of drones within VWM - SWM.
- Additionally, there is the national organisational unit of *Central Information Provision* (”Centrale Informatievoorziening” in Dutch or CIV). They are already involved in RWS’s drone dossier and work together with SWM.

Strategic and Innovative Steering and Development:

- The *Directors’ meeting Smart Mobility* is a meeting that brings together the directors involved in the Smart Mobility project and the Smart Mobility team itself. Smart Mobility is focused on the use of innovative technologies and data for both WVM and SWM. The meeting has the authority to make strategic decisions that significantly affect the implementation and use of drones within RWS. The Project Manager of Smart Mobility is a suitable interview candidate.
- The RWS Drone team originated from *Smart Patrol*, RWS’s innovation program in shipping (RWS VWM - SWM). Now Smart Mobility is working on the Drone2Go file and how drones can be further used in RWS operations.

Operational Implementation and Support:

- On 17 September 2020, the RWS Drone Team was transferred to *Bureau Incident Management Water and Shipping*. The bureau is responsible for all incidents throughout the Netherlands that affect Rijkswaterstaat’s primary process and decides which tools (including drones) to deploy in that operation (Interview 2, personal communication, 28 March 2024).
- The *RWS Drone team*, although a Key Player, has average power on the actual implementation of drones in road traffic. The RWS Drone team was originally established as a spin-off from a proof of concept testing drone technology for various incidents on the water. These initiatives have since expanded to include monitoring and managing incidents both on the water and on the road (Exploratory Interview 2, personal communication, 7 November 2023; Interview 10, personal communication, 3 May 2024). The team has been operational since 2019 and is deployed ad hoc for incidents, averaging one deployment per week. Besides incidents, drones are also deployed

for training purposes, with a total of 1,500 flights per year to meet the required flight hours (Exploratory Interview 1, personal communication, 29 September 2023). The team consists of 25 pilots with diverse backgrounds, shipping and road traffic, contributing to a diverse team composition (Interview 5, personal communication, 5 April 2024). There are multiple roles within the drone team. The training manager has been secured at SWM. As are the safety manager and 2 flight operation managers. In addition, the mechanic and 2 chiefpilots also come from SWM but they are not secured (Flight operation manager RWS Drone team, personal communication, 10 April 2024). CIV provides all resources to Bureau Incident Management. For this, CIV has budget and personnel to fill the roles: accountable manager and technical manager, both also secured at the CIV and one chief pilot and three pilots. This is at the *OSR water management department*. This department provides IV services for the domains: water management, crisis management and living environment. Incident management falls in the crisis management domain, which is for road traffic and water and shipping, and this includes drone services (Accountable manager RWS Droneteam, personal communication, 5 May 2024). It is noteworthy that the roles of the drone team (from CEO to chief pilot) are currently embedded within SWM and CIV-OSR. The emphasis clearly lies in the maritime domain. Both flight operation managers from VWM - SWM and the accountable and technical manager of the RWS Drone team from CIV - OSR are suitable candidates for conducting interviews because their roles provide crucial insights into the practical and technical aspects of drone operations within RWS.

- The *CEO of the RWS Drone Team* is VWM's Director of SWM, which gives this person a lot of influence over the resources and scope of the RWS drone team.

Regional and Local Implementation:

- *Regional organisational units* are responsible for day-to-day operations and maintenance of infrastructure, where drones can contribute significantly and drone footage can be streamed into traffic control centres The drone team is organised for the operation of both shipping and road traffic. Therefore, the drone team also sought to align with the some Regional organisational units. There are three drone pilots coming from traffic centres, namely traffic centre Noord-West Nederland, Noord- en Oost-Nederland and Zuid-West Nederland (Exploratory Interview 2, personal communication, 7 November 2023). Therefore, these three drone pilots are interview candidates.

5.2.1. Directorate VWM - WVM versus VWM - SWM

The distinction between the Directorate WVM -WVM and VWM - SWM needs to be made. This analysis will make many comparisons between the two Directions as drones have already been successfully applied in VWM - SWM (Interview 2/3/4/6, personal communication, 28 March / 2/3/15 April 2024).
Technology focus:

- SWM focuses on monitoring individual vessels and detecting specific objects, such as individual ships.

- WVM focuses more on monitoring large numbers of vehicles in traffic flows, where privacy considerations play a role and identification of individual vehicles is less common.

Innovation approach and implementation:

- SWM has more freedom to develop innovative ideas. There is an emphasis on creating work corridors and using staff as mentors and teachers, which promotes innovation. SWM adopts a gradual and flexible approach to technology implementation, with constant communication with operators and a slower pace of implementation for better validation.

- In contrast, WVM does not have that and therefore has less flexibility in developing innovations. Sometimes WVM tends to implement projects faster and with less patience, which can lead to loss of momentum after a few years which often results in projects being discontinued despite the viability of the technology. An example of this is smart cameras that were scaled up too quickly and too expensively after pilots.

5.3. The subjects, the context setters and the crowd

There are a number of actors who have an interest in knowing whether RWS uses drones within its road traffic operations, but who do not have (a lot of) influence over the decision. Since they have a high interest, cooperation with these Subjects can be looked into. Secondly, there are the Context Setters. They are crucial actors that influence the broader environment and conditions, such as law, regulations and permits, within which decisions are made regarding the use of drones. The context setters of this case study set standards, guidelines, technological capabilities and operational procedures that define and shape the wider context of the aviation sector in the Netherlands. Lastly, the crowd represents a group of actors involved in road management or drone implementation themselves, with a wide range of perspectives, needs, and expectations regarding the use of drones.

In the table below, the same typology has been used to sort these actors. However, this research will conduct interviews with the key players and that is also the focus of this research. If you are interested in more information about the actors in the table, see Appendix B.

Table 5.1: Subjects, the context setters and the crowd in the actor analysis

Stakeholder group	Typology	Actor within RWS Case study
Subjects	Strategic and Innovative Steering and Development	Steering committee of Drone2Go
	Operational Implementation and Support	RWS operation
	Cooperation partners	- Drone2Go partners - The National Road Traffic Data Portal (NDW) - Provinces
Context setters	Policy and regulatory authorities	The Human Environment and Transport Inspectorate (ILT)
	Technology and airspace management	- Air Traffic Control the Netherlands (LVNL) - Netherlands Aerospace Center (NLR) - Software and hardware developers
The crowd	Strategic and Innovative Steering and Development	Air Traffic Control the Netherlands (LVNL)
	Technology and airspace management	- LVMB - Dutch Drone Nederland Dutch Drone Delta
	Potential cooperation partners	- Various market parties - ANWB - KPN - Port of Rottterdam

5.4. Conclusion

The actor analysis identified seven key actor groups, including Policy and regulatory authorities, Policy authorities from other domains within RWS utilising drones, Strategic and innovative steering and development, Operational implementation and support, Regional and local Implementation, Technology and airspace management and Cooperation partners. By generalising these actors, the study provides a framework that is not only applicable within the RWS case study, but also relevant for similar situations and research areas. The insight provided by this actor analysis is essential for identifying suitable entrepreneurs of each stream. The next step involves conducting interviews with the identified key players.

6
Problem Stream

In the intricate world of road traffic management, Rijkswaterstaat faces a myriad of challenges. As the authority responsible for the management and maintenance of the Dutch road network, RWS shoulders the weight of ensuring smooth traffic flow, enhancing road safety, and mitigating the impact of incidents on the road. In this chapter, we delve into the various challenges encountered by RWS, representing the ”problem stream” as conceptualised by the theoretical framework. Through a detailed examination of these challenges, we aim to gain a deeper understanding of the intricacies involved and explore potential avenues for improvement and innovation in road traffic management practices.

6.1. Current challenges in the domain of road traffic management

6.1.1. Service level incident management

At Rijkswaterstaat, incident management is executed through a comprehensive approach involving various stakeholders. When an incident is reported, prompt responses are coordinated between road authorities and traffic control centres. The Netherlands benefits from extensive coverage of static road cameras, particularly in the Randstad area, which enables traffic control centres to provide real-time support to road inspectors. This includes precise information such as the incident’s location relative to the road, facilitating efficient incident response. Furthermore, RWS ensures rapid on-site presence of road inspectors, with an impressive response time of within 15 minutes. This expedited response is made possible by a fleet of 300 road inspectors actively patrolling the roads (Exploratory Interview 11, personal communication, 21 December 2023).

However, despite these efforts, not all roads in the Netherlands have camera coverage. When incidents occur outside the Randstad region, road inspectors are dispatched without prior situational awareness. There may be instances where traffic control centres or on-duty officers have limited visibility of the incident. In such cases, live streaming real-time data to the traffic control centre becomes crucial, providing immediate and up-to-date information on the road situation and enabling swift and effective decision-making. This capability can significantly impact whether a road inspector is dispatched to the scene with priority, thus enhancing incident management efficiency (Exploratory Interview 5/6/10, personal communication, 16/17/30 November 2023).

6.1.2. Inefficienies in traffic and infrastructure monitoring

One of the main issues is the increasing traffic congestion on Dutch roads. Traffic jams and bottlenecks not only lead to delays for road users but can also jeopardise traffic safety. Additionally, RWS faces challenges in effectively monitoring and managing traffic flows, as cameras are not present along all roadways, and RWS does not always have full situational awareness. Another significant issue is the necessity of regular inspections and maintenance of the infrastructure. RWS is tasked with the responsibility of conducting routine inspections of bridges, viaducts, roads, and other facilities to identify potential safety risks and perform timely maintenance (Exploratory Interview 1/2/4/5/7/12, personal communication, 29 September / 7/16/16/17 November 2023/ 24 January 2023; Interview 2, personal communication, 28 March 2024).

6.1.3. Pressure to innovate

RWS is certainly concerned about falling behind in technological advancements. They feel the pressure to keep up with technological developments to remain relevant and effective in their roles and responsibilities. It is important to understand and anticipate future problems and proactively addressing them to avoid falling behind (Interview 1, personal communication, March 27, 2024).

Furthermore, the Dutch government has recognised the importance of capitalising on the economic opportunities and societal applications of drones and unmanned aircraft. It has committed to taking

the lead in enhancing safety within this sector, in collaboration with stakeholders in general aviation (Ministry of Infrastructure and Water Management, 2020).

6.1.4. Capacity and budget scarcity

Budget constraints, limited capacity for innovation, and staffing shortages pose significant challenges to the operations of RWS. With finite resources, RWS must carefully allocate funds to prioritise critical projects and initiatives, often leading to trade-offs between competing needs through a cost-benefit analysis (Interview 1, personal communication, 27 March 2024). Additionally, constraints in innovation capacity hinder the organisation's ability to look into and adopt new technologies that could improve efficiency and effectiveness (Interview 4, personal communication, 3 April 2024). Moreover, staffing shortages further strain RWS operations of VWM (Interview 2, personal communication, 28 March 2024). There is, for instance, a shortage of personnel at the locks (Rijkswaterstaat, 2023c). Additionally, it is challenging to acquire personnel who can fulfil the role of a road inspector (RWS Drone coordinator, personal communication, 19 January 2024). Addressing these challenges requires strategic planning, resource optimisation, and investment in workforce development to ensure RWS can continue to fulfil its vital role in managing and maintaining the Dutch road traffic and infrastructure.

6.1.5. Ensuring citizens' privacy

As a pivotal authority responsible for managing and maintaining the Dutch infrastructure, RWS plays a crucial role in safeguarding citizens' privacy while adopting new innovations. In the pursuit of technological advancements and operational enhancements, RWS is committed to upholding stringent privacy standards and protecting sensitive personal data (Rijkswaterstaat, 2023a).

RWS implements compliance measures to ensure that any new innovation or technology deployed respects individuals' privacy rights and adheres to relevant data protection regulations. This involves conducting thorough data protection impact assessments (DPIAs) to identify and mitigate potential privacy risks associated with the adoption of innovative solutions (Interview 2, personal communication, 28 March 2024; Interview 3, personal communication, 2 April 2024).

6.2. Entrepreneurs of the problem stream

In the context of theoretical framework based on Kingdon, the "entrepreneurs" can be seen as the individuals or groups that are active in promoting specific issues and pushing for policy changes. These actors are crucial in the agenda-setting process as they draw attention to particular issues and try to put them on the policy agenda. Within RWS, different departments and teams can be considered internal "entrepreneurs" in this process.

For incident management, these include road traffic controllers and officers on duty from the operations department, as well as the Bureau Incident Management and the CIV-OSR Directorate responsible for incident management. The operators of traffic and infrastructure monitoring are the Directorate of VWM WVM, including road traffic controllers, and Major Projects and Maintenance (GPO) and Programmes, Projects and Maintenance (PPO) (Rijkswaterstaat, n.d.-b). The pressure to innovate is a problem for many departments of RWS, just as the aim to ensure citizens' privacy, however specifically for Department of Knowledge and innovation management, Smart Mobility, Smart Patrol, SWM Operational development and WVM Operational development. The capacity and budget scarcity are felt across all departments of RWS. However, within the domain of road traffic management, it is primarily the Directorate of VWM - WVM and the regional traffic control centres that serve as the entrepreneurs in addressing these challenges (Exploratory Interview 1/6/7, personal communication, 29 September / 17/17 November 2023; Interview 1/2/4/7/10, personal communication, 27/28 March / 3/18 April / 3 May 2024)

6.3. Conclusion

In conclusion, Rijkswaterstaat faces a complex array of challenges in its efforts to manage and maintain the Dutch road network and infrastructure. From the need for efficient incident management to addressing traffic congestion and ensuring adequate monitoring infrastructure, RWS confronts multifaceted obstacles requiring strategic planning and resource optimisation. Budget constraints, staffing shortages, and the imperative to safeguard citizens' privacy further underscore the complexity of RWS's

mission. In addressing these challenges, it is crucial to explore innovative solutions. In this context, the potential of drones needs to be explored. By examining the technological advancements in drone technology, we can assess whether they offer viable solutions to the issues faced by RWS.

7
Technology stream

In this chapter, the focus shifts to the technology stream of drones, which is the second stream from the theoretical framework. Drones represent a significant innovation with the potential to address various challenges faced by RWS in the domain of road traffic management. Here, the exploration centres on the diverse opportunities and purposes that drones offer, along with the associated challenges, to gain a comprehensive understanding of their role as a potential solution in improving road traffic management practices.

7.1. Opportunities and purposes of drones

Despite several business cases that have already been developed for the use of drones within RWS, the current scope of the RWS Drone Team remains on managing incidents in nautical and road contexts. Additionally, drones have been flown for use cases beyond these initial business cases and the current scope, demonstrating their versatility and expanding the scope of their potential utility within the organisation.

7.1.1. Business cases

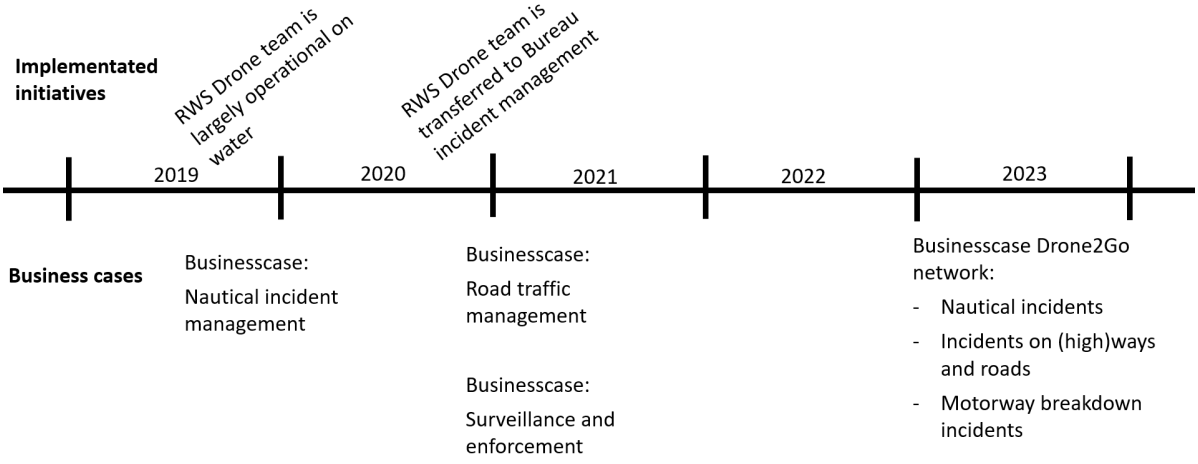


Figure 7.1: Business cases versus Implemented initiatives within scope

Initially, a business case was crafted to outline the deployment of drones for incidents along waterways, demonstrating their effectiveness in enhancing response capabilities. This led to expanding drone operations to road traffic incidents under the Bureau of Incident Management (Collection of decision notes and memos, personal communication, 2020/2021/2022)[1]. In parallel, a pilot initiative explored using drones for surveillance and enforcement, with ethical concerns by the Management Team delaying the effective implementation (Interview 2, personal communication, March 28, 2024; Interview 10, personal communication, May 3, 2024). This aligns with public perception studies that underscore acceptance for societal benefits but raise surveillance concerns (van der Grient & Kamphuis, 2021).

Drone2Go recently commissioned a business case study to explore the multifaceted applications of drones in a nationwide network coverage. The use cases for RWS included monitoring nautical incidents like oil spills, highway incidents for major accidents overview, and motorway breakdowns where

[1] Source taken from the P-disk of Smart Patrol (not publicly accessible)

RWS cameras are absent (Rijkswaterstaat, 2023b)[2]. A drone network could provide a valuable solution here by being quickly on the scene and providing real-time images of stationary vehicles, allowing emergency services to respond in a more informed and organised manner, or verifying whether a vehicle remains stationary or if it momentarily stopped, perhaps for a brief phone call, before continuing its journey (Interview 10, personal communication, 3 May 2024).

7.1.2. Use cases for drones within RWS

The RWS Drone Team operates for various purposes. While their initial scope is incident management, which typically involves 1 or 2 flights per week, they also undertake other missions to maintain their flight hours (Interview 2, personal communication, 28 March 2024; Interview 5, personal communication, 5 April 2024). These additional use cases help maximise the team's efficiency and are detailed in the following table.

In addition to these use cases, this study also looked at the potential of drones for de-icing roads. However, this data is collected by technologies such as wheel spin friction loss and sensors on the road. It is also sometimes difficult to determine on camera whether a road surface is slippery or wet. Therefore, it seems like with current drone technology, de-incing operations will look to other techniques (Exploratory interview 9, personal communication, 23 November 2023).

[2]Source taken from the P-disk of Smart Patrol (not publicly accessible)

Table 7.1: Use cases for drones

Use case	Explanation	Examples	Sources
Incident management (Current scope of the RWS Drone team)	The RWS Drone Team can respond to incidents by providing real-time data to traffic control centres. The Bureau Incident Management coordinates these deployments, determining the best response for each task and issuing formal orders for drone use. This allows for quicker and more informed decision-making during emergencies.	1. Valuable live images provided to Traffic Control Centre East Netherlands of an incident on the provincial road in April 2024. 2. Drone were immediately deployed by the RWS Drone team that witnessed an incident to inform the traffic control centre about the ANWB vehicle and ambulances en route.	Interview 2, 28 March 2024; Interview 5, 5 April 2024
Post-incident assessment and assistance (Already explored by the RWS Drone team)	Drones can be rapidly deployed to assess the situation and provide support by documenting the scene, locating vehicles, and providing crucial data for forensic investigations	1. Locating vehicles that have entered bodies of water in the Ijssel river. 2. One time forensic investigation when the police drone team was not available.	Exploratory Interview 1, 29 September, 2023; Interview 9, 30 April 2024
Traffic monitoring and management (Already explored by the RWS Drone team)	Drones can oversee various aspects of traffic conditions. They are used during incidents, road closures, and peak traffic to monitor detours, identify congestion, and assess accidents. Drones also monitor intersections, tunnels, and highway exits for smooth traffic flow and safety.	1. When the Vlaketunnel or Middelburg aqueduct was closed, the information about the intersections and exits was passed on to contractors, road traffic controllers and area managers. 2. During the Pentecost Weekend, rest areas experienced congestion. Truck drivers were parked along the Dutch border due to driving restrictions in Germany, causing congested sidings and hazardous situations by parking on emergency lanes. Drones monitored truck drivers stopping just before the border to change their tachographs.	Exploratory Interview 2, 7 November 2023; Exploratory Interview 4, 16 November 2023; Exploratory interview 5, 16 November, 2023; Exploratory Interview 12, 24 January, 2023; Interview 2, 28 March 2024
Event monitoring (Already explored by the RWS Drone team)	Drones maintain an overview of traffic and respond quickly to accidents observed in real-time, complemented with data from platforms like Google Maps and Waze.	Concert at Sea, Zwarte Cross, TT in Assen and during farmer protests	Exploratory Interview 2, 7 November 2023; Exploratory Interview 12, 24 January 2023
Asset management (Already explored by the RWS Drone team)	Although these tasks are typically outsources to specialised companies, drones have proven to be useful mapping or inspecting an object with high precision , enhancing safety, sustainability, and efficiency in asset management. RWS has developed guidelines based on successful pilot projects to assess the feasibility and effectiveness of using drones for these inspections.	Inspecting structures such as bridges and roads by identifying issues like cracks and holes	Exploratory Interview 4, 16 November 2023; (Rijkswaterstaat, n.d.-a, 2019; Shaghlil & Khalafallah, 2018)

7.2. Challenges of current drone technology

Although new technologies may seem promising, in the current operation of Rijkswaterstaat (RWS Drone Team), drones are manually flown. This is because RWS is allowed to conduct Visual Line of Sight (VLOS) flights for their daily operations. Visual Line of Sight means that the drone pilot must be able to see the drone at all times and continuously monitor the surroundings to avoid obstacles. This makes the effective deployment of drones for large-scale inspections or surveillance tasks or rapid presence at an incident difficult, since the drone pilot needs to be present at the location. Poor weather conditions can also hinder visibility and thus the ability to maintain VLOS (Meetings on POC Automated Drones for Road Traffic Management, personal communication, 10 October/24 October, 2023; Interview 11, personal communication, 21 December 2023).

Battery life, speed, range and connectivity

The drones used by the drone team now fly 60 to 70 km/h. Large drones can go up to 110 km/h. The batteries typically last for 40 minutes before they need to be manually replaced. However, in colder temperatures, this duration is shorter. The drones are resistant to wind forces ranging from 4 to 5. These products work well for the current operation of incident management with drones, as the drone pilot is typically located at the scene of the incident. However, the limited speed and range mean that drones can only be deployed in accidents that last longer, providing the pilot with enough time to arrive on-site. Drone footage can provide valuable insight into a situation, it may not always offer the means to swiftly resolve it. For prolonged monitoring, the battery duration is not necessarily a technical problem since the drone pilot can manually replace the battery and send the drone back into the air. The issue lies more in the lack of sheltered workspace, communication equipment, and office facilities. While GPS is commonly used for navigation, exploring alternative technologies is essential for situations where GPS connectivity is unreliable. Atti mode is implemented to maintain altitude stability when GPS signals are unavailable. However, there are persistent risks, such as communication loss, which could lead to hazardous incidents like collisions or crashes (Exploratory Interview 7, personal communication, 17 November 2023; Exploratory Interview 12, personal communication, 24 January 2023; Interview 2, personal communication, 28 March 2024)

7.2.1. Opportunities and challenges of collaboration

The reliance on VLOS (Visual Line of Sight) flying presents significant challenges for drone operations, primarily due to current laws and regulations. However, there are opportunities in collaborating with other parties to advocate for changes in these regulations and to jointly develop advanced drone technologies. By working together, stakeholders can push for regulatory adjustments that facilitate more efficient drone operations. The table below discusses the various collaboration opportunities and their challenges.

Table 7.2: Opportunities and challenges of collaboration

Collaboration	Opportunities	Challenges	Sources
Drone2Go	Opportunity to establish a functional nationwide drone network, by flying Beyond Visual Line of Sight (BVLOS).	Concerns focused on *security risks and geopolitical implications* about using drones from from Chinese manufacturers like DJI. RWS Drone team uses DJI drones due to *budget constraints*, but takes measures to mitigate security risks. A challenge in determining which partner the operation will eventually be placed with.	Drone2Go compliance, 7 March 2024; Exploratory Interview 1, 29 September 2023; Interview 2, 28 March 2024; (Drone2Go, 2023; Politieacademie.nl, 2021)
ANWB: Drones as an expansion of their existing medical helicopter operations Transportation of medical products such as blood samples, medicines, and organs	*Sharing* technological advancement and operational insights. Integration with ANWB's medical operations, *enhancing emergency medical services*. *Establishing a network* for drone flights across multiple medical locations, including hospitals and accident sites	*Different infrastructure compared to Drone2Go:* ANWB: Network where drones fly from point A to B, C, and D. Drone2Go: Network of drone-in-the-box systems where drones fly from point A to B (and possibly to C), but then return to A.	Exploratory Interview 8, 23 November 2023
National Growth Fund Application: Dutch companies and government entities (including RWS) increasingly recognise the value of integrating drones into their operations, marking a shift towards digital transformation and automation.	Application was established in the winter of 2023/2024 to develop a strong ecosystem for drones, leading to *increased labour productivity and economic growth*. Funding of the drone sector can improve emergency care, enhanced emergency services, and more efficient safety and enforcement, contributing to *societal benefits*. The application process can act as a catalyst for further *collaboration and coordination within the sector*.	Motioned concerning the National Growth Fund were dismissed during the parliamentary voting in the Netherlands on 19 March 2024. There's a prevailing notion that delay leads to cancellation. Subsidy application will have to be submitted *elsewhere*.	(Ministry of Economic Affairs and Climate, 2024; Ministry of Economic Affairs and Climate Policy, 2023; Ministry of Infrastructure and Water Management, n.d.)

7.3. Entrepreneurs of the technology stream

Within the context of RWS, several departments and teams are driving the integration of drone technologies. The RWS Drone Team is central to these efforts, with the team responsible for exploring and implementing drone solutions within the organisation. In addition, Bureau of Incident Management, Directorate CIV-OSR, Directorate of VWM - SWM and regional traffic centres play important roles as they already use drones within their operations. Within RWS, Drone2Go is responsible for developing automatic drones. Together, these departments and teams form the entrepreneurs of the drone technology stream within RWS. Their joint efforts focus on exploring opportunities, developing business cases and fostering cooperation with external stakeholders to encourage and promote the integration of drone technologies.

7.4. Conclusion

Exploring the technology flow of drones within the RWS framework has provided several insights regarding the opportunities, challenges and future developments. Drones offer significant opportunities for improving RWS's traffic management practices, with various applications ranging from incident management to asset management and traffic monitoring. The development of several business cases illustrates the growing recognition of the potential of drones within RWS, although ethical considerations and public perception remain important factors that may influence implementation. However, it is important to recognise that these business cases and use cases have not (yet) been developed and recognised by VWM - WVM. The regulatory and policy stream will provide an analysis of existing regulations, policy guidelines and internal procedures within VWM - WVM.

Despite its promising potential, the current state of drone technology brings challenges, especially in the area of manual control and limitations such as Visual Line of Sight (VLOS) flight. The limited autonomy and operational range of manual drones limit their effectiveness in large-scale inspections and surveillance tasks. Moreover, there are concerns about connectivity, safety and the choice of drone suppliers, encouraging further collaboration within the industry.

Nevertheless, there remains a strong demand for drone innovation and development, both nationally and within RWS. The preparation of the National Growth Fund application is testament to the efforts to strengthen the Dutch drone sector. Although there are challenges and the road to full integration of drones into RWS operations is still long, developments so far point to a potential role for drones in improving traffic management and infrastructure monitoring in the Netherlands.

8
Regulatory and policy stream

In this chapter, the focus shifts to the regulatory and policy stream, a pivotal aspect within the broader framework of policy formation and implementation at RWS. This stream entails an in-depth analysis of existing regulations, policies, and internal procedures governing the utilisation of drones and other technological solutions within the organisation. By examining these aspects, insights into the regulatory landscape surrounding drone usage and the internal policies guiding their integration within RWS operations are sought. Through this exploration, policymakers and stakeholders within RWS can develop a comprehensive understanding of the regulatory and policy environment surrounding drones, enabling informed decision-making and effective integration of these technologies into operational workflows.

8.1. Laws and regulations

The need for regulation within the drone sector became apparent as the industry grew, with concerns arising about illegal operations and safety. In 2015, the Netherlands introduced its first national regulations for professional drone use, known as the ROABL (Regulation on Remotely Piloted Aircraft Systems). Drones weighing under 150 kilograms were exempt from European legislation, remaining under national competence. However, discussions at the European level began in 2016, as it became apparent that each country applied its own rules needing for the European Commission to take responsibility. The Netherlands, eager to benefit from a unified European market, quickly embraced these regulations, formalising the decision in 2018 (Interview 8, personal communication, April 23, 2024).

Regulations from Brussels in 2019, such as Regulation (EU) 2019/945 and Regulation (EU) 2019/947, further standardized requirements for drone operations and product standards. Regulation (EU) 2019/947 regulates the operation of individual drones within the specific category (as currently used by Rijkswaterstaat). Remarkably, there is no restriction for ”Beyond Visual Line of Sight” (BVLOS) flying in the current Regulation 947. Due to EASA’s risk-based approach, BVLOS flying is not restricted in the legislation (European Commission Directorate-General for Mobility and Transport, 2019). The introduction of U-space Regulation 2021/664 in 2023 aimed to regulate airspace for busy drone operations, shifting responsibility from traditional air traffic control services to U-space service providers. While progress has been made, implementation has been slow due to unresolved issues. This raises questions about integration with existing air traffic management systems, especially at locations like airports. A practical example of U-space implementation is the port of Rotterdam, although it has not yet been officially designated as U-space airspace, it is already being treated as such (Interview 8, personal communication, April 23, 2024).

In the European Commission Drone Strategy 2.0, additional traffic rules are being developed under SERA (Standardised European Rules of the Air) to prevent collisions between aircraft (Interview 8, personal communication, April 23, 2024). The SERA are built on the principle of “see and avoid” which is used by the pilot to avoid mid-air collision. Considering that, in drone operations, the intention is for the pilot not to be on-board, a strict adherence to this principle cannot be applied and hence collision risks need to be mitigated with adequate alternative means (European Commission, 2022). This a great example of the traditional aviation processes that have struggled to keep pace with the rapid advancements in the drone industry, highlighting the need for innovative solutions to mitigate collision risks and ensure safe drone operations.

The risk-based approach of EASA presents a challenge for the sector to comprehensively assess and manage risks associated with drone operations. However, the process of obtaining a permit from the The Human Environment and Transport Inspectorate (ILT) inspectors appears to be complex. This complexity underscores the importance of further refining the BVLOS Roadmap. While implementing BVLOS operations presents numerous practical challenges, especially in urban settings, there is a growing recognition within ILT of the need for increased involvement in drone initiatives. Previously,

ILT's role was limited to processing license applications without prior engagement with stakeholders. However, there is now a shift towards greater involvement in the processes surrounding the BVLOS Roadmap (Interview 8, personal communication, 23 April 2024; Interview 10, personal communication, 3 May 2024).

Presently, drone operations are predominantly conducted using "Visual Line of Sight" (VLOS), wherein the pilot maintains direct visual contact with the drone. The next evolutionary step in drone technology involves BVLOS operations, which allow the drone to be controlled remotely from a location beyond the pilot's immediate line of sight. BVLOS operations extend the range and capabilities of drones, enabling control from a distance and facilitating diverse applications in various industries.

8.1.1. The BVLOS Roadmap

There are different types of BVLOS flights. Think of a situation where a drone disappears behind an object, or another situation where the flight is controlled by a pilot sitting in a traffic control centre. Therefore, a roadmap was created to establish what different BVLOS flights are and what criteria they must meet (BVLOS Roadmap 2023, personal communication, 4 December 2023)[1]. The image below shows some of the topics where steps still need to be taken. All different puzzle pieces are needed to make different BVLOS flights possible. Right now the first puzzle piece is being filled in, which shows the long road ahead. BVLOS has the potential to contribute to faster operations, which is crucial for resolving incidents within the "golden quarter-hour" time frame.

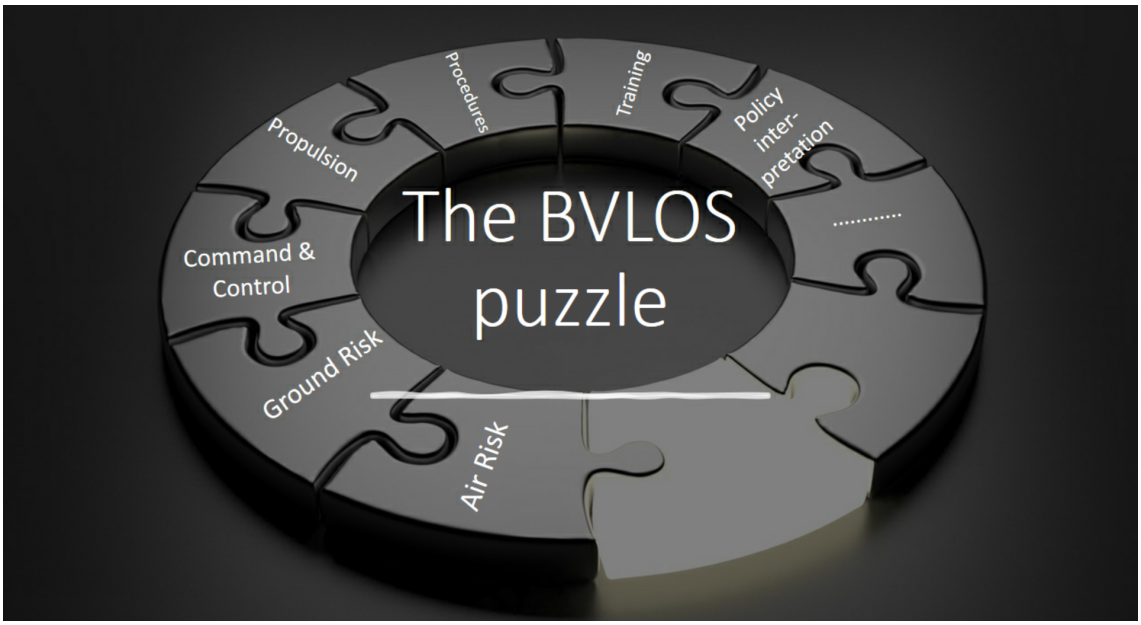


Figure 8.1: Image adapted from BVLOS Roadmap 2023

The goal of the air risk topic is that all types of BVLOS flights can be integrated into the airspace with minimal restrictions on all airspace users. In determining constraints to enable this integration, the interests of all airspace users are considered. To achieve this goal, four solution directions are envisioned.

1. A-Typical airspace
2. Uniform application of tactical mitigations
3. U-space services/traffic control
4. (On-board) detect and avoid

Currently, it is possible to get a permit for BVLOS flights where, to mitigate air risk, a TGB (a temporary restricted area) is established or one is conducted in a Controlled Traffic Region. This creates an

[1]Source taken from the P-disk of Smart Patrol (not publicly accessible)

A-typical airspace piece. The advantage of these ways is that it currently allows some types of BVLOS flights. The disadvantages are that it cannot be applied on an operational scale and gives restrictions or exclusions to other airspace users. Therefore, it can only be applied on a small scale and experimental basis. Consequently, the other three solution directions must also be realised to ultimately achieve the goal of the air risk topic (BVLOS Roadmap 2023, personal communication, 4 December 2023)[2].

The next step is to look at tactical mitigations limited to application within the lower air risk classes. This raises questions about the availability of suitable locations in the Netherlands that meet the conditions of the Pre Defined Risk Assessment for Aerial Work operations(PDRA-05), which is based upon SORA version 2.0 (Specific Operational Risk Assessment), prepared by JARUS and whether tactical mitigation can be applied in a uniform manner (JARUS, 2022). PDRA-05 deals with a predefined risk analysis, which includes a detailed methodology to determine the air risk class and a description of the measures to be taken to mitigate the associated risks. In principle, if the operator can demonstrate that all safety measures have been implemented, ILT should give the green light to conduct BVLOS flights.

Integrating BVLOS flights in all types of airspace can be achieved through some form of air traffic control. This could entail coordination with air traffic controllers or leveraging various U-space services. Furthermore, onboard technology, particularly detect and avoid systems, requires development to facilitate BVLOS operations (BVLOS Roadmap 2023, personal communication, 4 December 2023)[3].

The BVLOS roadmap tells that we are in an early stage where several development steps need to be considered to make BVLOS flights possible. It is crucial to identify the right experts and allocate specific roles to different stakeholders in advancing BVLOS operations. The engagement of operators, government agencies like ILT and NVWA, as well as organisations such as the police and fire brigade, is essential. Clarifying the roles and responsibilities of each party within the roadmap is necessary to ensure cohesive collaboration towards achieving operationally safe conditions (Interview 8, personal communication, 23 April 2024).

8.2. RWS policy

For the regulatory and policy stream will this research not only examine the laws and regulations regarding drones and how the sector collaborates with DGLM and ILT to ensure that the guidelines of these regulations are implemented in a way that can benefit the operations of the Netherlands, but also delve into the RWS policy and how it relates to the implementation of new innovations, specifically the drone subject. Given that this study specifically focuses on how drones are integrated within RWS's road traffic management, it will explore its organisational culture and strategic framework concerning innovation.

8.2.1. Policy developments and strategic framework at RWS Road Traffic Management

In examining the landscape of VWM - WVM's policies and strategic frameworks regarding drone integration, it's evident that political and policy developments significantly influence the agenda. The Directorate-General for Mobility (DGMO) has drawn up a vision for 2030, which focuses on, among other things, digitisation of traffic management functions, robust operations and financial stability. This vision acts as a framework document that sets the direction for RWS's innovation efforts. For example, when DGMO indicates that financial agility is important, RWS looks for ways to reduce costs, such as optimisation of incident management. The vision is updated very three years to remain relevant. While about 80% of the content is retained, the remaining 20% is revised to reflect changes in context and to address new developments (Interview 4, personal communication, 3 April 2024). Implementation plans have also been drawn up for each SWM and WVM directorate, setting out their mission for the next two years. The first one states that the SWM directorate is already deploying drones in implementing more sustainable production processes and equipment (*Uitvoeringsplan 2023-2025 Scheepvaartverkeer- en watermanagement*, 2023)[4]. The word 'drone' is not mentioned in VWM - WVM's implementation plan, reflecting the fact that the added value for drones is not yet seen by VWM - WVM's management (Exploratory Interview 4, personal communication, 16 November 2023).

An innovation agenda for 2030 has also been drawn up, of which roadmaps for Road Traffic Man-

[2] Source taken from the P-disk of Smart Patrol (not publicly accessible)
[3] Source taken from the P-disk of Smart Patrol (not publicly accessible)
[4] Source taken from the P-disk of Smart Patrol (not publicly accessible)

agement and Shipping and Water Management have been created. These roadmaps show the direction in which RWS is moving with innovation to achieve the goals set for 2030 (Interview 7, personal communication, 18 April 2024). However, external events, such as the Stint incident which had a major impact on vehicle automation and admission, can shape the strategic choice regarding that innovation. Such events can have both positive and negative effects on the acceptance and adoption of new technologies (Interview 1, personal communication, 27 March 2024).

Technological developments, such as those within Smart Mobility, depend on the availability of technology, but also on policy and strategic choices, such as sustainability. RWS considers it important to anticipate future problems and address them proactively to avoid lagging behind (Interview 1, personal communication, 27 March 2024).

Drone use is not explicitly included in these frameworks of VWM - WVM. This is because drone use is typically regarded as a service, which often does not feature prominently in strategic frameworks (Interview 10, personal communication, May 3, 2024). However, this does not preclude a director from making a strategic choice to embrace a particular innovation. One potential approach is to elevate the topic within the Smart Mobility domain, by engaging in discussions during Smart Mobility directors' meetings. In this context, the CEO of drones, who serves as the director of Smart Mobility, could play a pivotal role in influencing the perspectives of other directors. Emphasising the use of drones for incident detection is crucial to underscore its relevance within the realm of Smart Mobility (Interview 1, personal communication, 27 March 2024). Establishing synergies between drone initiatives and broader organisational objectives highlights the importance of getting the relevant stakeholders to understand or even push the issues in the operation (Interview 1, personal communication, 27 March 2024, Interview 7, personal communication, April 18, 2024). Leveraging the network services of road traffic management and engaging key stakeholders further increases the likelihood of drone drone integration within RWS Road Traffic operations (Exploratory Interview 3, personal communication, 10 November 2023).

8.2.2. Analysing innovation adoption in RWS Road traffic management

Initially, projects projects often emerged organically, with a mentality of "if there is a good idea, the money will follow," or through informal processes like "hustling, recruiting, and arranging", which in Dutch translates to "ritselen, rondselen, regelen". However, innovation efforts are largely reliant on the Central Information Provision (CIV) and Information Management and Projects (IBP), facing limitations due to resource constraints and a growing management burden. Despite guidelines suggesting allocating 10% of resources for innovation (as per RWS Kompas), capacity remains a significant barrier. There's a growing awareness that innovation is crucial for cost efficiency, sustainability, safety, regulatory compliance, and keeping pace with market developments. The aging population and projected increase in vehicle movements also highlight the need for innovation to augment operational capabilities. In contrast to VWM - SWM sectors, where agility is more prevalent due to the use of agile teams with shorter cycles, WVM - WVM operates with larger projects and a more traditional waterfall method, leading to less agility (Interview 4, personal communication, 3 April 2024). While the previous method of "hustling, recruiting, arranging" had its merits, the shift towards a more structured decision-making process, involving the Management Team (MT) and Information Provision (IV) departments, has its advantages. It provides clear focus and direction, optimises resource management, includes risk management, promotes integration with existing systems and processes, and increases stakeholder engagement within the organisation (*Aan de slag met IUP*, 2022). However, this structured approach can sometimes limit the freedom of consultants to make independent choices due to capacity constraints (Interview 4, personal communication, 3 April 2024).

Innovation process (IUP proces)

To streamline the innovation process, the board introduced the IUP (Innovate, Unify, Produce) process in 2019. This process involves exploring new opportunities for practical implementation (Interview 3, personal communication, April 2, 2024).

The first phase involves a proof of concept to test technical feasibility with which you test the Technology Readiness Level (TRL). Then you also test the Stakeholder Readiness Level (SRL), which assesses whether the organisation and environment are ready to embrace the innovation (Interview 7, personal communication, 18 April 2024). Parallel, a business case or value case is developed, where costs are weighed against benefits, taking into account risks. Then, an impact analysis on work processes is carried out (*Aan de slag met IUP*, 2022). This includes organisational changes, laws and

regulations and any adjustments to existing frameworks and guidelines (Interview 7, personal communication, 18 April 2024).

It is then decided whether there will be a phase transition from innovating to unifying. This phase consists of establishing new ways of working, converting and phasing out ways of working in the organisation (*Aan de slag met IUP*, 2022). Finally, after deciding on the phase transition, there is a phase of producing. Here, monitoring and optimisation is a continuous process (Exploratory Interview 3, personal communication, 10 November 2023).

It is essential to listen to users' needs and problems when developing technological solutions, such as drones, and to integrate innovations into existing operational processes. Stakeholders can be convinced of the relevance of an innovation by conducting a proof of concept. When technology is perceived as a solution to existing problems, it naturally generates demand for implementation. Having someone familiar with the regular process is beneficial for assessing how the innovation can be integrated, ensuring the involvement of relevant executives and experts. Additionally, it is crucial to ensure that the innovation complies with existing laws and regulations. This may require modifications to frameworks and guidelines, as exemplified by the case of asphalt rejuvenation cream, where changes were made within RWS to facilitate the application of the innovation (Interview 7, personal communication, 18 April 2024).

The Smart Mobiliy directors' meeting is a crucial moment for projects in this domain. During these meetings, project results are presented and recommendations are made or questions asked (Exploratory Interview 3, personal communication, 10 November 2023). Sometimes a decision is made to complete a proof of concept and not proceed to the unification phase (Interview 3, personal communication, 2 April 2024). These meetings take place monthly and are an important forum for discussing and approving innovative projects (Interview 4, personal communication, 3 April 2024).

8.3. Entrepreneurs

The entrepreneurs of the regulatory and policy stream are policy makers and legal experts from DGLM, who work with ILT to ensure that clear regulations are developed and that permits can eventually be released for BVLOS flying (Interview 10, personal communication, 3 May 2024).

Within RWS, the MT VWM - WVM is responsible for implementing policies and internal procedures while they have to comply with regulations regarding the use of drones and other technological solutions within road traffic management. However, they rely on the work of their employees and IV departments to come up with proposals, according to the IUP process, which is then decided upon at times, such as the Smart Mobility directors' consultation. They can also work with external stakeholders to align regulations and policies with broader societal and industry standards. In the area of drones, it is a good idea to collaborate with VWM - SWM and CIV-OSR as drones are already secured in their organisation, also these two Directorates are connected to the Drone2Go programme and the BVLOS Roadmap.

8.4. Conclusion

This chapter explored the regulatory and RWS policy stream, a key aspect within the broader framework of policy making and implementation at RWS. An in-depth analysis was made of existing regulations, policies and internal procedures regulating the conditions of use of drones and other technological solutions within the organisation. By examining these aspects, insight was gained into the regulatory landscape surrounding the use of drones and the internal policies that guide their integration within RWS operations.

With the rise of the drone industry, it soon became clear that regulation was necessary due to concerns about illegal activities and safety issues. This led to the introduction of both national and European regulations, such as the ROABL and subsequent EU regulations. Within this framework, the implementation of U-space regulations and challenges related to air traffic management were also considered. In terms of RWS policy, DGMO's 2030 vision was examined, highlighting the role of innovation. Noteworthy is the shift from intrapreneurship ('hustling, recruiting, arranging'), which is a more organic and opportunity-oriented gang approach, to a structured approach with the IUP process. Here, decisions on innovation are made using a business case, cost-benefit analysis and impact analysis, which is a method that focuses on clear goals, optimal resource management, risk management and stakeholder engagement.

This shift undoubtedly has implications for the 'window of innovation', i.e. the time during which

innovations can thrive and be accepted within an organisation. The structured IUP process can provide a framework to identify and exploit this ‘window of innovation’ in a more methodical and strategic way. However, in this context, it is crucial to examine how these changes affect the culture of innovation within RWS and how they affect the organisation’s ability to respond quickly to new technological developments.

9 Convergence

This chapter explores the convergence of three streams: the problem streams, the technological stream and the regulatory and policy stream. By examining their convergence, or factors why there is no convergence, insights can be gained into the complex dynamics of innovation adoption within organisations like Rijkswaterstaat. The analysed windows can serve as opportunities for the implementation of drones in road traffic.

9.1. Timeline

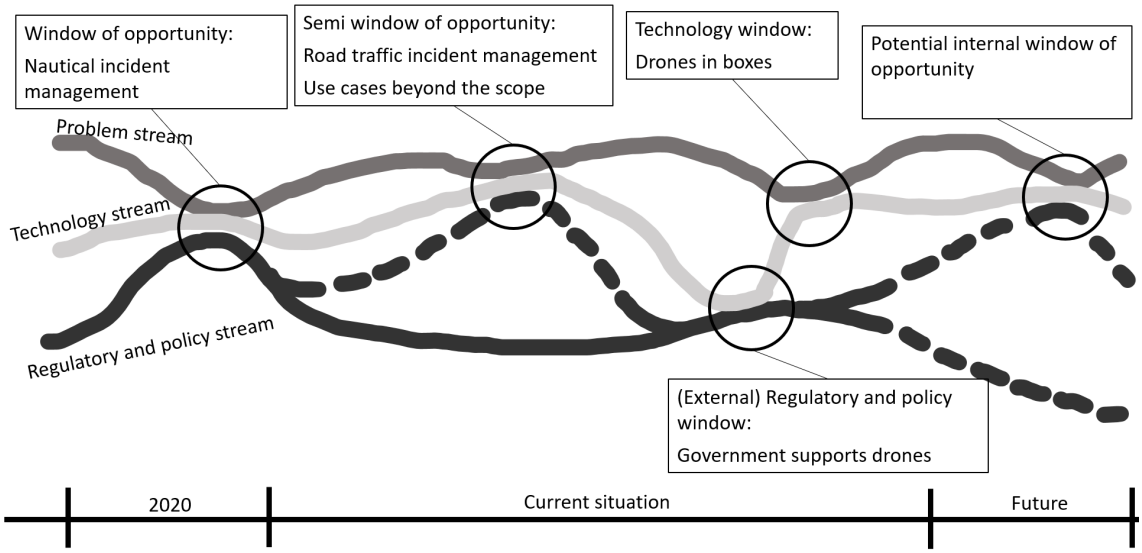


Figure 9.1: Timeline of the three streams

9.2. Exploring past convergence

The three streams have converged in the domains of VWM - SWM. In both operational and managerial circles within maritime operations, the issue of relatively slow incident handling on water was acknowledged as a concerning matter. Recognising the need to enhance efficiency and expedite response times, both the operations and management sectors identified the emergence of drone technology as a promising innovative solution to this problem, thus converging the three streams within the maritime domain.

In the past, managing long-term incidents like oil spills was challenging due to a lack of oversight and information. To address this, RWS Central Information Services (CIV) explored drone technology with POCs, and operators suggested the use of drones, citing their ability to provide better aerial views and access hard-to-reach locations, addressing the lack of accurate information regarding the extent of contamination and high-risk areas such as drinking water intakes and natural habitats. The idea of utilising drones for incident management was submitted to Smart Patrol. The team moved from the POC phase to conducting pilots, scaling operations from 5 to 25 pilots and enhancing visibility through broader communication strategies. Policy principles within the IUP framework required different departments to deploy drone pilots to allocate one day per week for competency development. Efforts included training, recruiting, equipment procurement, and software development for which Bureau IM

played a crucial role (Interview 2, personal communication, 28 March 2024; Interview 10, personal communication, 3 May 2024).

This progress did not go unnoticed, which externally prompted interest from other government agencies in establishing similar drone teams of their own. This collaborative approach fostered a community where organisations supported each other and shared expertise to operationalise drone teams effectively (Interview 2, personal communication, 28 March 2024). The recognition of unmanned aviation's significance prompted DGLM to incorporate it into their agenda (Ministry of Infrastructure and Water Management, 2020). They decided to boost the drone market in the Netherlands with formal endorsement and budget allocation (Interview 10, personal communication, May 3, 2024). Initially, there were limited opportunities for drone-based operations, which posed a significant problem. However, advancements in drone technology, such as RTK (Real-Time Kinematic) and transmitter masts, have now materialised in practical applications. Measures have been implemented to expand the possibilities for drone flights. Consequently, drones are now permitted to operate at night and near airports, and BVLOS flights are authorised in CTR (Controlled Traffic Region) areas (Interview 10, personal communication, 3 May 2024). Test areas have been established, such as Valkenburg and Woensdrecht, to conduct BVLOS experiments, alongside ongoing endeavours to establish an airspace corridor extending from Valkenburg to the North Sea (Interview 8, personal communication, 23 April 2024). In doing so, the technology stream intersects, on a national level, with the problem stream by testing the technology in practical settings, facilitated by permits from ILT. This convergence also involves the regulatory and policy streams, as there is progress in regulation. The aim is to facilitate closer collaboration and learning among all parties involved, including ILT inspectors, to ensure the safe implementation of BVLOS operations.

9.3. Exploring current situation

Firstly, there is a lack of policies or strategic frameworks for the use of drones within VWM - WVM. The word 'drones' does not appear in the implementation plan of WVM, nor in its innovation roadmap (Exploratory Interview 4, personal communication, 16 November 2023; Interview 7, personal communication, 18 April 2024). Although the mandate for an innovation project can come from higher management, the MT of VWM - WVM, as entrepreneurs within the regulatory and policy stream, will not easily issue a mandate for drone implementation without first identifying the problems that drones can solve (Interview 1, personal communication, 27 March 2024). The larger the problem one is trying to solve and the smaller the costs associated with the solution, the more risk one is willing to accept. However, it is worth noting that sometimes perceived problems are driven more by business models than by actual societal needs (Interview 1, personal communication, 27 March 2024).

Entrepreneurs within the technology stream do reach out to entrepreneurs within the problem stream. Through the IUP process, they attempt to demonstrate the value of drones and persuade stakeholders and their management. This is because a drone, in itself, is merely a tool. A drone only gains value when it is actually deployed to address a specific problem (Interview 1, personal communication, 27 March 2024). The initiative to experiment with new technologies such as drones often comes from bottom-up initiatives. However, formal approval and decision-making on large-scale implementation mainly follow a top-down approach, where everything has to be approved by the management hierarchy. This can lead to a lack of coordination between bottom-up initiatives and top-down strategic objectives (Interview 1, personal communication, 27 March 2024; Interview 4, personal communication, 3 April 2024; Interview 5, personal communication, 5 April 2024).

The timeline shows that a window of opportunity has not yet been reached. However, it is important to note that Bureau IM is operational in both sectors, hence the dotted line towards the semi window of opportunity. The accountable manager of the drone team does not believe that recognition from WVM is necessary (Interview 2, personal communication, 28 March 2024). Nonetheless, interviews indicate that drones are not yet being utilised optimally, which has led to the absence of a window of opportunity. The table examines whether convergence has been reached for each identified problem from the chapter on the problem stream and why this has not yet occurred.

Table 9.1: Convergence of the problem and technology stream

Problems in problem stream	**Convergence?**	**Factors hindering convergence**
Service level incident management	Despite the Incident Management Bureau deploying the drone team on the roads, only 20% of current incident flights occurred on the road (instead of water) (Community practice of drones, personal communication, 9 November 2023). Furthermore, although resources (in the form of budget for equipment and drone pilots from regional traffic control centres) are allocated, WVM is either unaware of or not convinced about the potential of drones. As a result, there is no active initiative from WVM to utilise drones.	The Highway patrol pilot conducted in 2017 resulted in three key conditions to effectively use a drone for IM ((Tasdelen, 2017)[1]. • *Real-time streaming in the control room of the traffic control centres.* The RWS Important that drones need to be integrated into operational workflows and systems. It should complement the existing camera network (Within the Randstad, value seems small, according to the spokesperson of road traffic IM (Exploratory Interview 11, personal communication, 21 December 2023). • *Incidents with long handling time with possible (serious) injuries and/or fatalities, and with serious and long-term effects on traffic flow on the main road network.* The RWS Drone team has the highest added value in these situations, however, other options have not been acknowledged enough (Interview 5, personal communication, 5 April 2024) • *Arrival of drone pilot must happen within a 'golden quarter-hour', since RWS currently deploys 300 road inspectors, who can arrive on-site within 15 minutes.* The RWS Drone Team can be on site for 1/1.5 hours, due to their capacity. OvD often lack the time to call upon the drone team or are unaware that this is an option. The drones in boxes could potentially bridge the gap between technology and the golden hour problem in the problem stream. However, this added value has not yet been tested in practice. Additionally, drones cannot fully replace the role of a road inspector since they are crucial for implementing safety measures (Exploratory Interview 1/2 / Interview 2/5/10, personal communication, 29 September/7 November 2023 / 28 March/5 April/3 May 2024; Interview 5, personal communication, 5 April 2024) 2. Within the current IM, the traffic centre also does not have a view of every situation. Outside the Randstad (as far as Amesfoort), there are no cameras or lane signals because the cost there does not outweigh the number of incidents. Road inspectors are send out regardless. (Exploratory Interview 11, personal communication, 21 December 2023). 3. No good communication between management and operations. An interviewee states that WVM hasn't heard any demand for drones yet from their operations (Exploratory Interview 10, personal communication, 30 November 2023) 4. Drone team is not widely known (Interview 9, personal communication, April 30, 2024) 5. Capacity limitations due to the low available FTE and the voluntary nature of the RWS Drone team outside regular work hours, leading to reluctance among individuals to request their assistance (Interview 10, personal communication, May 3, 2024).

Vehicle breakdown on the road	At present, there has been no convergence of streams through which drones are used in practice for this purpose.	1. Regulatory restrictions for a network (BVLOS) 2. Different viewpoints in the discussion surrounding drones as a solution for shortage of personnel. An expert in traffic information gathering does not see the deployment of drones as a realistic scenario due to the high frequency of such incidents, which are 100,000 per year (Exploratory Interview 10, personal communication, November 30, 2023). However, the business case of Drone2Go and two interviewees indicated that drones can be used to alleviate the strain on road inspectors by swiftly providing visuals of the situation (Rijkswaterstaat, 2023b) (Interview 4/10, personal communication, 2 April/3 May 2024)
Traffic and asset management	Despite the fact that drones have been applied for this problem, while it is not within the scope of the Drone Team, there is no convergence because there is no strategic framework for drones for this problem.	1. The government has determined that if the market can perform a certain task, it is mandatory to leave it to the market. Therefore, this use case is not part of the official scope of the drone team (Interview 4, personal communication, 3 April 2024). 2. The applications coming in to Drone Desk (allowing the team to complete its flying hours) cannot all be implemented due to capacity issues, leading to missed opportunities for exploitation (Exploratory Interview 1/Interview 9, personal communication, 29 September 2023/ 30 April 2024).
Pressure to innovate	Despite the importance of keeping up with technological developments to stay relevant, there is no convergence with the technology flow of drones (Interview 1, personal communication, March 27, 2024).	1. Lack of knowledge within WVM about the current potential of drones lead to no ambition to run a pilot (which is the first step in the innovation process) (Exploratory Interview 11/Interview 1, personal communication, 21 December 2023, 27 March 2024). 2. The choice whether road traffic should be at the forefront of adopting drone technology. The government has pledged to take the lead in realising economic opportunities, social applications and improving safety (Ministry of Infrastructure and Water Management, 2020)). RWS should already be wary of misuse of drones by companies flying under its contract (Exploratory Interview 6, personal communication, 17 November 2023). However, the spokesperson for WVM's IM network service believes that WVM should wait until a tipping point is reached where implementation becomes easier, especially in terms of regulations around BVLOS flying. As a result, there is currently no internal window of opportunity for innovation. (Exploratory Interview 11, personal communication, 21 December 2023).
Capacity and budget scarcity	There is no convergence of drone technology with the problem of capacity and budget, this problem actually holds back convergence.	Investing in a new innovation costs money and in terms of regulations, drones are not without their challenges. Without clear demand from operations, WVM will not readily release budget and capacity (Interview 4, personal communication, 3 April 2024).
Ensuring citizen's privacy	It depends on the application.	1. There is public acceptance for social benefits, but not for surveillance purposes (van der Grient & Kamphuis, 2021). 2. Ethical concerns about using drones for surveillance (Interview 10, personal communication, May 3, 2024)

9.4. Why have the three streams not yet converged?

The timetable and table clearly indicates that there is still no convergence between the three streams. The integration of drones into road traffic operations hinges on developing Beyond Visual Line of Sight (BVLOS) capabilities for widespread deployment. Challenges include establishing uniform airspace regulations, advanced detection and avoidance technologies, and fostering extensive collaboration among stakeholders. Delays in implementation and complexities in obtaining permits underscore the need for refining the BVLOS Roadmap and improving coordination among stakeholders. Regulatory frameworks for drone avionics are undergoing careful revision, given the slow adaptation of existing aviation systems. While some technological components for detect and avoid systems exist, comprehensive solutions are still under development, with expectations that operational standards may take several more years to solidify (Interview 8, personal communication, 23 April 2024, Interview 10, personal communication, 3 May 2024). Admittedly, there has yet to be an external window of opportunity, where the regulations and permits regarding BVLOS, come together with the technological developments of detect and avoid systems and which together can solve the problems regarding the operation of various government agencies. Moreover, looking internally at RWS. The recognition that drones can really solve their problems still missing within the management team of WVM and Smart Mobility (The policy and innovation bodies of WVM). Therefore, as part of this research, a presentation was given at the directors' meeting of Smart Mobility, where the benefits of drones were highlighted, with special emphasis on their potential value for road traffic management. The proposal was received with enthusiasm by attendees (Presentation Team Smart Mobility, personal communication, 21 February 2024). However, after a likely discussion withing the road traffic management team, the director of VWM - WVM indicated that the added value of drones for incident management is not perceived, at least for now (Director of VWM - WVM, personal communication, April 24, 2024). This final response indicates a discrepancy in the perception of the benefits of drones among different stakeholders within the organisation, which confirmed that no window of innovation has internally materialised yet.

Bottlenecks stopping convergence

The analysis clearly shows that there are still several bottlenecks regarding the implementation of drones in road traffic management.

1. **Limited capacity and budget**: VWM - WVM, and indeed all of RWS, faces capacity and budget constraints, making it difficult to fully fund and staff new projects such as drone implementation. A thorough cost-benefit analysis is needed to justify the added value, but the resources required for these analyses are limited.

2. **Perception and acceptance**: Within VWM - WVM, the added value of drones for incident management is not always recognised. Traditional methods, such as deploying road inspectors and fixed cameras, are considered sufficient. This perception limits the willingness to invest in drones.

3. **Regulatory restrictions**: Current regulations still restrict the deployment of drones, especially with regard to Beyond Visual Line of Sight (BVLOS) flights. This limits the operational flexibility and effectiveness of drones in road traffic. External window of opportunity is needed.

4. **Operational integration**: Integrating drones into existing operational workflows and systems, such as traffic centres and camera operations, is a must. There is a clear need to harmonise technologies and procedures to deploy drones effectively.

5. **Lack of experience and knowledge**: There is a lack of experience and knowledge about drone technology within certain departments of RWS. The drone team, traffic centres whose traffic controllers are affiliated to the drone team are already convinced of the added value. Younger employees see potential for drones, especially with a view to the staff shortage problem that is growing in the future. However, their ideas often do not reach the higher levels of the organisation (Interview 5, personal communication, April 5, 2024).

6. **Lack of direct demand from operations**: Without a clear and urgent demand for drones from operations departments to VWM - WVM remains difficult to justify investment requests. There is a need for proactive problem identification and stakeholder engagement at the regional level.

7. **Challenges in cooperation between sectors**: There are differences in innovation processes between the VWM -SWM and VWM - WVM sectors within RWS. These differences, together with differing policy and funding perspectives, make collaboration more difficult.

9.5. Lessons for potential future convergence

This study uses SWM as an example because a window of innovation opportunity for drones for nautical IM has arisen and been exploited. The actor analysis pointed out the differences between the two Directorates in terms of technology focus and innovation approach and implementation, were SWM seems more flexible and deals with individual vessels. These differences also contribute to the lack of opportunities for innovation. Despite similar projects and challenges, there is often insufficient cooperation between these SWM en WVM. Efforts for better collaboration exist, but are hindered by differing financial perspectives (DGLM/DGMO) and policy disparities (Interview 4, personal communication, April 3, 2024). This is important to take into account when analysing lessons which can be learned from the successful implementation of drones in the maritime sector.

1. **Importance of problem recognition**: It was crucial to clearly define and recognise the problem of slow incident handling on the water. This provided shared focus and motivation to find a solution.
2. **Proof of concept (POC) and pilots**: Conducting POCs and pilots was essential to demonstrate the practical benefits and feasibility of drone technology. This helped convince internal and external stakeholders of the added value of drones.
3. **Internal cooperation and coordination**: Success was helped by effective cooperation between different departments within RWS, such as the SWM (SWM) Central Information Services (CIV) and traffic centre team. Sharing of knowledge and resources was crucial.
4. **Policy Development and Training**: Establishing clear policy guidelines and investing in training and skill development of drone pilots ensured a professional and streamlined operation.
5. **Phased Implementation**: Gradually scaling up drone operations, rather than trying to grow too fast, ensured stable and manageable integration of the new technology.
6. **Cost-Benefit Analysis**: A thorough cost-benefit analysis was necessary to validate the economic benefits of drones. This helped secure funding and support for further rollout.

9.6. Conclusion

The analysis of the convergence of the problem stream, technology stream with its focus on drones, and the regulatory and RWS policy stream within Rijkswaterstaat offers insight into the complex dynamics of innovation and policy-making within a government organisation. It is noticeable that there is a big gap between how VWM - SWVM looks at the use of drones versus how VWM - WVM looks at it. In the maritime sector, RWS has shown an example of successful convergence. The timeline has shown that currently there has not emerged a window of opportunity for drones in road traffic.

Lessons from the maritime sector highlight the importance of problem recognition, thorough testing and pilots, policy development, cost-benefit analysis and internal cooperation. These can serve as a blueprint for the road transport sector. The lessons learnt from this process of convergence can be applied to to address the aforementioned bottlenecks. The importance of a holistic approach, aligning issues, technology and regulations, cannot be underestimated. The success of an innovation is contingent upon timing. However, there could be things that could be done that increase the chances of convergence. Increasing internal acceptance of drones is crucial; this can be done through awareness campaigns and POC projects demonstrating the benefits of drones. Collaboration with regulators such as DGLM and ILT is needed to address restrictions and promote flexible regulations, especially for BVLOS operations. Developing integration protocols and standards will ensure that drones can work seamlessly with existing traffic systems. By working together and being open to change, RWS can continue to innovate and respond effectively to the challenges of modern times.

10
Discussion and limitations

This chapter delves into the findings of the research on the implementation of drone technology at Rijkswaterstaat in road traffic management, with a focus on the theoretical frameworks employed to analyse the policy-making process. There is reflection on the use of Kingdon's Multiple Streams Approach as a descriptive policy-making theory. Additionally, some limitations of the study are identified, contributing to a critical reflection on the findings.

10.1. Reflection on the chosen theory

The multiple stream model of Kingdon is typically applied at the national policy level and in identifying policy issues at a more general level. The Kingdon model often focuses on opening policy windows and combining different streams of policy decisions to arrive at a solution. In the case of RWS, where drones are considered a solution to specific traffic problems, it is remarkable that the Kingdon model is being applied, considering that only one solution is being considered instead of a range of options. It is interesting that despite this deviation from the usual application of the Kingdon model, the RWS case study is being approached with it. This choice may be attributed to the Kingdon model's ability to identify policy issues and formulate solutions, even when only one solution is being considered. This choice was made due to the need for a structured approach to understand and manage the process of introducing drones into their operational activities. The Kingdon model could help map out the different decision-making streams and stakeholders involved in making this single decision, and identify the factors that led to the selection of drones as the preferred solution.

10.1.1. Kingdon's framework can provide insights into the organisation

Applying Kingdon's model to RWS instead of national policy formation can provide insights into how this framework can be adapted and applied to specific organisational contexts and policy areas. It can offer insights in the organisation of RWS and its ability to adopt innovations.

Firstly, there is a shift from intrapreneurship ("hustling, recruiting, arranging"), which is a more organic and opportunity-oriented approach, to a structured approach with the IUP process. This process involves phases such as proof of concept, business case development, cost-benefit analysis, and impact assessment. This does imply a slight change in the degree of flexibility and adoption of innovations. In this regard, a clear distinction can be found between the Directorate of Nautical Traffic Management (SWM) and the Directorate of Road Traffic Management (WVM). They differ not only in their functional objectives but also in their flexibility and capacity management. The SWM directorate operates with shorter cycles and agile teams, allowing for more flexibility in implementing innovations such as drone technology. On the other hand, the WVM directorate often deals with larger projects and a more traditional approach, which can limit flexibility.

Like the rest of RWS, both directorates experience pressure to innovate while successfully completing projects. Involving stakeholders, such as during Smart Mobility directors' meetings, plays a crucial role in approving and steering innovation projects. This may entail the need for collaboration between departments, such as the development department of SWM needing to cooperate with WVM if they intend to successfully implement drone technology in road traffic.

Another important aspect is the challenge of communication between management and operational execution within RWS. This can lead to misunderstandings about priorities, resistance to change, and inefficiencies in implementing innovations.

In summary, this analysis underscores the complex dynamics within RWS, where innovation and project management go hand in hand with challenges in flexibility, inter-departmental collaboration, and communication between management levels and operational teams.

10.1.2. Kingdon's framework is originally descriptive

In this research, the aim was to apply Kingdon's framework not only descriptively but also predictively. Originally, Kingdon's framework was not intended for predictions but rather for describing the policy-making process retrospectively. This is because policy making processes are complex and chaotic. The three streams can interact in unpredictable ways, and unexpected events can suddenly alter the agenda. Therefore, predicting the future is initially challenging. What is unique about Kingdon's approach is its emphasis on timing: when is the right moment for RWS to successfully implement innovation? The concept of 'windows of opportunity' provides predictive value by identifying when the right conditions align for policy change. Policymakers can recognise and capitalise on these windows to introduce new policy measures. By highlighting the role of problem, technology, and RWS policy entrepreneurs, the framework provides insight into who can wield influence in the process, aiding in predicting who is likely to drive change.

10.2. Prescriptive conclusion of Kingdon's descriptive theory

Kingdon's Multiple Streams Framework functions primarily as a descriptive theory that describes how policy changes occur when three independent streams converge. For RWS and its road traffic management sector, applying this framework can guide strategic decisions when integrating drones into incident management. Although Kingdon is inherently descriptive, prescribing concrete steps based on the principles can help RWS identify and create windows of opportunity (WO) for innovation. The alignment of the three streams creates a short-term period in which policy changes or project implementations are more likely to succeed. For RWS, recognising and leveraging this WO is crucial to the advancement of drone technology in road traffic management.

10.2.1. Current lack of convergence in RWS road traffic management

Despite the existence of an RWS Drone Team currently managing incidents for both water and road traffic, RWS road traffic management has not yet fully recognised the value of drones for incident management. This lack of recognition results in a failure to invest the necessary capacity and resources, and consequently no formal RWS policy has been developed to support the use of drones in this domain.

The potential value of drones, especially for Beyond Visual Line of Sight (BVLOS) operations, is recognised. Drones stationed in boxes and capable of reaching incidents within 10 minutes could significantly improve incident management. However, RWS lacks the necessary permits to conduct BVLOS operations across the entire operational range. A temporary licence for a Proof of Concept (POC) could be obtained to test the effectiveness of BVLOS drones for incident management, but this has not yet been done.

10.2.2. Window of opportunity for innovation

To create a 'window of opportunity' for effective drone implementation, changes need to emerge at various levels. Internally, RWS must prepare by identifying operational challenges, recognising the benefits of drones, and fostering a culture of innovation. This requires investments in resources, communication, and policy adjustments. Externally, efforts are needed to amend laws and regulations to enable BVLOS operations and to form partnerships with other Drone2Go partners to share knowledge and resources.

It's important to realise that RWS Road Traffic's internal 'window of opportunity', when the problem is recognised and investments are made in drone solutions, doesn't necessarily align with the external 'window of opportunity' in terms of legislation or willingness to collaborate with other partners. It's a gradual process that requires strategic planning, ongoing adjustments, and close collaboration to effectively capitalise on the opportunities drones offer for road traffic management.

10.2.3. Researching automated drones within the 'golden quarter-hour' in a POC

To assess the potential of boxed drones for incident management, it is essential to investigate whether these drones can contribute significantly to improving response times and effectiveness. Theoretically, this could align the technology stream (drone capabilities) with the problem stream (need for rapid incident response). Convincing and engaging the road traffic management (WVM) sector of this value could then lead to the allocation of capacity and resources, thus integrating the policy flow.

10.2.4. Strategic choices for RWS

RWS faces a strategic choice. If they strictly follow Kingdon's theory, they could choose to wait for an external WO at the national level, where regulations and permits converge favourably. The advantage of waiting is that it increases the chances of successful implementation of the drone project because of supportive regulatory frameworks. The POC would then be ready to be implemented immediately when the external WO occurs. However, this approach has significant drawbacks, such as the unpredictability of when this WO will occur. According to the European Drone Strategy, this could take until 2030; given the slowness of regulation, it could take even longer.

Another option is to proceed with the POC now, with the aim of creating an internal WO by demonstrating the value of drones to the road traffic management sector. This proactive approach could persuade WVM to invest the necessary resources, encouraging regulatory change by allowing RWS to demonstrate what it needs to do. The primary benefit is immediate progress in demonstrating the value of the technology and gaining internal support, which could ultimately influence external regulation. This also aligns with the goals of the development department of VWM - SWM, which also needs to continue making progress, as they also face capacity and budget constraints.

The downside is the risk that, even with a successful POC, full implementation might be delayed by regulatory hurdles and the time needed to obtain sufficient internal capacity and budget.

Table 10.1: Comparison of strategic choices for RWS

Option	Advantages	Disadvantages
Waiting for External WO	• Greater chance of success due to supporting laws and regulations. • POC can be implemented immediately when WO occurs.	• Unpredictable when WO will occur. • Could take until 2030 according to European Drone Strategy or even later. • Delay innovation and development.
Execute POC now	• Immediate progress and demonstrate value. • Obtain internal support and resources. • Stimulate external regulation through demonstrated need. • Supports goals of the development department.	• Risk of delayed implementation due to regulatory hurdles. • Requires internal capacity and budget. • Riks of being shelved in the absence of immediate regulatory change.

Robustness of the POC during shelf-time
To make the decision to run a POC now more robust, so that it is less detrimental if the project is put on hold, the following steps can be taken:

- **Stakeholder engagement**: Involve relevant stakeholders continuously in the POC to strengthen their support and understanding of the value of drones. This can help maintain internal support even if full implementation is delayed.

  This can be done by maintaining regular updates and communication with the stakeholders. The RWS Drone team organises periodic information sessions and meetings where they increase awareness for their team. There are also often community of practice meetings where the current state of affairs and future steps regarding drone use within RWS are discussed. Involving stakeholders in this session, or drawing inspiration from these sessions to provide their own platform, gives space for stakeholders to express their feedback and concerns, which helps to maintain their involvement and remove any misunderstandings. In addition, technology entrepreneurs can help bridge the gap between management and operations staff by directly involving them in simulations and workshops that demonstrate the potential impact of drones. This makes the problem that drones can solve more tangible and helps keep both management and operations staff enthusiastic and engaged. It's also useful to share successes and best practices, even if they come from other projects. By presenting case studies and success stories, the benefits of drones can be clearly communicated and support increased. Finally, identify and support enthusiastic employees who can act as ambassadors, not only at an operational level such as traffic pilots, but also within WVM's development department and within Smart Mobility. They can share their positive experiences and insights with their colleagues, which can help to reduce any resistance and promote a positive attitude towards drone technology.

- **Flexible planning**: Develop a flexible implementation schedule that can adapt to changing regulatory conditions. This will keep the project relevant and allow it to resume quickly when a WO arises.
  Within RWS, innovations must go through the IUP process, which uses iterative loops that allow returning to earlier phases or ending processes. This inspires the development of a modular implementation schedule with different phases that can be prepared and completed independently. Developing an action plan for the POC is an example of such a phase. It is essential to proactively identify any bottlenecks in this process early, before the POC is shelved, to prevent these obstacles from permanently hindering progress. This allows quick switching when conditions are favourable. Stakeholder engagement is crucial to continuously stay informed of the latest regulations and sector developments. Flexible budgeting is recommended so that resources can be shifted to different project components depending on need and progress. This ensures that there are always sufficient resources available to respond quickly when a Window of Opportunity arises.

- **Document and transfer knowledge**: Ensure comprehensive documentation of the POC activities, findings and results. This ensures that the knowledge gained is retained and can be reused when regulations and permits become more favourable without losing time on reinventing already developed processes and solutions.

- **Interim solutions**: Discover interim solutions that can work within current regulatory frameworks, such as obtaining temporary permits for limited activities and locations. For example, in the past RWS has already received a temporary permit to fly BVLOS at the traffic post in Nijmegen. This keeps the project active and visible. It ensures that the project remains active and visible, even within existing regulatory frameworks. This provides practical experience, validates new developments in technology, and demonstrates flexibility and adaptability in dealing with regulations.

- **Networking and Lobbying**: Strengthen networking and lobbying activities to influence laws and regulations. RWS must remain involved in initiatives such as Drone2Go, but certainly also the BVLOS Roadmap. This can help accelerate the external WO and ensure that POC results are taken into account in policy decisions internal RWS.

10.2.5. Conclusion

Kingdon's MSF, although descriptive, offers valuable insights for RWS in strategising the integration of drones in road traffic management. The choice between waiting for an external WO and creating an internal WO through direct POC implementation requires weighing the risks and benefits of each approach. By making the POC more robust while waiting, RWS can ensure readiness to act when the opportunity arises, while also working to demonstrate the value of drone technology in the meantime. This dual approach can position RWS to effectively harness the potential of drones for incident management, aligning technological innovation with organisational and regulatory readiness.

10.3. Limitations

There may be selection bias if certain groups within the sample are overrepresented, potentially biasing the results. Specifically, 7 people from the drone team were interviewed, 3 of whom came from the road traffic sector. However, there were only 2 people from VWM - WVM who could provide insight into current IM and traffic information gathering within WVM. Both of them were still wary about the use of drones. Respondents may give biased answers due to social desirability, time constraints, or other factors influencing their responses. The only individuals interviewed from the operation were those involved with the drone team. Additionally, one interview was conducted at RWS WVL (Water, Traffic, and Living Environment), which develops the vision for the main road network, the main waterway network, and the main water system, as well as our living environment. This interview focused on the IUP process. It was outside the scope to also interview this department based on the problem and technological flow or specifically on drone policy.

The research may be limited by constraints on the time available to conduct interviews, which can limit the depth and breadth of the collected data. The final interviews were conducted close together, and one interview was not conducted at all. The initial project manager of Highway Patrol was no longer working at RWS.

The interpretation of the interviewer can influence how the collected data is analysed and reported, which can lead to biased findings. The researcher had an internship with the development department of VWN - WVS, and their supervisor was the RWS drone coordinator. Therefore, the subjectivity of the researcher can affect how the interviews are conducted and analysed, potentially compromising the reliability and objectivity of the findings. Additionally, respondents may have given biased answers based on the interviewer's perception (Thomas, 2006).

11 Conclusion

This chapter concludes the results of the research and answers the main question. By addressing the sub-questions, a deeper understanding of the different aspects of the topic is gained, which will eventually lead to a conclusion that answers the main question. The main points of the analysis are summarised and links are made between the different sub-themes that were investigated.

11.1. The three streams and their opportunities for future convergence

The Chapters 6, 7, 8 and 9 each answered the sub-questions prepared for this research.

11.1.1. What are the challenges RWS has faced in regard to road traffic management over time?

The analysis in Chapter 6 gave a description of the problem stream and answers the first subquestion. The challenges faced over time are complex and not easy to overcome. From efficient incident management, monitoring traffic flows and infrastructure and ensuring the privacy of citizens, RWS faces a multitude of obstacles in their operation that require strategic planning and optimisation of resources. Budget constraints and staff shortages force the Directorate road traffic management (VWM - WVM) to make strategic choices, while the constant pressure to innovate increases the complexity of their tasks through the need to embrace new technologies and ways of working.

11.1.2. What are the opportunities and challenges of drone technology in relation to RWS road traffic management, both historically and currently?

The second question is answered based on the analysis in Chapter 7, which analysed the technology stream. Drones offer many opportunities for improving road traffic management. They can be used on road plays in incident management by providing an overview of major accidents and other incidents, and in motor breakdowns on highways where camera coverage is lacking. In addition, drones are also used for post-incident assessment and assistance, such as quickly assessing post-incident situations and locating vehicles that have ended up in water. For forensic investigations of accidents, drones are invaluable because of their ability to be at the scene quickly and take aerial photographs. Drones are used in traffic monitoring and management at events and protests, where they help maintain an overview of traffic and respond quickly to accidents. They can also be used for asset management, such as inspecting structures and infrastructure, detecting road defects and collecting accurate data for inspection. Furthermore, drones are used for observation of tunnels, mapping of shortcuts and congestion at exits during road closures. Potentially, they could be used for intersection-level traffic analysis and monitoring of traffic flows on highways, and should be explored for contributing to solutions to personnel shortages by integrating them into operational frameworks, such as reducing the need for extended personnel for visual assessments.

The development of various business cases illustrates the growing potential of drones within RWS. There is general acceptance of the use of drones for societal benefits. However, concerns arise regarding their deployment for surveillance purposes. These public perception and ethical considerations are important factors that can influence their implementation.

The current challenges for drones in relation to RWS' road traffic management include limitations such as manual drone piloting, limited autonomy and operational range, and connectivity issues. These hinder effective large-scale inspections and surveillance tasks, as well as rapid presence at an incident, as the drone pilot needs to be present at the location. Research needs to be conducted to assess the effectiveness of drone-in-the-box systems for road traffic operations.

Within the RWS framework, various departments and teams play a significant role in promoting the integration of drone technologies, such as the RWS Drone Team, Bureau of Incident Management, Directorate CIV-OSR, Directorate of VWM - SWM, and regional traffic centers. Together, they form the entrepreneurs of the drone technology stream within RWS, with joint efforts focused on exploring opportunities, developing business cases, and fostering collaboration with external stakeholders to encourage the integration of drone technologies.

11.1.3. What are the challenges of laws, regulations and RWS policies related to drones for RWS road traffic management over time?

The third question is answered based on the analysis in Chapter 8. The current challenges in terms of legislation and RWS policy regarding drones for RWS road traffic management highlight various complexities and issues that hinder the effective integration of drone technologies.

Firstly, there is the issue concerning Beyond Visual Line of Sight (BVLOS) operations. The current laws and regulations do not provide a clear framework for such operations, complicating the licensing procedures. It's a complex process that requires involvement from multiple stakeholders, including ILT. This complexity can impede the speed and efficiency of drone implementation, especially in situations requiring a rapid response, such as incidents within the 'golden quarter-hour'. This issue underscores the need to establish a clear legal framework for BVLOS operations, facilitating smoother integration of drones into operational workflows.

Moreover, within RWS, there may still be a lack of full awareness regarding the potential benefits of drone technologies, particularly within the VWM - WVM directorate. The absence of explicit strategic plans for drones can hinder the integration of drone initiatives and influence the prioritisation of innovation within the organisation. The transition from an intrapreneurship mindset, characterised by a more organic and opportunistic approach, to a structured process like the IUP process, can also pose challenges for the emergence of a 'window of innovation'.

Overcoming these challenges requires close collaboration between policymakers, legislators, internal RWS departments, notably VVM - WVM, and external stakeholders. An integrated approach addressing both technical and organisational aspects is essential for achieving a 'window of innovation'.

11.1.4. In what way have the findings from the problem stream, technology stream and regulatory and policy stream converged over time to create a window of innovation opportunity for the effective implementation of drones for RWS road traffic management?

The fourth question is answered based on the analysis in Chapter 9. The findings from the problem, technology and policy streams provide valuable insights that RWS can use to be prepared for a window of innovation opportunity and offering a roadmap for to push this creation of a window of innovation opportunity for effective drone implementation in RWS road traffic management.

Recognising the inefficiencies in incident management on roads, such as the need for quicker and more accurate situational assessments, particularly in areas without camera coverage, is crucial. This mirrors the challenges previously faced in the maritime sector, where drones have proven to be an effective solution. The technological potential of drones to enhance incident management through rapid response and detailed aerial views, as demonstrated in maritime operations, underscores their feasibility and benefits. The successful pilots and scaling of drone use in maritime incidents can be replicated for road traffic management. This involves experimenting with BVLOS flights to see if they can be at an incident within the "golden quarter hour". The regulatory and policy stream has shown that RWS can navigate and shape policy to support drone use, as seen in the maritime sector. Efforts to integrate drone technology into regular operations, backed by regulatory advancements such as BVLOS flight permissions, provide a framework that can be adapted for road traffic management.

To push a creation of a window of innovation opportunity for drones in RWS road traffic management, RWS should engage stakeholders from different levels within RWS, including operational staff, management, and external regulatory bodies. This is essential to build a consensus on the necessity and benefits of drone integration.

Initiating targeted pilot programs for drone use in road traffic management, focusing on specific areas where current technologies fall short, is a key step. Conducting thorough cost-benefit analyses

will showcase the financial and operational efficiencies drones can bring, similar to the maritime sector's approach. Allocating sufficient resources and budget to support the integration of drones, involving investment in drone technology, and establishing a dedicated drone operations team or Drone2Go network within the road traffic management division, is necessary.

Working closely with regulatory bodies to advocate for the necessary policy changes that enable drone operations in road traffic management is also crucial. This includes obtaining permissions for BVLOS flights, first in experimental settings, and then integrating drones into existing traffic management systems. Promoting a culture of innovation within RWS by encouraging collaboration between departments, such as those responsible for maritime and road traffic management, and engaging with external partners, including technology providers and Drone2Go partners, will help stay at the forefront of drone technology developments.

11.2. Main conclusion

The implementation of an innovative technology such as drones by a road management organisation such as Rijkswaterstaat (RWS) requires a thorough approach by implementing Kingdon's framework that takes into account several aspects, including challenges, the drone technology opportunities and barriers, the regulatory framework and RWS policy structures.

The current challenges RWS faces in road traffic management are diverse and complex. These include efficient incident management, monitoring traffic flows and infrastructure, and safeguarding citizens' privacy. Budget constraints and staff shortages force RWS to make strategic choices, while the pressure to innovate increases the complexity of their tasks through the need to embrace new technologies and ways of working. Drone technology offers numerous opportunities to improve road traffic management, such as improving incident management, traffic monitoring, infrastructure inspection and even addressing staff shortages. However, current challenges for drones in relation to RWS road traffic management include limitations such as manual drone control, limited autonomy and operational range. That is why automatic drones-in-boxes will have to be used, which have regulatory challenges. These challenges related to BVLOS operations and the lack of a clear legal framework. Within RWS, there is also a lack of full awareness about the benefits of drone technology, which hinder its integration. The transition to structured innovation processes such as IUP processes can also be challenging for rapid adoption of innovations within RWS.

All these factors led to the conclusion that there has not yet been a window of innovation opportunity in which drones are implemented as a solution to problems in road traffic management. However, this research also analysed how this implementation could possibly happen in the future.

To create a 'window of opportunity' for effective drone implementation, changes need to be made at different levels. Internally, RWS needs to prepare by identifying operational challenges though its management and operations teams, recognising the benefits of drones and fostering a willingness of exploring this innovation despite its challenges.

This requires investment in resources, communication with stakeholders in higher and lower levels of the organisation and policy adjustments regarding drones. In addition, a Proof of Concept can be performed to demonstrate the value of the drone technology according to the IUP process. Externally, efforts must be made to adapt laws and regulations to enable BVLOS operations and to establish partnerships with other Drone2Go partners to share knowledge and resources.

It is important to realise that the internal 'window of opportunity' of RWS Road Traffic, when the problem is recognised and investments are made in drone solutions, does not necessarily coincide with the external 'window of opportunity' in terms of laws and regulations or willingness to cooperate with other partners. It is a gradual process that requires strategic planning, continuous adjustments and close cooperation to effectively take advantage of the opportunities that drones offer for road traffic management.

12
Recommendations

The Recommendations chapter translates the findings of this study into concrete recommendations for practice and policy. These recommendations are based on the findings and conclusions discussed in earlier chapters.

12.1. Academic recommendations

Based on the insights gained from the application of Kingdon's framework within the organization, further research should be conducted into the dynamic interaction of the three streams over time in an organization. Future research could focus on a specific policy area or project within the organization and track its evolution over a certain period. It is crucial not only to look at successful cases of convergence but also at situations where the streams do not come together. By mapping the dynamics between the streams, researchers can gain insights into the factors influencing the agenda-setting process within the organization. Additionally, conducting in-depth interviews with key stakeholders and decision-makers to understand their perspectives on the policy-making process would be beneficial. Longitudinal research can provide valuable insights into the changing nature of policy issues and how organizations respond to new challenges and opportunities. In this study, the final interviews were closely spaced, so it is recommended to spread them out better. It is also important to first research the stakeholders involved within the specific policy area or project to understand who has influence. With this approach, researchers can develop a deeper understanding of how policy is formed and implemented in organizational contexts and contribute to the development of more effective strategies for promoting innovation and change.

A second recommendation is to further research the application of Kingdon's framework for a specific innovation. Based on this study, it is recommended to shift the focus of the original policy stream to a single solution, specifically the innovation in question. This shift presents opportunities to identify multiple challenges and opportunities associated with the innovation. This research has shown that it is essential to consider not just one variant of the innovation but also further developments that need to be made. For example, testing drones in boxes was found to be crucial for obtaining a window of opportunity for innovation in the road traffic sector. Therefore, it is important to explore and understand a wide range of possible approaches and technological developments and how they fit within the existing policy and political context. This requires a thorough analysis of the problems the innovation aims to address, as well as a careful evaluation of the various policy and political factors that may impact its acceptance and implementation. Additionally, it is crucial to adopt an inclusive stakeholder engagement process, involving key stakeholders from different sectors and disciplines in the discussion about the innovation. This can help to bring forward different perspectives and insights and avoid overlooking potential obstacles. This research assumes that BVLOS flights will be feasible in the future and that drones in boxes, which still need to be tested, can ultimately contribute to solving the identified problems. However, future research should consider flexible and adaptive strategies that can handle uncertainty and changing circumstances, as innovation often involves unpredictability and risks.

12.2. RWS specific recommendations

Consider internal reallocation of existing resources and budgets to support drone projects, and establish a dedicated drone team or Drone2Go network within VWM. While the Drone Team is currently integrated with VWM - SWM and CIV - OSR, key roles are not filled by VWM - WVM. It may be worth exploring the possibility of sourcing a flight operation manager from WVM. Further conduct internal awareness campaigns to communicate the benefits of drones, including successful case studies from the maritime sector. Additionally, develop integration protocols. It would be advantageous for an On-Scene Duty

Officer to seriously consider calling the Drone Team in the event of an incident. Collaborate with ILT and other relevant bodies to amend regulations, specifically aimed at facilitating Beyond Visual Line of Sight (BVLOS) operations. It is advisable for RWS to remain actively involved in the BVLOS Roadmap. Conduct additional research on groups currently outside the scope of the study. Conversations with Waterways and other Incident Management experts, as well as traffic information gathering experts within VWM - WVM, could be considered. Focus on problem identification, which is currently lacking within VWM - WVM. Collaborate with regional operational teams to identify specific issues that drones can address. The Traffic Control Centre North-West Netherlands shows great enthusiasm for drones. Ultimately, dialogue should occur not only between the development department of VWM - SWM and operations, but also between the VWM - WVM Management Team and operations. Execute a proof of concept to test whether automated drones add value in incident management compared to the golden hour, and in traffic management compared to information gathering. RWS faces an important decision here, whether to wait for an external Window of Opportunity (WO) or to use the POC for an internal WO. As discussed in section 10.2.4, there are pros and cons to each choice. The research has already outlined a framework for this POC in collaboration with the National Road Traffic Data Portal and the Province of North Holland in the following chapter.

13 Proof of Concept

Deployment of drones for incident management and traffic management is now becoming increasingly opportune. Drones offer a range of benefits, including real-time aerial imaging, rapid deployment, and even the ability to explore hard-to-reach or dangerous locations. Moreover, drones can be equipped with advanced sensors such as thermal imaging cameras and air quality monitors, allowing them to provide valuable information to emergency responders in managing emergencies ranging from hard-to-reach locations such as wildfires to search and rescue operations. This pilot is focused on investigating the added value of deploying drones for road incidents outside of standard monitoring and traffic management. In large long-term accidents on the road, drones can already add value, in the future automatic/autonomous drones will fly (Beyond Visual Line of Sight) BVLOS and the “approach time” will be significantly shorter, than now the approach time of a drone pilot. With automation and a drone network (in the longer term), the time to deployment will be shortened, faster visibility of a situation/location, more timely adequate assistance in view, shorter overall time of the incident/situation, etc.

13.1. Participating parties

RWS-VWM coordinates incident management and traffic management on Dutch highways and waterways. This includes detecting and handling traffic accidents, breakdowns and other incidents on the road, as well as managing shipping traffic and solving problems such as bridge and lock failures. RWS is affiliated with the collaborative project Drone2Go which aims to enable BVLOS flying and achieve a functional nationwide drone network. It is working with 6 partners on this: Police, Fire Service, NVWA, ILT, Coast Guard, Customs. Rijkswaterstaat currently has an RWS Drone Team, and group of 23 certified drone pilots, which are deployed in, among other things, the faster resolution of incidents on the Dutch (shipping) road network. Currently, the RWS Droneteam uses non-automatic drones, because of this, cases for which they use drones are 80 percent on the water and 20 percent on the road. Theoretically, automatic drones could make gains on a larger scale in incidents and breakdowns on the road for RWS. A proof of concept will be done for this purpose.

National Road Traffic Data Portal (NDW) for its partners on the real-time and historical processing of data to provide real-time information about the situation on the road and to evaluate the use of the road network with historical data. For data acquisition and provision, partly NDW’s partners are the source and partly NDW provides the procurement/acquisition of traffic data. Innovation is an important topic in mobility data and that is where NDW seeks to improve and renew existing and new services. One example is the NDW backbone development that processes near-real-time data to send out as enrichment in the real-time data stream. When incidents occur on the road, the NDW/IM backbone verifies incident data by making combinations with different independent data streams, using specially developed algorithms, expectations based on history. The use of drone data can add value to the IM backbone setup. From that perspective, NDW wants to participate in this drone pilot. Current is probe vehicle data processing and this innovation learning cycle also applies to processing actual drone data. That could mean real-time processing of drone video images into the IM backbone to determine relevant traffic data from. Think about interpreting images with specific SW, AI techniques, ML techniques.

Province of North Holland (PNH) is participating in a “Dronelab” as a living lab in its province. Much attention is being paid to drones and their various applications in PNH’s various policy areas. Urban air Mobility is an important theme that is being fleshed out more organisationally.

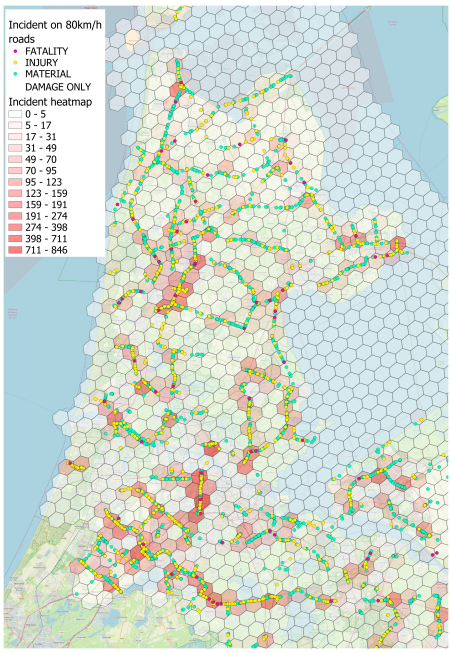
13.2. Pilot expectations

The research focuses on determining the added value and operational requirements of using drones for incident and traffic management on the road, as requested by Rijkswaterstaat, the Province of North

Holland, and NDW. Key aspects include the speed of drone deployment, range, costs and benefits, and operational processes. It is expected that the research will help determine the effectiveness and feasibility of drones for these applications.

13.3. Looking for a specific location

First, data is collected on the location (or locations) where we can conduct a test with a drone-in-the-box. Since the Province of North Holland has joined the POC, only location in North Holland are considered. Furthermore, the information gathered by the drone will be used for IM. Therefore, the preparation of the POC involves looking for a location where many accidents happen. Of course, drone testing will be tested as a unique innovation that offers a unique perspective and can be deployed on-demand. Therefore, locations of with fixed roadside cameras are excluded.



(a) Map with incident locations on max 80km/h road

(b) Map with camera locations

The maps are overlaid to identify areas where there are no cameras and a high number of accidents.

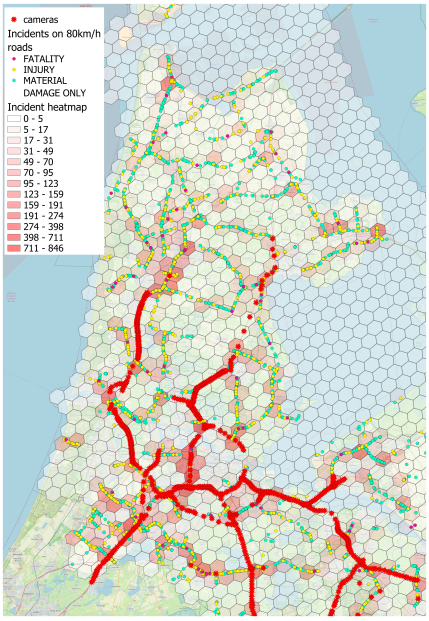


Figure 13.2: Map with incidents and camera's

To fly BVLOS, one must fly in segregated or controlled airspace, or fly outside segregated or controlled airspace in a-typical airspace over controlled or sparsely populated territory. A-typical airspace is a portion of airspace where manned aircraft cannot normally enter. This is airspace within 30 meters of buildings or obstacles such as trees. However, since it must be a sparsely populated location, only roadside trees are considered. Furthermore, the maximum road speed should not exceed 80 km, since in terms of aviation regulations, there are more mitigating measures taken at 100 km. This is already done in the previous maps as well.

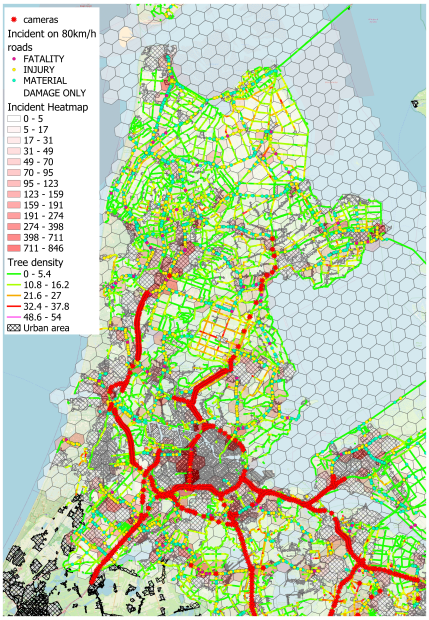


Figure 13.3: Map with incidents, cameras, three density and urban areas

Another option is to conduct a BVLOS flight in segregated or military controlled airspace (CTR). A

military CTR is the airspace above and around a military airport, and it is controlled by air traffic control. When this map is laid over the existing map, a location emerges, namely the military CTR De Kooy.

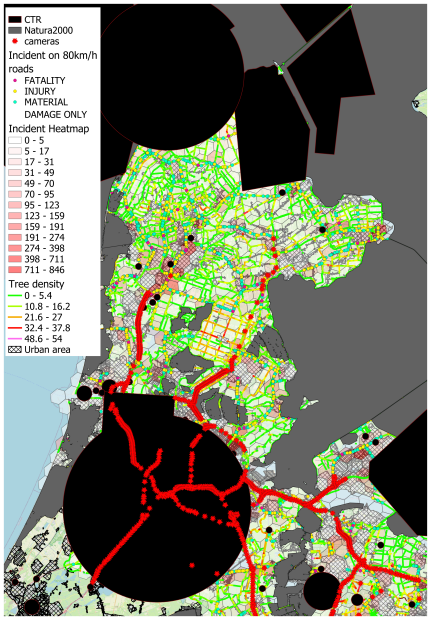


Figure 13.4: Map with CTR

13.4. Conclusion Location

Based on the various considerations per party and the prepared map, the N250/N99 intersection was chosen because it is located in the military CTR De Kooy. There are possibilities to fly BVLOS here (provided a covenant is concluded with De Kooy air traffic control, no Atypical Airspace is required). It is also a location where incidents occur more frequently.

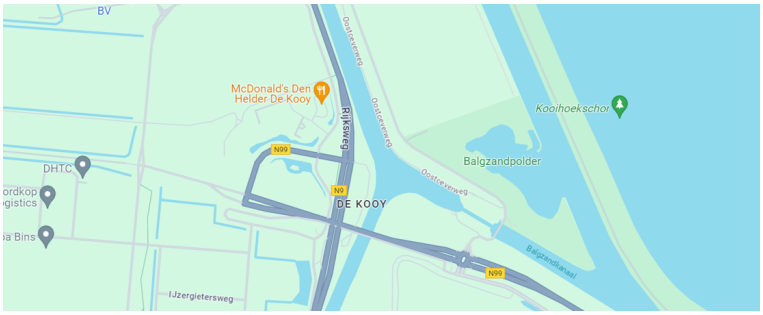


Figure 13.5: POC location (Source copied from Google Maps)

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A
Appendix A

The first method used to find literature is by using a search engine. The search engines Scopus and Google Scholar are used for this literature review. The technology category looks at various techniques that already exist for drones. The search terms used in articles consist of ”drones”, ”unmanned aerial vehicle”, ”application”, ”road safety”, ”traffic”, ”road traffic, ”accident”, ”emergency”, ”surveillance”, ”monitoring”, ”disaster responses”, or a combination of those search terms. A lot of articles came up, therefore the search was limited to certain keywords. For the articles about emergency responses, the keywords were limited to ”accidents”, ”emergency response” and their synonyms. The articles concerning traffic monitoring were selected based on specific keywords mentioned, like ”monitoring” and by the snowballing method. For the process category, the search is done by looking at topics such as laws and regulations and social acceptance, but also how stakeholders can collaborate in operationalising drones. The search terms used for finding the articles are ”drones”, ”safety”, ”regulation” and ”acceptance”. This resulted in many articles which needed to be scaled down. Therefore, only articles for the Netherlands were selected in order to get a good picture of what the rules and norms are in the Netherlands.

A.0.1. Overview table

The literature search resulted in some articles that could be reviewed. In the table below are the articles listed. It is also described to which category they belong, which search terms were used and on which keywords they were selected.

Table A.1: Article selection criteria

Article	**Category**	**Search term or snowballing method**	**Keywords mentioned**
(Outay et al., 2020)	Technique	(”drones” OR ”unmanned aerial vehicle”) AND ” applications ” AND ”road safety”	Application of UAVs
(Chowdhury et al., 2023)	Technique	(”drones” OR ”unmanned aerial vehicle”) AND ”traffic” AND (”accident” OR ”emergency”)	Drone in emergency
(Iman Norahim et al., 2023)	Technique	(”drones” OR ”unmanned aerial vehicle”) AND ”traffic” AND (”accident” OR ”emergency”)	Reconstructing of accident scene
(Gupta et al., 2020)	Technique	(”drones” OR ”unmanned aerial vehicle”) AND ”road traffic” AND ”surveillance”	Drones for first responders
(Bisio et al., 2022)	Technique	(”drones” OR ”unmanned aerial vehicle”) AND ”road traffic” AND ”surveillance”	Drone based road traffic monitoring system
(J. Li et al., 2019)	Technique	snowballing (Bisio et al., 2022)	Multi-Vehicle Ground Speed Estimation
(W. Li et al., 2019)	Technique	(”drones” OR ”unmanned aerial vehicle”) AND ”applications” AND ”safety”	Counting drones
(Hu et al., 2023)	Technique	(”drones” OR ”unmanned aerial vehicle”) and ”disaster responses”	Drone mission planning
(Casierra et al., 2022)	Technique	(”drones” OR ”unmanned aerial vehicle” or ”UAV”) and ”monitoring”	Infrastructure
(Wang et al., 2021)	Process	(”drones” OR ”unmanned aerial vehicle”) AND ”regulation”	Ethical considerations
(Lee et al., 2022)	Process	(”drones” OR ”unmanned aerial vehicle”) AND ”safety” AND ”regulation”	Safety and privacy regulations
(Oltvoort et al., 2019)	Process	(”drones” OR ”unmanned aerial vehicle”) AND ”acceptance”	Public Concerns Towards Drone Use

B
Actor Analysis

B.1. Key players

The Directorate General of Aviation and Maritime Affairs (DGLM), part of the Ministry of Infrastructure and Water Management, develops policy on maritime affairs and aviation. They are a major player in the Dutch drone field. They are the driving force behind the application for the national growth fund related to drones.

RWS VWM WVM stands for Rijkswaterstaat Verkeer- en Watermanagement - Road Traffic Management. This is the Directorate within Rijkswaterstaat responsible for the management and regulation of road traffic in the Netherlands. Its core tasks include operating objects in the main road network, crisis management, maintenance measures, providing traffic information, reviewing permits, implementing process improvements and international coordination at tactical level. The Network Services encompass de-icing operations, enforcement activities (including the deployment of BOAs - special enforcement officers), object operation (involving traffic controllers in traffic control centers), incident management (covering detection, rapid deployment, securing, and towing), network optimization (involving the routing of overall traffic flows across the main road network), works in progress (encompassing all road works and coordination with contractors), as well as travel and route information exchange with service providers (Exploratory Interview 4, personal communication, 16 November 16, 2023).

RWS VWM SWM stands for a directorate within the organizational unit Rijkswaterstaat Traffic and Water Management. Rijkswaterstaat is the executive department of the Ministry of Infrastructure and Water Management in the Netherlands and responsible for the management and maintenance of the Dutch infrastructure, including roads, waterways, locks and water management. VWM is specifically charged with the management and maintenance of the Dutch infrastructure in the field of traffic and water. The SWM Directorate stands for Shipping and Water Management, and includes management and maintenance of locks, roads and waterways, as well as traffic management for shipping on Dutch inland waterways.

RWS CIV stands for Rijkswaterstaat Centrale Informatievoorziening. This is the department within Rijkswaterstaat responsible for developing, managing and providing information and communication systems to support Rijkswaterstaat's tasks, such as traffic management, water management and infrastructure management.

The Directors' meeting Smart Mobility is a meeting that brings together the directors involved in the Smart Mobility project and the Smart Mobility team itself. Smart Mobility is focused on the use of innovative technologies and data for both WVM and SWM.

Smart Patrol is the RWS innovation program for shipping.

The RWS drone team consists of operators from Rijkswaterstaat who specialise in the use of drones for incident management, such as accident support and obtaining real-time emergency information. Their focus is on providing support to emergency services and promoting efficient and safe incident handling.

Bureau Incident Managmement is responsible for all incidents throughout the Netherlands that affect Rijkswaterstaat's primary process

B.2. Subjects

Drone2Go's steering committee consists of directors and experts from the various partners and is responsible for directing, coordinating and monitoring activities related to the use of drones. Their role includes setting strategic goals and facilitating cooperation among partners for effective deployment of drone technology.

Drone2Go team members are individuals involved in the initiative to create a nationwide drone network between various partners, including the Department of Public Works, police, fire department, NVWA, ILT, coast guard and customs. Currently there is no operational network yet, but team members are sharing knowledge and exploring compliance issues to achieve this goal.

Customs is responsible for enforcing border and customs laws, including checking incoming and outgoing goods and collecting taxes and duties. They use drones for surveillance and inspection purposes to monitor cross-border activities. As a partner of the Drone2Go organization, they contribute to the development and implementation of drone technologies for various applications.

The fire department is an emergency service dedicated to fighting fires, saving lives and providing assistance during accidents. They can use drones to explore hot spots and hard-to-reach areas, monitor major incidents and map situations from the air. As a partner of the Drone2Go organization, they can benefit from collaborations and knowledge exchange on drone use within the fire department industry.

The NVWA (Dutch Food and Consumer Product Safety Authority) oversees the safety of food and consumer products, animal welfare and nature. They can use drones for inspections of agricultural areas, food production facilities and nature reserves. As a partner of the Drone2Go organization, they can benefit from expertise and collaborations in drone use for inspection purposes.

The Coast Guard is responsible for guarding Dutch waters and coordinating emergency response to maritime accidents and emergencies. They can deploy drones for maritime surveillance, search and rescue operations and environmental monitoring. As a partner of the Drone2Go organization, they can participate in a joint network and knowledge exchanges in the field of maritime drone operations.

Police are charged with maintaining public order and safety, investigating crimes and providing assistance. They can use drones for surveillance purposes, detection of suspects and missing persons, and assistance in emergency situations. As a partner of the Drone2Go organization, they can benefit from expertise and collaborations in law enforcement using drones.

The RWS operation comprises the regional presence of the Department of Public Works, including traffic posts and traffic control centers throughout the country. These posts and centers are responsible for monitoring and managing road traffic on highways and waterways, performing incident management, and providing traffic information to road users. It also includes OvDs, (Officers on Duty), road inspectors, and individual road traffic controllers.

National Road Traffic Data Portal is an online platform that aggregates and provides access to various traffic-related data collected from different sources across the country. They have taken an interest in using drones for their own operations and is looking to RWS due to their expertise and similar operations (Meetings on POC Automated Drones for Road Traffic Management, personal communication, 26 September/10 October, 2023).

Province Noord-Holland oversees and manages the road network within its jurisdiction. This includes planning, construction, maintenance, and operation of roads, as well as implementing traffic management measures to ensure smooth traffic flow, enhance road safety, and address congestion issues. They have taken an interest in the potential of using drones. (Meetings on POC Automated Drones for Road Traffic Management, personal communication, 26 September/10 October, 2023).

B.3. Context setters

ILT, the Environmental and Transport Inspectorate, is responsible for supervising compliance with laws and regulations in the areas of transport, the environment and the living environment. Specifically regarding drones, ILT oversees the safe and legal use of drones in the Netherlands, including licensing and enforcing regulations surrounding drone operations.

Air Traffic Control the Netherlands (LVNL) is an independent administrative body (zbo) of the Ministry of Infrastructure and Water Management (IenW). LVNL is primarily responsible for ensuring the safety of civil air traffic in the Netherlands. In addition to managing air traffic, LVNL is engaged in tasks such as renewing and managing technical systems, providing aviation intelligence, providing air traffic control training, and providing aviation maps and publications. LVNL plays a crucial role in maintaining the safety, efficiency and reliability of air traffic in the Netherlands.

The Netherlands Aerospace Center (NLR) is a leading knowledge institute in the field of aerospace. NLR conducts research, develops technologies and offers services in various areas of the aerospace sector. In doing so, it focuses on a wide range of activities, such as renewing and managing technical systems, providing aviation intelligence, and providing air traffic control training. Within this context, NLR also plays an important role in the development and application of drone technologies. The NLR Drone Centre serves as the knowledge partner for innovative solutions with drones, aimed at addressing societal, economic and safety challenges. It provides expertise and facilities for designing, testing, and certifying advanced drones, as well as support in integrating drones into airspace and advising on policy and regulations.

Software developers: These are companies that specialise in developing software for drones, including flight controller software, autopilot systems, mission planning software and image processing algorithms and detect and avoid systems. Hardware developers: these are companies engaged in designing, manufacturing and improving physical components of drones, such as frames, motors, sensors and cameras. Airhub, Avy and Aeret are an examples of such companies.

B.4. The crowd

The LVMB is a national platform where Dutch road authorities meet to discuss (road) traffic management issues and formulate preconditions for implementing measures. For applications of drones in road traffic, they can contribute by advising on strategic and tactical aspects, such as integrating drones in traffic management plans and formulating guidelines for safe and efficient use of drones on the road.
The Dutch Drone Nederland is an alliance of several organisations in the Netherlands that focuses on the development and use of drones. Its goal is to promote the growth of the drone industry and contribute to the safe integration of drones into Dutch airspace. The council brings together various stakeholders, such as companies, governments and research institutions, to jointly work on issues surrounding drones, such as regulation, safety and innovation. By working together within the Dutch Drone Council, members strive to support and grow the drone sector in the Netherlands.

The Dutch Drone Delta is a national initiative focused on the development and application of drones in the Netherlands. It brings together various stakeholders to position the Netherlands as a leading ecosystem for drones. Their focus is on stimulating innovation, creating an enabling environment for the growth of the drone industry and promoting the safe integration of drones into airspace.

The ANWB, is a Dutch organisation originally focused on supporting motorists and cyclists. Today, ANWB offers a wide range of services, including roadside assistance, insurance, mobility services, recreational activities and assistance. Recently, ANWB began exploring new technologies and applications, including the development of a medical drone. This medical drone is intended to provide emergency medical assistance in hard-to-reach locations or emergency situations where speed is critical.

KPN is a leading telecommunications company in the Netherlands focused on providing mobile and fixed telecommunications services. They are introducing innovative solutions such as ”Drone Connect,”

which supports commercial drone applications by connecting drones to the 5G network, enabling efficient and safe flights with guaranteed wireless connectivity.

The Port of Rotterdam is Europe's largest port and a major logistics hub. They use drones for port operations, such as inspections and surveillance, and are developing a U-Space airspace to improve the integration of drones in the port area.

C
Interview Structures

In this appendix chapter, the structure of the interviews conducted is presented. It is important to note that these interviews were semi-structured, allowing for flexibility in questioning and response patterns. Therefore, the structure outlined below may not perfectly mirror the actual interviews conducted.

C.1. Structure of exploratory interviews

C.1.1. The interviewee is not affiliated with RWS

1. Introduction & introduction research
2. Background interviewee
3. How does your organisation use drones?
4. Are there possibilities for collaboration within both our organisations?
5. Do you have tips regarding the use of drones for road traffic?

C.1.2. Interviewee is from RWS

1. Introduction & introduction research
2. Background interviewee
3. Are you involved with the RWS drone dossier?
   (a) Can you elaborate on the operation of the RWS Droneteam?
   (b) In your opinion, what are the opportunities of drones?
   (c) In your opinion, what are the limitations of drones?
4. Is there discussion about drones within your department/project?
5. What, in your opinion, are the use cases of drones?
6. Do you know of any other individuals I could speak to?

C.2. Structure of final interviews

C.2.1. Problem stream

1. What were the most common challenges in managing incidents in the past?
2. How have discussions about using drones for incident management evolved within the road and waterway management departments of Rijkswaterstaat?
3. What are the main differences between incident management on waterways and roads, and how do these differences affect the potential use of drones?
   (a) Besides the extended response time due to not yet being allowed to fly BVLOS.
4. What are the current problems Rijkswaterstaat faces in managing road incidents?
5. Have there been specific incidents where the use of drones would have been beneficial for road incident management? If so, can you provide examples?
6. In what ways do you think drones can help improve road incident management in the future?

C.2.2. Technological stream

1. What technological developments have occurred in the past that are relevant to incident management on roads?
2. Have there been significant decisions made in the past regarding the deployment of technologies for incident management on roads, and how have these decisions influenced the development of drones for incident management?
3. What are the current technological capabilities and limitations of drones for incident management on roads?
4. What technical challenges need to be overcome to deploy drones more effectively for incident management on roads?
5. What key technological breakthroughs or innovations are necessary to promote the acceptance and implementation of drones for incident management on roads, and what decisions need to be made to support these developments?

C.2.3. Regulatory and policy stream

1. What political or policy developments have influenced the agenda in the past regarding:
   (a) Technology adoption within the road management department of Rijkswaterstaat?
   (b) Emergency management within the road management department of Rijkswaterstaat?
   (c) Legislation regarding drones for public organizations and/or the Netherlands?
2. Have there been significant decision-making moments in the past regarding policy on drone usage?
   (a) And for incident management on roads?
3. What policy guidelines currently exist regarding the use of drones for incident management on roads within Rijkswaterstaat?
4. How are these policy guidelines implemented in practice?
5. What changes in the political or policy landscape could influence decision-making on drone usage for incident management on roads in the future?

D
Summaries of exploratory interviews

D.1. Exploratory Interview 1

Background description The person works for VWM Shipping and Water Management. He is part of the drone team, serving as one of the two flight operation managers. Additionally, he also holds the position of Officer in Charge (OvD).

Can you manage being a drone operator while being a OvD? The person mentions that he starts his shift as OvD in his area from Monday to the following Monday. During this time, he can be called 24/7 for collisions or minor contaminations. He can also be involved in drone operations simultaneously, but only if there are no duties as OvD, which is rarely the case. He would be switching hats, therefore he would ideally need to call the drone team and request an additional pilot.

Can you elaborate on the operation of the RWS Droneteam? The person responds that the drone team has been operational since 2019. They are deployed ad hoc for incidents on water and road, averaging once a week. The other times they fly are for training purposes. In total, they conduct 1500 flights per year to meet their required flight hours. Regular training sessions are held, consisting of 30 regional trainings and 4 national trainings. There are 25 pilots, each employed by the drone team one day a week. Therefore, from Monday to Friday between 9 AM and 5 PM, there is a guarantee that a pilot can arrive at an incident location within 1 to 1.5 hours. The pilots have diverse backgrounds, some from traffic control centers, others from waterways. Drones are deployed from land, water, and even near highways. As an aviation organization, they have a flight operation manager from RWS VWM, a training manager also from VWM, an accountable manager from CIV, and a technical manager from CIV. There is also the Bureau Incident Management Water and Shipping from VWM, with the CEO serving as the director. They also have a manual that outlines all the flight and organizational rules. The Droneloket has been established for inquiries and requests.

What, in your opinion, are the use cases of drones? The person provides several examples. As OvD, he recently found a car in the Ijssel river using a drone. People were already out of the car, emergency services had left, and highway users were not affected. At that moment, there was no vessel available to search for the car. So, he briefly took on the role of drone pilot. He thought he might could see a silhouette of the car or oil droplets. Another example was waste processing in Rotterdam, which posed a challenge for the fire brigade. The OvD could have asked if the RWS Droneteam was observing, but they likely had already been monitoring the images from the fire brigade. A third example is in traffic for forensic investigation. Drones can take photos of skid marks, etc. In such a situation, the preference is for the police drone team or police helicopter or military police, but they were all unavailable. Then the question arose whether the RWS Drone Team could come. The answer is still undecided at this moment because the police would need to fund the RWS Drone Team (at a higher level). In this specific case, the RWS Drone Team was deployed, but there was some reluctance. Example four is about a traffic control center that wants to know the situation at a specific intersection, they want images of the main road and the side road that intersect, but that request encounters difficulties. Or example five, for example, trucks parking alongside the road at a rest area.

Are there differences in use cases for shipping vs road traffic? The person responds that in shipping, you often can't get close to the incident, so the drone pilot is called in more quickly. On the road, the OvD actually doesn't call because the incident is manageable. Unfortunately, the drone team isn't even called for large-scale incidents.

Are drones also often deployed on these use cases? The person explains that the primary scope is incident management from Monday to Friday, 9 AM to 5 PM. Plannable assignments should actually go to market. So, how do you justify drones flying for other cases? Other tasks can be carried out as training moments, such as traffic monitoring. Communication also wants fun footage, for instance. Perhaps a permit could be granted for supervision and enforcement. The person is open to expanding

the scope. Often, requests in the drone desk also have to be declined. However, this would also mean expanding the team.

In your opinion, what are the opportunities of automatic drones? This person believes that a drone-in-the-box would be a handy tool. You could log in per process or organization and utilize it. It's actually odd that every government organization now has its own drone team.

In your opinion, what are the limitations of drones and/or the current drone operation? The person responds that drones are also used by various parties outside of RWS and not always by the book. RWS, on the other hand, always seeks permission for everything, even if there is no enforcement. This sometimes means they refrain from doing things that others (without permission) might do.

What kind of drone do you use? The type of drone the person uses is often around 1 kg, not very large. The Phantom is being phased out. They use the Enterprise (2 different types) or the Mavik 3-T (Thermal, infrared images). The Drone-in-the-box will likely be a larger size.

D.2. Exploratory Interview 2

Background description The person is from RWS CIV and is part of the drone team as the technical manager.

I've heard a lot about the operation of the droneteam, but what are the limitations of the droneteam for road traffic? The person responds that traffic control centers probably want to do some things with drones. The drone team should also be called in if it's a traffic incident, but that operation doesn't seem to be taking off. The road inspectors have a pretty good overview of the situation, so they're not necessarily essential. Sometimes an incident is resolved very quickly, within the golden quarter-hour. By the time the drone team arrives, it's over. That's why it's not really thriving within RWS Road Traffic Management. Additionally, accidents are often well-managed, and those people have experience. So you can mainly deploy drones for major incidents of which the situation is not clear. However, three drone pilots coming from traffic centres have joined the drone team to reduce the gap between shipping and road traffic.

What, in your opinion, are the use cases of drones? The person discusses several requests for which they have flown drones. During major incidents leading to road closures, they monitor the underlying road network. For example, they observe the flow of detour traffic, checking for congestion or accidents. They also monitor areas behind sound barriers where regular cameras cannot see, to understand traffic flow. They provide traffic monitoring services for control centers and environmental managers. For instance, they conducted monitoring at the Vlaketunnel, capturing several intersections and exits via live stream, with data distributed to contractors, traffic managers, and environmental managers. Another example was the aqueduct near Middelburg which is closing. They also monitor traffic on highways like A76 and A67 during German holidays, focusing on truck traffic, as trucks are prohibited from entering Germany during these holidays, leading to congestion at rest areas. They monitor truck drivers who stop on the shoulder just before the border to change their tachograph and rejoin traffic. They provide traffic monitoring at events like the Zwarte Cross and during farmer protests, where aerial views are useful for maintaining an overview. They respond quickly to accidents witnessed in real-time, providing updates to control centers about emergency services' arrivals. They use drones for real-time traffic monitoring to complement predictions made by platforms like Google Maps and Waze. Real-time aerial views help identify incidents within traffic jams.

That's a lot of examples of applications, is that your scope of the drone team? The person explains that the scope primarily involves incident management. Other requests are submitted to the Drone Desk, where they assess whether it's interesting for them to gain experience with them, for instance, flying in the dark. Our pilots also need to keep track of their flight hours, so this provides opportunities for assignments beyond incident management. Essentially, he explains that they should leave those to the market, so if they don't have availability, it's up to the market.

So would you actually want to fly just for incident management? The person also mentions specific locations, such as the A59 between Waalwijk and Raamdonk, where accidents often occur without the drone team being called in. On the other hand, incidents are often resolved within a 'golden quarter-hour'. Therefore, he emphasizes the need for more awareness about the availability of the drone team and mentions that they are rather called in more often than not.

He shares a situation where they witnessed an accident and were able to immediately deploy a drone. This enabled them to inform the traffic control center that the ANWB vehicle was already en

route and that ambulances would soon arrive.

While it might seem convenient to have road inspectors or OvDs equipped with drones, however they are usually occupied with managing traffic. Hence, there is always a need for an additional person to operate the drone.

What could automatic drones do for the current operation?

The person responds that drones could potentially assist at junctions, especially where there are blackspots. With just the press of a button, you could have a drone in the air. However, the issue lies in the laws and regulations, not the technology itself.

Regarding whether automated drones could help with the 'golden quarter-hour' issue, the person responds with a question about the total length of roads in the Netherlands. Therefore, it could be feasible to deploy them in sections of roads prone to accidents.

D.3. Exploratory Interview 3

Background description The person is project manager of Smart Mobility.

Is there discussion about drones within Smart Mobility? The person responds that Smart Patrol, which includes the drone dossier, is part of Smart Mobility. In this way, drones are involved in Smart Mobility.

Do you have suggestions on where I can find people to talk about the usage of drones in the road traffic operation? The person suggests reaching out to the creator of the road traffic management implementation plan. Additionally, they mention the possibility of contacting network facilitators, who serve as advisors for processes. This could involve engaging with individuals who champion this topic or department heads overseeing incident management. Portfolio holders who take ownership of the work process may also be beneficial to engage with, as well as the management team in road traffic management. Furthermore, there will be a directors' meeting on Smart Mobility in February where the research could be presented, offering an opportunity to provide recommendations or pose questions.

Can you tell me about the way new innovations are implemented at RWS? The person responds that there is a document about IUP (Innoveren Uniformeren Produceren). The process involves innovating, piloting to test technical feasibility, then establishing a business case or value case, and conducting an impact analysis on work processes. Finally, there's a phase of standardizing and one of producing.

D.4. Exploratory Interview 4

Background description The person works in the department of operational development for road traffic.

Can you elaborate on the operation of the RWS Droneteam? The person answers no, so I explain that there is a drone team for incident management, but it's not widely known within road traffic management. I'm exploring potential applications within road traffic. I elaborate on the challenge of VLOS (Visual Line of Sight) versus BVLOS (Beyond Visual Line of Sight) flying.

Are drones mentioned in the road traffic execution plan? The person responds that the word "drone" does not appear in the plan, as there hasn't been any consideration given to its applications. There's still limited awareness. Currently, the focus is primarily on Drone2Go for maritime traffic. The person is still searching for use cases in road traffic. There is a brainstorming about potential applications, such as monitoring roads without traffic cameras, assisting in roadside assistance scenarios (to determine if a road inspector needs to respond), traffic monitoring, monitoring large events, monitoring long heavy trucks, how do they integrate, and assessing road conditions at a broader scale. For instance, if there's a pothole on the road, while a road inspector drives over it, a drone could fly alongside to provide additional perspective and zoom in on the issue.

What different network services ("netwerkdiensten") are there? De-icing operations, which deal with when to spread salt, enforcement, including BOAs (special enforcement officers), object operation (traffic controllers in traffic control centers), incident management (detection, rapid deployment, securing, towing), network optimization (routing of overall traffic flows across the main road network), works in progress (all road works, coordination with contractors), travel and route (everything about information to and from service providers).

The person adds that traffic monitoring mainly occurs at RWS WVL and suggest that ANWB also works with drones.

D.5. Exploratory Interview 5

Background description The person works at the traffic control center in Rhoon, which is the Southwest Nederlands traffic control center. One day a week he flies for the RWS Droneteam.

Can you elaborate on the operation of the RWS Droneteam for VC Rhoon The person mentions that the drone team at VC Rhoon is minimally utilized. There is 100 percent camera coverage at the Rotterdam ring road. The VOA (Traffic Accident Analysis) team swiftly arrives on-site in case of accidents.

In your opinion, what are the opportunities of drones? The person explains that although there is little need for drones to replace fixed cameras in his region, there is potential for the use of cameras in areas where there are no roadside cameras.

In your opinion, what are the limitations of the RWS Droneteam? The person feels that the RWS drone team is underutilised, as the region fails to reach out to them or call upon their services. They believe that the drone team needs better promotion and visibility to be recognised and utilised effectively.

What, in your opinions, are the use cases of drones? The person responds that in addition to the incidents they handle, which may be less relevant for VC Rhoon, monitoring parked trucks upon request could be beneficial. Another application could be monitoring a busy intersection.

D.6. Exploratory Interview 6

Background description The person is employed at the Traffic Control Center Velzen, or VC Northwest Netherlands, and flies for the drone team.

Can you elaborate on the operation of the RWS Droneteam? The person explains that the RWS drone team flies for incidents both on water and on the road, and assumes that the team will remain as it is without any changes. He is surprised by the discussion about Drone2Go and the exploration of other applications beyond incident management. Sometimes, they conduct different types of flights for their training purposes.

In your opinion, what are the limitations of drones? The person responds that we need to be cautious about the misuse of drones. For instance, commercial entities flying drones just along the highway to conduct inspections can distract road users. Even RWS GPO asks contractors to inspect things like guardrails, but they are not told how to do so safely. Additionally, flying around Schiphol with the drone team is challenging and requires special permission.

In your opinion, what are the opportunities of drones? The person recounts a situation in Zeeland involving a bend made difficult to navigate by trees, where they witnessed an accident. They contacted the traffic control centre but couldn't offer much assistance, as the accident fell outside their jurisdiction. Drones could potentially provide a solution in such cases. Utilising drones could make a difference in directing a road inspector with priority to the situation or allowing them to proceed at a slower pace.

The person emphasises that the drone serves as a flying incident management camera. Therefore, both operational staff and management should discard the notion that it's solely for major incidents and explore its potential in various situations.

The person becomes enthusiastic about the possibility of a collaborative network. They believe in maximising the utility of available resources. However, using drones for purposes beyond incident management can create significant costs, hence cooperation is desirable. A nationwide drone operation is feasible, given that flying for all government agencies adheres to the same rules. They are familiar with the regulations and can fly safely.

What are the use cases of drones?

He also mentions organizing an exercise along the highway once, greatly planned, including a "missing person in the roadside." They monitored traffic during this exercise. While his traffic control center is enthusiastic, he notice less enthusiasm from other centers. He believes that RWS should not handle maintenance of objects, but rather outsource it to the market.

Is there a map available that shows the locations of registered incidents and/or the camera placements? The person responds that he has indeed a file showing the locations of the cameras, but there isn't a map or file indicating where the accidents occur. Each accident would need to be individually highlighted, making it a less straightforward task. Frontal collisions often occur on the N9 or N99.

D.7. Exploratory Interview 7

Background description

The individual has been part of the drone team for several years and typically operates from the traffic control center in Wolfheze, North and East Netherlands, as a road traffic controller.

Can you elaborate on the operation of the RWS Droneteam?

The drone pilot explains that the RWS Droneteam primarily monitors incident reports themselves, as they are not automatically or promptly notified of accidents. This lack of immediate notification could be attributed to various factors, including limited awareness of drone availability and the busyness of the traffic control center, which may lead to oversight in monitoring incident reports. Additionally, the individual mentions that much of the team's work occurs outside regular hours on a voluntary basis. When there are incident reports outside office hours, members of the team are asked via the app group if they are available to respond. Despite potential challenges, it is noted that there is generally a sense of enthusiasm within the team for the work they do and the value of drones.

In your opinion, what are the limitations of drones?

The person highlighted the limitations of drones, including their restricted speed and range. Due to these limitations, drones can only be deployed in accidents that last longer, allowing the pilot enough time to arrive on-site. Additionally, while drone footage can provide valuable insight into a situation, it may not always offer the means to swiftly resolve it. For instance, extensive detours may be necessary for large accidents, a process that takes time and often requires resources beyond visual information provided by drones.

Moreover, the person emphasized the complexity of drone legislation, particularly the requirements for flying beyond visual line of sight (BVLOS). He noted that advancements such as the utilization of drone-in-the-box systems could help address these limitations.

What are the use cases of drones?

He outlines several use cases for drones. Firstly, drones are employed for event monitoring, particularly at large events like the TT in Assen and the Zwarte Cross. In this capacity, they assist traffic control centers in identifying traffic flow issues, allowing for swift deployment of traffic controllers or adjustments to traffic lights to better manage traffic.

Secondly, drones provide assistance in accident response, especially in the case of prolonged accidents. The drone pilot can be called to the scene to gather imagery, aiding the traffic control center in assessing the road situation and making decisions regarding diversions or traffic management. These images can also be shared with law enforcement or other emergency services. He emphasizes the lack of fixed cameras in some regions outside the Randstad due to budget constraints, limiting the traffic control center's ability to fully monitor traffic and respond promptly to issues.

Furthermore, the suggestion is made to deploy drones at strategic locations, such as junctions, to monitor traffic, providing better insights into traffic flows and detecting delays elsewhere in the network.

Additionally, the interviewee discusses potential new tasks for the drone team, such as object and object inspections, although these tasks currently fall outside their current scope of work.

Finally, he talks about collaboration opportunities between the drone team and the police, particularly in cases requiring forensic investigation. He provides an example of an incident where the drone team was able to capture images, negating the need for the forensic team to visit the site, resulting in expedited incident resolution.

D.8. Exploratory Interview 8

Background description The interviewee is an embodiment of the ANWB, and is part of the company Medical Air Assistance, which operates trauma helicopters in the Netherlands.

How is your organisation deploying drones? The person begins by explaining ANWB's drone project, focused on the use case of medical transport of products such as blood samples, medicines and organs. This expansion of their medical helicopter operations is considered a logical step.

ANWB's trauma helicopter is mainly used to transport trauma doctors and equipment to accident sites for emergency care, performing surgeries on site and stabilising patients for transport. It is a flying

operating theatre. There are also patient helicopters. The drones add a third service by quickly and efficiently transporting medical products for remote analysis and treatment.

ANWB's drone project differs from other initiatives, such as Drone2Go, because it focuses on medical applications rather than road traffic and accidents.

What are the differences in the deployment of drones between your organisation and Rijkswaterstaat? The person explains that the difference in the deployment of drones between ANWB and Rijkswaterstaat lies mainly in the focus and applications. ANWB focuses primarily on medical applications, especially for emergency transport and medical logistics. They also fly from point A to point B, C and D in a network, whereas Rijkswaterstaat flies from point A to point B and back to A. Other uses for drones have been sought within ANWB, but for now the focus is on scaling up in the medical sector, partly because of operational differences with other initiatives such as Drone2Go and consultations with Rijkswaterstaat on traffic monitoring.

In what way can knowledge about the use of drones be relevant to RWS in relation to road traffic?

The person says ANWB can offer insights into operational aspects such as setting up a network for drone flights, managing pilots and licences, and managing logistics for transporting medical products, which can also apply to traffic monitoring and incident management on the road. ANWB's experience in testing drone flights abroad could provide useful lessons for Rijkswaterstaat when exploring international collaborations or expanding drone operations to other regions. ANWB's focus on emergency response and medical logistics could complement Rijkswaterstaat's research into the use of drones in traffic incidents. By working together and sharing expertise, ANWB and Rijkswaterstaat may be able to create synergies and deal more efficiently with the challenges and opportunities in drone use in relation to road traffic. It is important to think realistically and create actual needs and applications rather than just being driven by technological possibilities.

D.9. Exploratory Interview 9

Background description The person advises on the network service for de-icing operations.

How is icing currently being tackled, and are there any issues where drones could assist? The person responds that they monitor weather and road conditions. However, they aim to make decisions based on data, which is challenging. They are currently exploring the use of in-car data, such as wheel spin friction loss. The road network is also equipped with sensors to measure temperature and other relevant factors where needed. This person assesses the potential for drones as low because visual inspection by people on-site is crucial. Even with an infrared camera, they may sometimes be off by a few degrees. Drones are occasionally used for capturing appealing visuals for the media during snowfall, but during heavy snowfall, they believe drones might not be feasible. However, drones tethered to a cable could work, continuously streaming images, essentially functioning as a fixed camera.

D.10. Exploratory Interview 10

Background interviewee The person works at the department of operational development for road traffic.

Is there discussion about drones within your department? The person answers that he knows drones from Concert at Sea

Do you think drones could be useful for road traffic operations? The person responds with the following question: Do we have a problem that can be solved with drones, or do we have drones that we want to utilize to the maximum?

The person continues by stating that the current traffic management situation is being examined using new techniques in vehicles, which are much cheaper than drones.

Drones are already being used to observe incidents or other situations on water. Do you think there are also applications in road traffic? The person acknowledges the significant benefits of using drones over water but perceives fewer advantages on the road. They point out that a road inspector can arrive within 15 minutes, and there are already many cameras along the road. However, they recognise the potential added value in situations where there are no cameras. Nonetheless, they question the necessity in such cases. For instance, in conditions of poor visibility like fog, cameras would also be ineffective, and even in those cases they can offer assistance. Concerning the use case of roadside assistance for breakdowns, the person doesn't see it as a realistic scenario due to the high frequency of such incidents (100,000 per year). Realistically, they doubt drones would be deployed for this purpose.

From an operational perspective, they haven't heard any demand for drones yet. They emphasise the need to gather information about drone specifications, performance, and operational capabilities before making decisions. Questions such as the number of drone-in-the-box installations, flight duration, response time to incidents, and comparison with the speed of a road inspector need to be addressed.

Are there, in your opinion, other use cases of drones? The person replied that they are aware of a commercial company using drones to capture aerial views of traffic flow at intersections. This application, targeted traffic analysis at intersection level, could already be seen as a potential use case. They also utilize data from vehicles for this purpose, but a concrete overview from drones could provide more information. However, drones would need to hover above an intersection for several hours for this purpose. This could potentially reduce the need for human intervention.

D.11. Exploratory Interview 11

Background description The person works at the Department of Operational Tasks for Road Traffic. He is involved in the incident management network service.

Is there currently discussion about the use case of drones for incident management? The person replies that drones in IM is tricky. It is also difficult to experiment with them, as they have an execution to run in the here and now, as operators. He sees the deployment of the RWS drone team as something that is for shipping and water management. After all, there you have places you can't get to. In road traffic, you can get there. He does not see the addition of calling in the drone team for an incident and is therefore not that keen on the Road Traffic Drone Team. He believes it is a niche of people who believe drones will be used more in the near future, just as people once believed there would be self-driving cars in 2025. Still, they acknowledge that the situation could be different if drones were autonomous. Right now, integrating drones within the current IM operation costs more than it would generate.

How is incident management done now? The person explains that a road inspector will always come to the spot to commandeer the location. The car will be put across or the lane will be blocked off. There are 800 yellow cars driving around the Netherlands and they are on site within 15 or 10 minutes. If there are cameras, there is certainly an advantage in the approach phase for the road inspector because the traffic control centre can then help them, for example by indicating whether the accident is on the left or right side of the road. Also, lane signals are used to make the situation safer.

Could a drone assist in this, or even replace a road inspector? It could be useful to know in advance exactly what is going on, yet the person thinks the added value is small, especially compared to the wet domain. The road inspector himself cannot be replaced. Still, it could be useful when the road inspector is already there but there is not a full view of the situation, such as in a major accident, when hazardous materials are released.

Could drones help in places where there are no cameras? The person replies that currently we also do IM where there are no cameras. Outside the Randstad (as far as Amesfoort), there are no cameras or lane signals because the cost there does not outweigh the amount of incidents. We also now accept sending a road inspector there without having a view of the situation. Drones could help, but then there should be a clear plan what the approach time is and where they are stationed, yet drones will not change the process on the front end.

Are there more requirements that need to be fulfilled to properly integrate drones into operations, provided the added value is clear? The person says it would only work if the images given by the drones were integrated with the current camera operation in a traffic centre. It is busy enough without being on a separate laptop. The person stressed that the drones are currently too expensive if a drone pilot would have to sit in the car with a road inspector.

There should be a clear narrative with the figures telling how fast the drones can be on the spot and how far apart the drone-in-the-box are. The drones should be there within 5/10 min otherwise the road inspector is already there. Also if the drone now works only 40 per cent of the time, for example, the person thinks there is no need to really implement it in the operation. For example, it might not work in certain weather conditions and those are precisely the times with the most incidents. The current operation has to run 24/7, the person does not want to drive them crazy yet with an innovation that is not yet legal. They believe that road traffic is not early adapters. Only after the tipping point, when the implementation is low-threshold because it is allowed by law, for example, will they start thinking about the added value.

How can I access expertise and guidance on the policy aspect of drone use before operational steps

are taken? The person explains that the researcher can knock on WVL's door, who help set policy. The researcher can also ask around at the operational development department of road traffic.

D.12. Exploratory Interview 12

Background description The person works for the department of operational tasks water and shipping management and is a drone operator at the drone team.

Can you elaborate more on the technical aspects and its limitations of the drones the Droneteam uses?

The person talks about measurements tasks to fly a drone. They mainly fly with GPS, but they should definitely look into flying with other technologies if there is no connection to the GPS. There is already a solution for flying in Atti mode, in which the drone stabilises at altitude compared to the ground if there is no contact with the GPS. However, there are therefore still definitely risks of losing contact with the drone, causing collision or crash hazards.

They also tell us that the drones used by the drone team now fly 60 to 70 km/h. Large drones can go up to 110 km/h. The batteries last 40 min until they are changed again (manually), when temperatures are cold this is less. The wind force the drones are resistant to is 4-5.

Do you know usecases of drones for road traffic? The person talks about a pilot to have flown in a tunnel with a drone where the traffic centre and OvDs were watching. Drones have also been used to map shortcuts and congestion at an exit.

E
Summaries of final interviews

E.1. Interview 1

Background The person is the Project Manager of Smart Mobility.

How are decisions made with regard to investing and adopting new technologies? The person has previously attended innovation training that focused on the seven preconditions for transitions. These conditions include the availability of technology, the perception of a problem, and the availability of financial resources to stimulate innovation. The person acknowledges that sometimes experiencing a problem is driven more by business models than actual societal needs. The interviewee points out that technological developments, such as those within Smart Mobility, depend not only on the availability of technology, but also on policy and strategic choices, such as sustainability. Examples of innovations arising from these choices include the development of circular construction methods and the emergence of smart vehicles. In this context, it is important to understand and anticipate user needs. This includes adapting to the growing trend of users increasingly using their own technologies. The interviewee emphasises the importance of anticipating future problems and proactively addressing them to avoid falling behind.

So do you see drones as a technology what the user uses? The interviewee does not currently see drones as a user-owned technology. From her perspective, a drone in itself is a technology or technique. However, she emphasises that there is a big difference between the device with rotating blades that can fly in the air and its actual application in relation to problems or strategies. The drone gains value only when it is actually deployed. Currently, the interviewee sees it as a vehicle that is central, but she recognises that much remains to be done to make the drone valuable. The services this technology can provide and how it can help solve problems and achieve strategic goals need to be demonstrated. It is still a puzzle whose pieces still need to be put together, from the interviewee's perspective.

What are the reasons that drones are a different kind of innovation than what we normally see in Smart Mobility? Person notes that there are two main ways in which drones stand out. First, she emphasises that Smart Mobility focuses primarily on user-centred processes, such as traffic and vessel management, using data-driven work and new sources of information. She does make the link between these processes and the use of drones as a new sensor.

Second, she points out the uniqueness of drones as another type of asset. Unlike many other assets, drones can move around and perform tasks independently. This contrasts with, for example, static sensing systems such as traffic light loops. While in traditional detection systems improvements often focus on replacing existing equipment, the use of drones adds a new element to the detection process.

The person emphasises that the real innovation lies not so much in the drone itself, but in its effective use. She explains that with traditional assets such as traffic light loops, improvements often amount to a 1-to-1 replacement. With drones, however, it's more about innovating processes.

Using drones involves addressing problems that were previously difficult to solve. This includes, for example, situations where information is missing or processes take too long. The person emphasises that it is crucial to identify what problem is actually being solved by the use of drones, such as staff shortages or long wait times at incidents.

How is a policy choice made regarding the deployment of this technology (drones)? The person explains that making a policy decision regarding the deployment of drones is all about weighing risks and benefits. She emphasises that identifying the risks of using drones is essential to determining the

effectiveness of the solution. This includes analysing the time savings that can be achieved by using drones, as well as preparing a cost-benefit risk analysis. This involves looking at the cost of solving the problem, the benefits it brings, as well as the new risks introduced by using drones. The person emphasises that different people may weigh risks differently, leading to ongoing trade-offs.

In addition, she points out that the strategy or course that one makes can be seen as the solution to a problem. She explains that the larger the problem one is trying to solve, and the smaller the cost associated with the solution, the more risk one may be willing to accept. This is related to the degree of urgency and the size of the problem. Although these factors are intertwined, making a strategy course remains essentially a trade-off between different considerations.

How is that strategic choice formed? The person explains that the strategic choice is shaped by several factors, including the role of the CEO drones within RWS, in this case the director of OOWS. She emphasises that this person may play a role in shaping this strategic choice. One possible approach is to put the topic on the agenda within Smart Mobility, involving the Smart Mobility directors' meeting. Here, it is important to strongly link the use of drones to incident detection in order to emphasise its relevance within Smart Mobility.

However, she emphasises that it is essential to have more than just a meeting to actually get people on board. This requires a compelling story that sticks with those involved. The story must be simple, but also surprising and interesting enough to hold attention and convince people that this is the right strategy. This requires a concrete plan or roadmap, credible information, an appeal to emotions and the ability to tell the story in an engaging way. She emphasises that these elements of SUCCESS - Simple, Unexpected, Concrete, Credible, Emotional and Narrative - must all apply.

The person reflects that these elements are relevant to the three core areas: problem-oriented, technology-oriented and people-oriented. She concludes that in applying Kingdon, a problem must be solved, the technology to do it must be available, and have the support of the people involved to carry it out.

Suppose an assignment were about implementing drones for road traffic operations. Is that assignment determined from higher levels of management at RWS, or does the implementation project arise bottom-up? The person indicated that sometimes the assignment can come from higher management, especially when it comes to smaller projects. For example, the director general may decide, "Let's take up this project." However, she does not foresee the assignment to implement drones being given that way.

Further, she distinguishes between trying a project and actually implementing it. She emphasises that the implementation of drones in road traffic does not seem to be on the horizon yet. It seems that the CEO of drones plays an important role in convincing her colleagues within road traffic management and other stakeholders. The story behind the project must be compelling and show why this is something we want to pursue.

Is a directors' meeting (DO) the time to make such a decision? The person indicates that a directors' meeting may be appropriate, but she actually advocates a different approach. She emphasizes that some innovations come about thanks to such a meeting, while others come about despite such a meeting. Therefore, it is not a sacred route for decision-making. It depends on the specific problem to be solved and whether everyone should be involved. If there is one clear problem owner who has a strong interest in a particular technology, that person can bring the rest of the team along . At the director level, there actually needs to be an owner or stakeholder who picks up and researches the initiative.

What are things that may change in the future that affect current policy around drone use for incident management on roads? The person points out the importance of readiness levels, such as technological, organizational, societal acceptance, market readiness and regulation. She indicates that policy, or rather strategy, must ultimately be translated into procedures and involves more than just good intentions.

Are there events that may happen that could affect the strategic frameworks? The person points to external events that can affect strategic frameworks. For example, she cites the Stint accident as

an example that has had a major impact on vehicle automation and admissions. She emphasizes that such events can have both positive and negative effects on the acceptance and adoption of new technologies. She further notes that if the need is high enough, for example due to staff shortages, and all the prerequisites for using drones are already in place, this can cause an acceleration in the acceptance and implementation of drone technologies.

Could you say that this innovation has to come from a problem? The person explains that when the human side is willing to embrace change, the other two aspects, technology and policy, will move with it. Indeed, they believe that we do not have the luxury of seeking a problem for a solution.

E.2. Interview 2

Background description The person works Department of Water Management Services at the CIV (Central Information Facility). The person started using drones after delving into regulations and taking training to become a knowledge holder within the CIV. Then came the idea of using drones for incident management through Smart Patrol, and this person led the project from idea to implementation and standard services, combining different aspects and integrating it into the organization.

What challenges were most common in managing incidents in the past?

The person explained that the biggest challenges in managing incidents in the past were mainly related to the lack of oversight and information during long-term incidents, such as oil spills that could sometimes last a day. There was a lack of accurate information about the extent of contamination and the locations of high-risk areas, such as drinking water intakes and natural areas, which could only be easily seen from the air. The use of drones offered the opportunity to get a better overview from above, such as identifying shallows near stalled ships. The idea was also submitted by, among others, officers on duty of mobile traffic controllers from water and shipping management

Would you say that similar challenges also occurred in traffic incidents, since drones are now being used for road incident management as well? The person explains that the use of drones for traffic monitoring was not immediately considered necessary because many cameras are already installed along the roads. These cameras provide a constant video stream to the traffic control center, so there was initially little need for drones. Mobile cameras were used for monitoring at events such as Zwarte Cross and the TT Assen, so the added value of drones was not immediately seen. As a result, those involved did not initially express a need for using drones for traffic monitoring.

So is the drone team now organized from the shipping side? The person explains that the drone team has currently become a joint initiative organized for both shipping and road traffic. It was placed under shipping because of its focus, it now falls under the Incident Management Bureau. This bureau is responsible for incidents throughout the Netherlands that affect Rijkswaterstaat's primary process.

Are drones used for road traffic because they were already available or because there were actual challenges there? The answer indicates that the use of drones for road traffic began not because of specific challenges, but rather as a spin-off from once it was there. One started as a proof of concept, where the technology quickly seemed to be useful for different types of incidents, such as oil spills and road accidents.

Initially, these POCs were done by the department within the CIV responsible for data collection. However, over time, the drone file was transferred within the CIV to the Water Management Department, which deals with crisis and incident management.

There was initial resistance from the road traffic side to the idea of setting up a drone team, because of the complexity of flying a drone over the road and the many obstacles to being able to get to the scene of an accident within a golden fifteen minutes. The latter came from the Highway Patrol pilot. Highway Patrol stuck with the pilot phase and did not join the drone team at the time. This was compounded by practical considerations, such as the scheduling problem, where it proved difficult to free up personnel.

The person developed the drone team within the Rijkswaterstaat incrementally. After learning the necessary lessons and gaining experience in implementation, equipment procurement, contracting and

software development, the team became increasingly professional and effective. This progress did not go unnoticed, and other government agencies showed interest in setting up similar teams. This created a community in which different organisations supported each other and shared expertise to make drone teams operational.

Over time, the Rijkswaterstaat drone team decided to professionalise even further. This included investing in further training of pilots and obtaining the necessary permits to fly over highways as well. To achieve this expansion, a recruitment campaign was launched to increase the number of pilots to 25, who would operate throughout the Netherlands. Through direct consultation with the Road Traffic Department, efforts were made to involve personnel from that department in the drone team as well, emphasising the added value of drones in traffic monitoring and major incidents. But with growing awareness and positive coverage of drones, acceptance is beginning to grow. Colleagues at traffic centers, for example, are increasingly seeing the added value of live streaming images from drones in major traffic situations, which is helping to gain acceptance. It takes time and education before the added value of new technologies is fully understood and accepted within an organisation.

The added value of the drone team became increasingly clear, especially in situations such as road diversions, major accidents and in monitoring high-risk infrastructure projects. Although there may still be some unawareness among officers on duty about how to reach the drone team, the use of drones in traffic accidents and other situations is now fully accepted within the road traffic department of the Rijkswaterstaat.

Were/are there then capacity challenges that affect the willingness to cooperate with the drone team within the road sector? The person indicated that financial investment for the drone team was not an immediate problem, as funding was arranged centrally. However, the challenge lay in freeing up employees to participate in the team. Fortunately, this was formally arranged by the RWS board, allocating five full-time equivalent (FTE) positions to join the drone team. While one day a week does not equal one FTE, there was change available within VWM to resolve some road traffic bottlenecks to enable collaboration.

Road Traffic noticed that in traffic monitoring, the number of road inspectors needed decreased when drones were deployed, increasing efficiency. However, the person thinks the CIV is more cautious about innovations, possibly because of workload and organizational culture. It is more conservatively structured. At SWM, employees seem to have more freedom to engage in innovative ideas.

Within water management, there was more focused work in corridors, employees acted as teachers for newcomers and mentored specialists, while this seemed to be less the case within traffic management. This difference depended on the specific department and leadership style. The person felt that staff shortages were similar in both water and road traffic, with similar problems.

So would you also say that there are still problems right now that are actually solvable with a drone? And that that is also made known within the organisation itself?

The person explains that VWM lobbies and coordinates within the organisation. After the recent major reorganisation of the Rijkswaterstaat, it took a while for everything to fall into place. The focus was on centralisation and the implementation of new systems, which sometimes made innovations less of a priority. However, the benefits of drones, such as clearing highways more efficiently and cleaning up oil spills faster, are recognised.

Are drone a solution to staff shortages? The person says you actually need more people, namely the five FTE assigned. This is because the pilots have to spend one day a week on training to stay compliant and meet the requirements for drone pilots.

The business case states that drones can also be used for smaller incidents and breakdowns on the road. Do you see that as a realistic application?

The person doesn't see it that way. For deployment for breakdowns on the road, that's not realistic. Where breakdowns on the road have a big impact, that's where we already have cameras hanging that provide sufficient images actually sufficient images. If it's a larger scale situation, then you might want to have an image with bird's eye view attached.

Do you see bridge inspection and traffic monitoring as applications for RWS and could there be

other applications?

The person feels that the applications for drones at RWS, such as bridge inspection or 3D mapping, are better outsourced to specialized companies because of the specialism required. He sees no added value in performing these tasks himself and have already made arrangements with external parties for these services. The distinction is in ad hoc situations. Nevertheless, the VC asked Velzen to perform a flight in a tunnel. Although these inspections are normally outsourced to companies, it was a learning process for them to work with drones in this situation. He is also concerned about unauthorized use of drones by RWS employees and wants to prevent this.Lin

The person further explained that traffic information is gathered through automated systems, such as loops in the road surface and roadside boxes. These systems continuously collect data on traffic flow and density. However, this is different from traffic monitoring, which takes place during major events or when roads are closed. During such situations, other roads are opened and bypasses closed based on traffic volumes and congestion. This allows traffic to be effectively monitored and regulated. The person emphasises the importance of this monitoring to prevent life-threatening situations, giving as an example the Whitsun Weekend where truck drivers parked along the Dutch border due to driving restrictions in Germany. This led to congested sidings and dangerous situations, such as trucks parked on the emergency lane. Despite warnings of the risks, no consensus was reached on expanding truck parking spaces. Aerial photographs were suggested to better understand the situation and reduce risks.

However, the person states that planable and long-term deployments for traffic monitoring, such as at Zwarte Cross, can be outsourced to external parties with a drone box, with RWS road traffic watching.

Regarding enforcement, a business case is currently being made and consideration is being given to expanding the drone team.However, this will be a challenge with the current capacity and organisational structure of the drone team, public acceptance, preparation of DPIA et cetera.

However, this process could be faster since it is not so much related to service delivery and permits and waivers are not an obstacle since they are not limited to incident management.The challenge lies in its organisation.

How will the Drone2Go network of automated drones (in the box) affect RWS operations? The person answers that for RWS drone operations in terms of application, not much will change. In fact, there are 1 or 2 incidents per week. The main benefit of a network of drone boxes would be mainly for the RWS partners.The drone boxes can be used more efficiently by partners who have pre-planned tasks, allowing them to be used, for example, for tasks such as crop mapping for agencies such as the NVWA. For the Rijkswaterstaat itself, the added value would mainly be in reducing the need for physical presence on sites by enabling more remote operations, which would reduce the number of times they have to sell ”no” to drone team requests. This could come in handy in situations such as the example of the Lemmer accident, where the drone team could not be deployed due to various logistical constraints.

However, it is important to remain realistic about the capabilities of drones. For example, a multirotor drone will be limited to a flight time of about half an hour and a range of only a few kilometers. This means that drone boxes need to be strategically placed to be effective, before that road cameras may be a cheaper solution for continuous monitoring.

What technological developments have taken place in the past that are relevant to incident management on roads? At one point, the person knew that drones could add value in various areas, however, no one within the Rijkswaterstaat knew much about it. Within the CIV, however, they had heard about it. From then on, this person started looking into regulations to see if this technology could be implemented within RWS operations.

What are the current technological limitations we still have as an organization? The person explains that the current technological landscape offers the RWS organisation almost unlimited opportunities, with only a few remaining challenges. The Drone2Go project, where drones can be sent autonomously to locations, is still on the agenda as a potential solution to these challenges. The person illustrates one of the current challenges. A request for a drone deployment at a truck accident near Zwolle was complicated by the fact that the nearest pilot had just had another deployment. Although another pilot

was available, it had to come from Utrecht, causing delays.

Does a drone currently fly automatically when there is an incident? The person explains that currently a drone does not fly automatically in the event of an incident. Moreover, every flight presents a risk. And those risks have to be weighed to see if they add actual value. The drone team is currently being called up. We have a central number known to all traffic centers and stations.

Although this system is effective, they still occasionally miss an incident. However, this is becoming less and less. They communicate a lot to improve this, such as through the website on Plein, communication bulletins, and through ambassadors, including traffic pilots, who share experiences and receive reports. They also have drone topics on the agenda of officer of service days and give presentations at events and operational teams for traffic. Thus, we try to pay attention to the use of drones on several fronts.

Are there any software or hardware developments needed to better perform RWS tasks? The person indicates that their software product and support are optimal. He emphasises that at incidents, they are ready within 10-15min and thus handled with one battery. However, on long-term deployments, they lack facilities such as a sheltered workstation, communication equipment and office facilities. A solution to this could be to use a drone box, which recharges automatically, with commercial parties performing scheduled monitoring flights.

Would you say drones should also be incorporated into strategic frameworks or policies? The person emphasizes that drones should be seen as a service they can provide, with customers deciding whether it makes sense to use this service. Sometimes the idea may arise that it would have been helpful to have used a drone, but the clients assess the situation and decide if it is necessary. Priority is given to dangerous situations where it is clear what needs to be done to clear the road again.

In addition, it is wiser to let Bureau IM, the operational club providing air support, make the choice of which means is best for the task. This could be a normal drone, for example, or another means such as a drone-in-the-box or a helicopter. It is already embedded in the organisation that Bureau IM provides air support and makes the choice of the appropriate means, as is done for deployment requests through the drone counter. It is important to keep the focus on incident management and leave other tasks such as traffic monitoring to specialised companies, where Bureau IM can provide guidance and authorisation. This process is already done well, but there is a need for more capacity at the drone counter due to the increasing number of requests. Furthermore, the CEO of the drone team is steering and withdrawing focus to incident management.

What does Bureau Incident Management do?

The person explains that Bureau Incident Management coordinates the air deployment at incidents, including contract management for tasks such as oil cleanup and shipping issues. They are responsible for all aspects from flying to full incident handling.

Would you say drones are already fully implemented in RWS road traffic operations? The person feels that the implementation of drones is already quite advanced in RWS road traffic operations. While not everyone in the road traffic department may be aware of it, drones are already being used regularly, about four to five times a month. There is a certain demand for the use of drones, and if it is not possible, it is perceived as a lack.

The person replies that the use of drones can no longer be considered a separate project, but rather a service and service of RWS. It is included in the organisation's service catalogue. Within the road department, drones are used only when other means are not as effective or in places where other means are less suitable.

What the milestones that the drone team has achieved in recent years? The person says first you have a POC, outsourced to companies, administrative easy task. Then you start a pilot, that's low-key. You don't do that in contracts yet. Then you do a scale-up from 5 to 25 pilots, starting the process for notoriety and communication. CIV implements the technical part, VWM the operational part. Then policy principles were established that require departments that deploy drone pilots to give those pilots one day off per week to develop their competencies. In addition, we now have a quality system in place,

of which April 23 will see the final audit by IL&T as to whether we have a good flying organization. The pre-audits indicate that we are very high in terms of quality, also compared to other governments.

Bureau IM has been running in parallel, Bureau IM was established in the last four years. They have played a significant role in setting up training profiles, recruitment activities and arranging PSU on the operational side.

As of January 1, our new software is live. They buy the drones through a European framework contract with the Belastingdienst, VWA and IL&T. The flying organisation is solid after five years of work. They are still performing small iterations now and have monthly tuning meetings for any adjustments.

There are discussions within Drone2Go that DJI drones are from a Chinese manufacturer. How important is drone development for Dutch or European companies? The person says that for Rijkswaterstaat, the DJI drone meets our needs, mainly because of budgetary considerations. They have a ton for everything needed, including training, hardware replacements and other supplies. Our approach is to think of drones as a standard piece of equipment, similar to a laptop or smartphone. They specifically use the Enterprise version of commercial drones, which is customized for government and emergency services, with additional features such as zoom and infrared lenses, and the ability to encrypt data without connecting to China. While there are developments in the area of specific drones for specialized applications, such as VTOL from the Dutch company Avy, I don't see a need for that for Rijkswaterstaat at the moment, though collectively, with RWS using them from time to time. They are open to future developments and not tied to a specific brand, but right now DJI is still the best option for our needs. Their drone operations are focused on incident imaging rather than sensitive data collection, and are often used on scene for real-time decision making without even taking a picture.

E.3. Interview 3

Background description The person has extensive experience at the Rijkswaterstaat in various places. He currently works for the road traffic operational development department. He has worked on projects such as Smart Cameras and also has a background in management, including being a district head, making him familiar with management within the Department of Public Works. He is currently involved in three major programs: the replacement of a software platform in highway traffic control centers, the introduction of truck tolls and the temporary toll at the Blankenburg. He also has a background in telecommunications, which helps him understand technical aspects. He is interested in innovations and implementing them, as seen in his smart home appliances. In short, this person has broad experience and expertise in project management, technology and innovation.

The person sees drones primarily as vehicles that can perform various tasks, such as delivering packages and putting out fires. He recognises the potential of drones to provide new perspectives by bringing cameras to places that traditional methods have difficulty accessing. He points out that much has already been done with drones, such as inspecting bridges, supporting traffic management at events such as Concert at Sea, and deployment within the maritime industry, particularly with OVDs. Here drones are used for inspections, emergency response and enforcement.

Can you talk briefly about your smart camera project? The person explains the importance of camera and AI technology within the Rijkswaterstaat, especially with regard to traffic management. He explains that the interest is not so much in the camera image itself, but rather in the technology behind it that can automate human tasks. Artificial intelligence (AI) is becoming increasingly prominent and is considered especially effective in repetitive tasks, where humans often lose attention and can make mistakes. However, the person identifies an important aspect: the purpose of AI applications. He emphasises that detecting normal scenarios, such as cars on highways, or cars stopped in traffic jams, is not enough. The key is to detect exceptions to normal situations

In the context of traffic management, the person focuses on using AI to detect incidents and understand their nature. This includes not only collisions, but also other situations such as a vehicle stopped in the emergency lane. The AI must be able to determine whether help is needed based on factors such as the reason for the stop (e.g., a bathroom break versus an emergency). This requires specific questions and analysis from the AI, which are critical to its effective deployment within Rijkswaterstaat.

Are discussions surrounding the use of drones within the road traffic department?

The person discusses his own ideas for applications of drones in road traffic, particularly focused on incident management. He emphasises that drones should be used especially when there is a need for an overview view of major traffic chaos in places where standard cameras are lacking. He points to a specific project in which a Dutch company is working with a Belgian company on a ”drone in a box,” in which Rijkswaterstaat is also involved. These drones are being tested particularly in port areas, where being quickly on site with visual images is crucial.

The person suggests that the use of such drones could potentially reduce the deployment of road inspectors because they can quickly create a visual image from a traffic center. He illustrates this with a hypothetical example where 30 of these drone boxes are placed at a traffic control center, allowing staff deployment to be managed more efficiently. The drone can paint an initial picture of the situation, and depending on that, further assistance can be deployed. The speaker said these are just a few examples of how drones can be deployed within road traffic, with a view to improving operational efficiency and effective incident response.

Have there been key decision-making moments in the past regarding forms of the strategic framework around smart cameras?

The person describes the innovation process within Rijkswaterstaat as a gradual evolution that begins with exploring new possibilities, making steady progress from conceptual development to practical implementation. The first phase involves innovating and looking at the potential added value of technologies to the organisation. This is followed by conducting a proof of concept or developing a minimum viable product. The second phase looks at the possibility of standardising services and converting them into a standard service that can be widely used within Rijkswaterstaat. Finally, the third phase focuses on actually producing and implementing the developed service within the organisation.

Are there differences between shipping and road traffic in the innovation process?

The person discusses the use of AI pilots within Rijkswaterstaat, focusing on different aspects of shipping and road traffic. For example, a project in shipping focuses on individual ship guidance and detection of specific objects, such as individual ships. In contrast, road traffic emphasizes monitoring large numbers of vehicles in traffic flows, with privacy considerations playing a role and identification of individual vehicles being less common.

The person emphasizes the importance of defining specific applications of drones, highlighting the differences between shipping and road traffic. For example, in shipping, being able to read features such as the ship’s license plate is important due to existing information systems and legislation, while this is less common in road traffic due to privacy considerations.

The innovation process within Rijkswaterstaat is described, with a strong business case being crucial for management buy-in and financing. Concrete examples are given of how innovative technologies, such as vision analytics, can contribute to improved safety and more efficient traffic flow management, both in shipping and road traffic.

It is noted that automated technologies, such as smart cameras with vision analytics, can take over tasks and make them more efficient, but may also face resistance from employees who see traditional tasks disappearing.

How does RWS decide when to transition from the innovation phase (POC phase) to the standardization phase? What considerations are involved? Rijkswaterstaat makes this decision based on several factors. Firstly, they assess the minimal disruptions caused by the innovation during testing, akin to the approach taken in laboratories, such as those at TU Delft. Additionally, they evaluate the practical applicability of the innovation, including necessary adjustments to integrate the technology within Rijkswaterstaat’s existing architecture. This assessment also includes the robustness of the innovation, ensuring reliability and stability under varying conditions. Furthermore, compliance with existing regulations and policy frameworks, such as the General Data Protection Regulation (GDPR), is checked, and policy adjustments are made if necessary. Special attention is given to privacy aspects, including conducting a Departmental Privacy Impact Assessment (DPIA). Finally, a broader perspective beyond technological aspects is considered, including policy, legal, and organizational issues, to determine how the technology will ultimately fit into Rijkswaterstaat’s architecture.

What factors influence the adjustment of frameworks or agendas for projects within Rijkswaterstaat,

considering external developments such as political changes alongside internal factors like societal cost-benefit analysis?

The person emphasizes that the environment plays a crucial role in determining frameworks and agendas for projects within Rijkswaterstaat, particularly due to the public interests and opinions that must be taken into account. An example of this process is a moral deliberation involving various stakeholders, including citizens, municipal officials, and academics, to discuss the public perception of using Artificial Intelligence by Rijkswaterstaat. This process helped identify concerns about privacy and ethics and fostered a deeper awareness of the implications of technological innovations such as Vision Analytics. Through this experience, the person became more conscious of the importance of privacy protection and setting goals for data processing within Rijkswaterstaat. It also underscores the importance of looking beyond the predetermined scope of a project and considering broader societal and ethical issues.

How is the implementation of Visual Analytics, or smart cameras, progressing within Rijkswaterstaat? Is the project ongoing or has it been discontinued, and what are the reasons behind this?

Answer: The person refers to a diagram titled ”On the way to autonomous rush lanes,” which he created in 2016. He explains that this diagram depicts the SAE level used in autonomous vehicles. He investigated what a stepped automation would entail to gain confidence in this system. He illustrates this with examples of decision-supporting systems that could assist the road traffic controller. However, despite his optimism, he acknowledges that the project has not been realised and that progress has remained limited thus far.

The speaker reports that the project was partially discontinued after he compiled an overview of ongoing research on Visual Analytics. To his surprise, he discovered dozens of studies all seeking answers to the same question, which he believed he had already addressed. In 2016 and 2017, he had tackled this question, and again in 2018 and 2019, but within the context of the production chain. The outcomes of these studies largely echoed the same sentiment: the technology could be deployed, and Rijkswaterstaat’s networks were robust enough for large-scale implementation.

Following these findings, the speaker advised management to discontinue the numerous studies as they were stuck in the innovation phase and were not progressing towards standardisation. He emphasised the importance of deciding whether to proceed to standardisation or actually bring the implementation into the production chain. In response to his advice, management decided to highlight two projects to continue: one involving bridges and one involving tunnels for road traffic in the West-Netherlands-South region.

The bridge project (in Delft) appears to yield positive results, and actual progress has been made, but he stresses that it is not yet fully standardised service implemented nationwide. He anticipates that the project may eventually operate as a stand-alone system on one bridge before being fully integrated into the national ICT environment.

The speaker notes that projects involving bridges (in the nautical domain) can serve as examples for applications in road traffic. He explains that if the system is successfully implemented in bridges, it can then be expanded to road traffic. Here, he emphasises the importance of standardised service, where systems in different domains function on the same network and in the same environment.

What changes in the political or policy landscape could influence decision-making regarding smart camera projects in the future?

The speaker discusses various events that could increase the urgency for management to push forward certain projects. Examples include accidents involving bridges opening while vehicles or people are on them, or accidents on open rush lanes where vehicles are stationary and rear-end collisions occur. These situations highlight the importance of preventive measures. However, management must also consider other priorities, such as large-scale replacement and renovation projects. Additionally, there are ongoing projects aimed at standardising and maintaining the robustness of video cameras, networks, and architecture, which also require management’s attention. So, while management is not averse to the projects of the Smart Cameras Visual Analytics program, they must prioritise and balance available capacity against other ongoing activities.

It is common for a significant negative event to act as a catalyst for innovation, necessitating a wake-up call. Yet, if an individual is the driving force behind innovation, that person can mobilise the organisation. It is an admirable aspect of the shipping colleagues that they continue to invest in this

innovation. The speaker also noted that his own need for new challenges after five to six years influenced his decision to leave the Smart Cameras program, indicating that energy in a project diminishes when those involved seek change.

What are the decision points in the timeline at which projects are selected to continue or be discontinued?

The speaker emphasized that it was logical to conclude a proof of concept because every project has a beginning and an end. He also wanted to receive a conclusive judgment from his client to confirm that the project had been executed properly. According to him, this process also requires a decision-making moment, where the organisation becomes aware of the outcomes of the project and the recommendations that arise from it. This decision-making took place during the Smart Mobility directors' meeting, where a memo was presented with the advice. This was followed by an inventory by the CIO office, part of the CIV, which led to proposals to continue some innovation trajectories and stop others.

E.4. Interview4

Background The person works for the road operational development department.

How are decisions made within RWS Road Traffic regarding investing in and adopting new innovations or technologies, such as drones? The person replied that decision-making within RWS is highly fragmented, with each business unit having its own approach. Upon entering RWS, the person noted that projects often emerged organically, with a "if there is a good idea, the money will follow" mentality or through informal processes such as "hustling, recruiting and arranging", (which in Dutch translates to "ritselen, rondselen, regelen"). Innovation seems to rely heavily on the Central Information Facility (CIV) and Information Management and Projects (IBP), with limitations mainly in the number of people available and the growing management burden. Capacity appears to be the biggest barrier to innovation, with only a small proportion of resources actually able to be spent on innovation, despite guidelines requiring 10% of resources for innovation (see RWS Kompas). There is an awareness that innovation must be targeted and effective, focusing on cost efficiency, sustainability, safety, compliance with laws and regulations, and keeping up with developments in the market. It is also noted that the aging population and projected increase in vehicle movements through 2050 will lead to an increased demand for operational personnel, necessitating innovation to do more work with the same number of people. Innovation is advocated to speed up processes and support staff in their decision-making.

Do you think there is more room for innovation, more capacity and so on in shipping and water management? The person responds that, in their opinion, there is not necessarily more room for innovation and capability in shipping, but that this sector is organized differently. They note that shipping uses more agile teams with shorter cycles, making them more agile and able to move faster. In contrast, RWS Road has 15 large projects that require a lot of capacity, in addition to numerous small projects that are done using a more traditional waterfall method, where everything is planned a year in advance. As a result, they experience less agility compared to the marine sector.

Is this new way of innovating better than "hustling, hustling, arranging"? The person replies that it depends on whom you ask. Of course, the team likes the old method of "hustle, hustle and haggle" because whoever has the best network comes first. However, now there is a structure where decisions are weighed in the Management Team (MT) before they go to the IT department. As a result, more of what the MT thinks is important is done and consultants have less freedom to make their own choices, mainly due to a lack of capacity. This forces them to be very goal-oriented. In January, an IT annual plan is established in which all projects are defined, and then feasibility and available resources are considered, followed by selection based on strategy. In addition, the person emphasizes the importance of having specific time blocks for departments, such as operational tasks and development within road traffic management. Incremental innovation here occurs within a time frame of two to eight years. While system leaps come from focus areas such as Smart Mobility, the data and IT council and innovation tables. While there are many people thinking about innovations, most ideas come from these

specific corners.

Are there any political or policy developments that affect the agenda? The person answers in the affirmative, explaining that there are certainly political or policy developments that affect the agenda. The Directorate General of Mobility (DGMO), for example, issues a vision for 2030, although this vision sometimes seems far removed from their day-to-day operations. Nevertheless, it acts as a framework document that focuses on digitization of traffic management functions, ensuring robust and reliable operations, and financial stability. This document identifies several themes on which policy is focused for the coming years, and Rijkswaterstaat translates these into concrete actions. For example, when DGMO indicates that financial agility is important, Rijkswaterstaat looks for ways to reduce costs, such as optimization of incident management. Although DGMO indicates that the number of traffic management functions will not change, they will be experienced differently by road users, prompting Rijkswaterstaat to invest in digitization of these functions. These policy developments provide a useful framework and direction for Rijkswaterstaat's innovation efforts.

How often will the roadmap be released? The person explains that the roadmap is updated every three years. Of that, you can roughly estimate that 80% stays, but we revisit the remaining 20% to see what context has changed and what aspects need attention.

Are there sometimes sudden events that completely change the course? The person answers that there are no sudden events that completely change the course. They sense transitions coming by being involved in the process on a daily basis and actively participating in the working groups that create the roadmap. Funding is also approved in the Service Level Agreement (SLA), which means decision-makers once again agree to the course set and the associated costs.

Is there more room for innovation in the shipping department compared to road traffic (in terms of drones)? The person says they have many pilots running where people are encouraged to take one day a week to see if new technologies are useful. For drones, they have decided that the complexity and delay of getting to the scene is too great, given aviation laws and other constraints. For example, they are now experimenting with collecting data from trucks, which is relevant to things like tolling and sustainability. They are interested in the potential of this data for avoiding toll roads and improving safety. They are considering different ways to use this data more efficiently and are participating in pilots to explore this.

Is a pilot project normally conducted first to evaluate the added value of a new technology, and are social cost-benefit analyses or business cases made during this evaluation to determine whether the project has added value?

The person feels that too few value and business cases are made when evaluating new technologies, which he considers a missed opportunity. He stresses the importance of pilots, which usually start small with a Proof of Concept (POC), where technologies are explored and sometimes work, sometimes not. He calls it disappointing that some promising technologies, such as smart cameras, are discontinued after the POC phase, while they are successful in shipping. He points out the importance of taking risks and pursuing promising projects. In general, it remains a surprise which projects will ultimately be successful.

Is capacity then the main reason is that you have to prioritize and are less likely to "give it a try"?

The person confirms this and says that in addition, the government has determined that if the market can perform a certain task, it is mandatory to leave it to the market.

In addition to the strategic framework (and policies that change slightly every three years), are there other events that can cause unexpected changes, such as perhaps the arrival of a new director?

The person notes that both top-down innovation and bottom-up responses play a role. Although the focus is primarily on top-down innovation, incidents that occur during day-to-day operations are also taken seriously. These incidents can lead to improvement and optimisation of processes. Every three months, an inventory is taken with the network service, identifying new developments. For example, recently heat protocols have received a lot of attention due to rising temperatures, and flooding

protocols due to more frequent flooding. These responses are often bottom-up driven, with network services setting their own priorities based on operational needs and innovation. Sometimes even life cycle management is deferred to give more room for innovation and flexibility in capacity.

Is a directors' meeting a crucial moment for such projects? And might more similar moments be needed in the future to further develop initiatives such as the drone project?

The person confirms that decision-making is that way, with director meetings being a common forum for discussing and approving innovative projects. He indicates that operational developments usually take several years and that Smart Mobility is an important body for innovation within the road traffic domain. He explains that requests to participate in innovative projects are frequent and that the directors' meeting takes place monthly. He emphasises that his department makes an important contribution to these meetings by bringing in projects they are already involved in.

Is there generally much collaboration or overlap between the domains of shipping and road traffic within the framework of Smart Mobility, or are these domains generally separate?

The person acknowledges that there is often too little collaboration between the shipping and road traffic domains within Smart Mobility, despite equivalent projects and similarities in issues. While there have been initiatives to improve collaboration, such as joint days and projects such as the BOA app, there remain obstacles, such as funding from a different angle (DGLM/DGMO) and policy differences, that make collaboration difficult. Efforts are being made to improve integration, such as identical workplaces for road and marine operators, but resistance remains due to differences in emphasis and practical considerations. The individual emphasises that growth and collaboration within the organisation are critical, especially in a time of digitisation, but also recognises the challenges this presents.

Is there a need for changes in the strategic framework or policy development if drones are considered a major innovation project that will be invested in? Or are existing policy guidelines related to digitisation and security sufficient, provided the right project is chosen?

The person indicates that he does not expect changes anytime soon. He emphasises that it is crucial to find applications that can be directly linked to operational problems. If there is no clear demand from operations, investing in drones becomes difficult. He points to the possibility that evolution in laws and regulations can play an important role, where relaxed regulations can accelerate the adoption of drone technology. He also points to the importance of the success of initiatives such as tests on roads such as the N250, which can serve as proof of the potential and applicability of drones, increasing support for further investment.

E.5. Interview 5

Background description The person is Flight operation manager, OvD and works for VWM Shipping and Water Management.

What were the most common challenges in managing incidents in the past?

The individual responds that in the past, Rijkswaterstaat initiated testing to explore how drones could be integrated within the organisation. This initiative was started by colleagues from Highway Patrol and Smart Patrol to assess how drones could fit into their operations. Unfortunately, the initiative with Highway Patrol stalled because it was concluded that it wasn't feasible to deploy a drone quickly within the short time frame of the "golden hour."

However, for water and maritime incidents, the use of drones proved to be cost-effective. An analysis was conducted to compare the costs of not having adequate visualisation of water pollution and the costs of alternative methods versus the use of drones. This analysis demonstrated that employing drones was cost-effective, leading to a decision to further develop their use for these purposes.

Although there was no formal signing of the business case, the decision was made to continue using drones for water and maritime incidents. The drone team was primarily set up for these tasks, but it can also be deployed for road traffic incidents if necessary. There is no preference for drone team pilots from within the organisation, whether they come from road traffic or water and maritime departments, as borrowing personnel from other organisational units even offers cost benefits. This also contributes to a diverse composition of the team, which is seen as valuable.

Also, the individual suggests revisiting the business case prepared for the Drone Team.

Could you say that the use of drones is now implemented for both shipping and road traffic? The person mentions that, when it comes to incident management for road traffic, there are still some challenges. An example of this is a recent incident on a provincial road, involving the Traffic Control Centre East Netherlands and the duty officer of Rijkswaterstaat. In this situation, the drone team was asked to capture images with drones to assess the situation. Although this request came late, it proved valuable to view live images and confirm the situation.

How have the discussions around drones evolved within RWS?

The person responds that discussions surrounding drones have evolved based on previous projects and initiatives from Smart Patrol and Highway Patrol. However, there is a lack of adjustments or revisions to the scope, which can lead to operational bottlenecks. These bottlenecks arise because the discussion doesn't always reach the right individuals and because the benefits of drone usage aren't always recognised.

There are also some perceptual challenges, where people may sometimes be hesitant towards the use of drones or may not immediately grasp their benefits. This can result in a lack of support for drone usage in operational situations.

How does the decision-making process for the acceptance of drones within the organisation unfold? Does there need to be proof that drones can add value before further decisions are made?

The person explains that the decision-making process for accepting drones within the organisation primarily follows a top-down approach. Everything must be substantiated with a business case and vetted through the management hierarchy, including considerations of time and capacity. Without explicit direction, progress is halted. While the drone team initially originated from grassroots enthusiasm to experiment with something new, expanding the scope has proven challenging.

Regarding road traffic management, not everyone within this department sees the necessity or potential of drones for problem-solving. There is some resistance to change, particularly from individuals accustomed to traditional methods who may feel that drones are unnecessary because they haven't been used before. Younger generations generally have a greater affinity for technology and see opportunities for drones, but they may struggle to communicate their ideas to higher levels within the organisation. Currently, there is a disparity between the number of incidents where the drone team is deployed (40 per year) and the total number of flights they conduct.

What are the strategies to enhance the acceptance of drones within road traffic management? Are there specific moments that could provide opportunities to engage in this discussion?

The person explains that there are several approaches to increase awareness. By demonstrating the benefits of drones in real-life situations. Integrating the drone team into operational exercises and training sessions for road inspectors and other relevant staff. Regular discussions with traffic engineers and professional event planners, where front line staff communicate the value of drones to their supervisors, can be effective. This person emphasises the need for improved communication to ensure that the drone team's contributions are not taken for granted but recognised as essential to the organisation. The drone team now requests better housing and facilities during their work, especially for longer monitoring tasks. The bill is sent to the requester.

How do you perceive the acceptance within road traffic regarding the fact that some issues within road traffic are not being addressed?

The person suggests that for the processes within the traffic control centre, it doesn't really matter whether some issues within road traffic are addressed or not. They are content with redirecting traffic in the event of accidents or implementing large-scale detours without fully feeling the impact of the incident. The visualisation of the incident is also not perceived as highly valuable unless there are specific circumstances such as hazardous materials or railway investigations. However, it would help if the traffic control centre projected the incident more frequently so that employees could have a better understanding of what is happening outside and become more engaged in the situation. Overall, the person believes that projecting incidents in the traffic control centre could help provide a clearer picture of what's happening outside and foster greater engagement with the situation. The current approach

is perceived as impersonal due to the large area served by just one central hub with a limited number of cameras.

Could drones potentially address the staffing shortage if we approach the problem from a different angle?

The person states that a drone cannot serve as a replacement for a highway inspector. The highway inspector is on-site and responsible for safety measures, such as securing the road section and ensuring a safe working environment. These tasks cannot be carried out by a drone.

What do you see as problems that could be addressed with a drone?

The person suggests that one potential issue could be the delay in the arrival of a highway inspector. With a drone, a clear picture of the situation and necessary resources can be obtained within 10 minutes. Additionally, a drone can assist in gathering information before the highway inspector arrives, such as scanning vehicles for potential casualties and leaks.

Have there been past technological developments that suddenly made the use of drones relevant? And currently, do you see any limitations or opportunities for further implementation of drone technology in our context?

The person acknowledges that the primary limitations currently lie in regulations and the fact that drones still require piloting. He emphasises that the next step is Beyond Visual Line of Sight (BVLOS) flying, which means drones can fly without visual contact with the pilot. He advocates for exploring this possibility and underscores the importance of testing such technologies by government agencies. He suggests that the government, with its various agencies, is an ideal candidate for testing such developments.

He also emphasises the importance of expanding the scope of drone use, not only for incident management but also for other applications. Additionally, he proposes using a drone bus with 360-degree cameras, where the drone operator is inside the bus and can conduct BVLOS flights. He believes that with proper risk analysis and mitigation strategies, the risks of such operations can be managed. He explains that modern drones are equipped with advanced sensors that can detect and prevent collisions with obstacles. He concludes that it is important to test and implement these technologies to see if they truly work.

What future events do you foresee that could lead to increased usage of drones?

The person indicates that they don't foresee any specific events in the future that would lead to a significant increase in drone usage. Currently, the primary focus of drone deployment is on obtaining useful imagery to support processes rather than a direct need for drone usage itself.

They highlight that if the current situation persists, the drone team may not grow or change. Initiatives like Drone2Go, while beneficial, are not necessarily essential for RWS's operations since RWS already has a standardised and structured maintenance process where the contract is typically awarded to the contractor.

To integrate drones more effectively into RWS operations, they emphasise the importance of awareness at the management level and creating more awareness and involvement among different departments, such as road traffic.

They explain that while there is clear interest in drones within the surveillance and enforcement permit, this is often addressed more at the regional level rather than coming directly from VWM.

Would you automatically consider deploying a drone for every incident, or do you still prefer a human decision on the necessity of a flight?

The person indicates that they wouldn't automatically deploy a drone for every incident, but rather evaluate the specific needs and circumstances of the traffic centre, reporting post, or other involved parties. They emphasise that they themselves don't make the decision to fly but wait for a formal order. In doing so, they stress the importance of the actual added value and relevance of using a drone for each incident, to avoid its deployment becoming unnecessary. Therefore, the ultimate decision on whether or not to deploy a drone remains dependent on its necessity and utility for the specific situation.

Would you consider the use of drones for incident management to be nearing its maximum level, or are there further opportunities for drone utilisation?

The person suggests that there are indeed further opportunities for the use of drones in incident management, but it requires a change in the organisational structure of the drone team. They propose a combination of manned and unmanned drones, with drone pilots able to adapt flexibly to the situation. They suggest a model where drones are permanently stationed at critical locations and a team of drone pilots is available to operate these drones. This could mean that drones can be quickly dispatched to incident locations and that pilots on-site can take control.

However, they point out that there are currently limitations, particularly regarding available financial resources and capacity. They emphasise the need to appoint a specific responsible person for the drone team and to no longer consider it merely as an innovation project but as an ongoing development within the organisation.

E.6. Interview 6

Background description The person works for the Department of Operational Development, Shipping, and Water Management, and is part of Team Smart Patrol.

Background project The project ”Detectie op een brug” focuses on improving the safety and efficiency of bridge and lock operation, especially in remote operations. Bridge and lock operators often have to rely on multiple camera feeds, ranging from 4 to sometimes as many as 20, to get a good understanding of the situation. The main goal of the project is to prevent accidents and support colleagues' operation by providing the operator with better and more efficient tools. Various technologies are used, such as smart cameras with image recognition technology and laser technology (LIDAR). The system assists the operator in making decisions by presenting relevant information, such as an object on a bridge when it is about to open, in a clear and concise manner.

Have there been any political, policy, or strategic framework developments that have influenced the Smart Patrol agenda regarding the execution of this project?

The person responds that primarily, issues they observed, which also appeared in the newspaper, led to this project being placed on the shortlist of Smart Patrol. Then, they looked at that list and selected this project, among others.

Have there been significant decision-making moments that led to the current status of this project?

The person explains that it has been built up gradually step by step. Initially, they conducted a POC at the Biesboschsluis, which was a crucial step in proving the technology and identifying the problem. Currently, they are in the process of developing a Minimal Viable Product (MVP). During this process, they also explored ways to address more challenging situations, such as detecting unidentifiable objects, which they are now doing using LIDAR technology.

The project leader emphasizes that the project is progressing gradually, taking small steps. This can sometimes be challenging for the people to whom they present the project, as they often want to see everything resolved immediately. However, the project leader has learned that it is important to have realistic expectations and not to try to do too much at once, as this can ultimately be counterproductive.

For another project called Overzichtsbeeld, there is currently insufficient capacity to develop it beyond the POC phase. Therefore, they decide to raise this issue with the Management Team. To do this, they first consult the knowledge table and network service to obtain input and support.

What is the difference between the use of smart cameras on the road and in maritime operations within Rijkswaterstaat?

The person believes that the difference lies in the approach taken by the road traffic department compared to the maritime traffic department. Road traffic aimed to produce the entire project at once, even considering a European application, which made the project too expensive and ambitious from the start. As a result, road traffic remained stuck in the POC phase with various smaller projects, leading to the recommendation to halt further progress. Additionally, road traffic had a project leader from the CIV, who approached the problem more from a technical standpoint rather than a human aspect. In contrast, when the project leader is from the VWM department, as in the case of Shipping, it is approached

more operationally, focusing on the needs of the people and addressing issues. This approach has been beneficial for Shipping. The project progresses in smaller steps, with constant communication with operators. This slower implementation pace has allowed them to not only prove the technology with a POC at the Biesbosch lock but also to apply it in Delft, aiming to achieve a more robust minimum viable product.

Are there differences in the strategic framework between road traffic and maritime traffic?
The person cannot really answer this question. However, they expect that in terms of innovation, road traffic's focus lies on the CHARM project, which requires them to make priority choices. There is even political involvement in this project. This assumption is supported by the lack of interest shown by road traffic personnel when the person gave a presentation on the "Detectie op een brug" project.

E.7. Interview 7

Background description The person has a background in technical public administration, with a focus on innovation in the triangle of business, knowledge institutions and governments. Also holds a PhD in technical public administration and has also studied in technical earth sciences and environmental sciences. Previously, the person has worked at Deltares in the field of innovation, and is currently involved in the innovation agenda 2030 of the Department of Public Works. They work to accelerate and improve innovation processes, mainly through collaboration with partners.

What are the decision-making moments where the necessary decisions are made for further development and implementation of a project? The speaker describes the process of transitioning from a proof of concept to wide-scale production within Rijkswaterstaat, with a focus on innovation in road traffic, such as the use of automatic drones. They explain that this process is led by the IUP (Innovate, Standardize, Produce) approach, where the innovation is first tested at different levels of technological readiness (TRL) before implementation. The person then emphasizes the importance of the Stakeholder Readiness Level (SRL), which assesses whether the organization and environment are ready to embrace the innovation. They illustrate this with examples such as changing work processes and potential stakeholder resistance and point out the importance of governance and explains that decisions about innovations are often made within forums such as the Smart Mobility directors' meeting. The speaker emphasizes that it is crucial to go through the standardization phase effectively to achieve the transition from proof of concept to production, which is currently a weak point within Rijkswaterstaat.

Is setting up a POC on incident management in road traffic in cooperation with other parties a good way to test this innovation? The speaker emphasizes that innovation often also means introducing a new application into another domain, and that the playing field around road traffic is significantly different from that of maritime traffic. Therefore, it is important to revisit the relevant stakeholders and their needs and involvement in road traffic. The speaker points out the importance of police involvement, which plays an important role in road traffic. As an example, the person cites a recent development involving police working with drones, as reported on the Department of Public Works website. This development shows that there is interest in using drones for road traffic and emphasizes the importance of re-aligning stakeholders and the context of the new application.

In the unification phase, should you make sure your innovation fits within the legislation? The person emphasizes that it is important to make sure that laws and regulations are formulated so that the innovation can be widely applied. This may mean that laws and regulations need to be changed to make the innovation possible. The speaker illustrates this with the example of an asphalt rejuvenation cream, for which various frameworks and guidelines had to be modified within the Rijkswaterstaat in order for the innovation to be applied. While this can be a challenging process, the speaker emphasizes that it is possible to adapt laws and regulations to support innovation, as seen previously with waste recycling.

Do you think Rijkswaterstaat has sufficient influence to initiate changes in laws and regulations, or do you believe this requires a broader effort, possibly at multiple levels and by multiple parties? The answer indicates that the degree of influence Rijkswaterstaat has in initiating changes in laws and regulations depends on the subject. For example, in the case of asphalt, where Rijkswaterstaat has a

dominant role as a purchaser, the agency may have more influence in initiating changes. However, in cases such as concrete, where Rijkswaterstaat is only a small player compared to other sectors such as housing, collaboration with other stakeholders and players may be needed to bring about change. This highlights the importance of broader cooperation and effort when pursuing changes in laws and regulations.

Have any political or policy developments in the past influenced the agenda regarding innovation adaptation? The answer suggests that political or policy developments in the past have certainly influenced the agenda related to innovation adaptation. The speaker that the acceptance of innovations often depends on a power play between costs, benefits and the seriousness and urgency of the problem the innovation is intended to solve. Sometimes innovations are temporarily ”put on hold,” but for certain urgent problems, they can quickly be brought forward again for implementation in practice. For example, the speaker cited the recent example of bridges, where few innovations were available to solve certain urgent problems, so innovations such as drones were quickly deployed. The flow model of innovation, in which technology, problems, policy and politics flow together, is mentioned as a useful concept for understanding how innovations are accepted and implemented.

So is Rijkswaterstaat more inclined to a closed identity in which innovations are assessed and decided internally without much external influence, including political influence? The speaker finds it difficult to give a clear answer to this. However, on the subject of drones, the speaker stresses the importance of involving the network of stakeholders and all players who have an interest in efficient road traffic, such as the ANWB and the police. For the specific use of drones in incident management, it is recommended to approach it precisely from the problem rather than purely from the technological possibilities. The speaker points out the importance of identifying the problems that drones can actually solve and acknowledges that there are still some obstacles to overcome. This highlights the complexity of implementing innovations such as drones within the Rijkswaterstaat, where various factors must be weighed and integrated.

In view of decision-making moments where flows converge, should a proof of concept be done to convince stakeholders of a problem?

The person approaches the importance of involving those who actually experience problems in developing and implementing technological solutions, such as drones. Instead of focusing on what is technologically possible, it is crucial to listen to users' needs and problems. When technology is seen as a solution to existing problems, it creates a natural demand for implementation. This is especially relevant within asset management, where innovations must fit daily operational needs.

Is it necessary to adjust strategic frameworks when a director decides to participate in a new initiative or innovation within the organization?

The person explains that it is necessary to conduct an impact analysis at the U stage. This analysis includes identifying all aspects affected by the innovation, such as organizational changes, laws and regulations, and any adjustments to existing frameworks and guidelines. This process is often incorporated into a unification plan, which defines all necessary steps and changes.

It is further emphasized that it is essential to have someone familiar with the regular road process to assess how the innovation can be integrated into this process. This includes examining changes throughout the chain of operations, identifying new procedures or points of contact, and carefully considering any operational aspects that need to be modified or revised as a result of the innovation. An important step of unification is to integrate the innovation into the process and ensure that it is invested in the right place, with the involvement of relevant executives and experts.

Are drones a more unique innovation within RWS than other innovations, given their focus is more on their specific application than on the technology itself, and does this present additional challenges for implementation within RWS operations?

The person talks about various innovations going on within RWS, such as digital twins and other data-related and smart mobility initiatives, here drones are not unique in their focus on specific applications. What is unique to drones, however, is the strict laws and regulations that hinder automated flight. This aspect brings additional challenges to the implementation of drones within the operations

of the Rijkswaterstaat.

Do I understand correctly that collecting problems in the problem stream and conducting a proof of concept is necessary to convince the road side?

The person emphasizes that you don't just need to convince the road side, but rather ensure that they actively come and ask for a solution to their problems. This implies that the road side itself starts to see the need for the solutions that drones can provide. To achieve this, it is essential to properly identify where the real problems are and how drones can effectively contribute to them. The person also explains that if the drone team tries to convince the directors' meeting, the case may not be as strong as if the production people themselves try to convince the directors' meeting. Therefore, it is suggested to engage with stakeholders and explore their perspectives and ideas, potentially creating new insights and broad support for implementing drone solutions.

Have there been any important decision-making moments in the past, besides the directors' meeting, regarding policy around new innovations?

The person shares information about the Road Traffic Management Roadmap and the Shipping Management Roadmap within the Rijkswaterstaat. The person also discusses how drones can play a role within these roadmaps, especially in the context of data-driven traffic and shipping management. In addition, the person emphasizes the importance of creating good connections between initiatives such as Smart Mobility and the existing roadmaps. Still, the most important moment is the directors' meeting, and so for that the relevant stakeholders should be involved to push the issues to get things positively on the agenda there.

E.8. Interview 8

Background description The person has been working in the policy core since 2006, starting at the ILT (Inspectorate for Living Environment and Transport), which was then known as IVW (Inspectorate for Transport and Water Management). In 2012, they transitioned to the policy core and have been fully engaged in the Unmanned Aviation program since then. They have been responsible for the national implementation of regulations concerning unmanned aviation, assisting in developing regulations in 2015 and contributing to European component regulations during the EU presidency in 2016. They are also active internationally, including involvement with IKO (International Civil Aviation Organization). Additionally, they have seen Rijkswaterstaat become involved in this dossier.

What have been the key decision-making moments in the past regarding legislation concerning drones in the Netherlands and Europe?

The person explains that there have been several significant decision-making moments regarding drone legislation. In July 2015, the first national regulations for the professional use of drones in the Netherlands were published, known as the ROABL (Regulation on Remotely Piloted Aircraft Systems). Prior to this, regulations existed for model flying, but this was the first specific legislation for professional use. Discussions about European drone regulations began in 2016, as aviation falls under the responsibility of the European Commission. Drones weighing under 150 kilograms were exempt from European legislation, remaining under national competence. However, the Netherlands quickly decided to embrace European regulations to establish a unified European market and gain economic benefits over other countries. This decision was formalized in 2018, transferring responsibility for drone regulation to the European Commission. In 2019, the first regulations from Brussels were published, including specific requirements for operational aspects and product standards for drones, Regulation (EU) 2019/945 and Regulation (EU) 2019/947. Finally, in 2023, the Uspace Regulation 2021/664 was published to regulate airspace for busy drone operations. However, implementation of this legislation is still progressing slowly due to some outstanding issues and challenges.

Why did the U-space regulation proceed so quickly?

The person responded that there was a need for regulation within the sector, which had been contemplating low-risk operations of small drones since 2002. Traditional aviation processes, focused on lengthy development, clashed with the rapidly evolving drone industry, akin to the rapid advancement

of mobile technology. The realization grew that establishing rules was essential to prevent illegal drone operations and ensure safety.

Regulation (EU) 947 regulates the operation of individual drones within the specific category (as currently used by Rijkswaterstaat). There is no fixed altitude limit in this category. As airspace becomes busier, a traffic management system is required. The U-space regulation shifts responsibility from traditional air traffic control services to U-space service providers. This raises questions about how this change will be implemented and integrated with existing air traffic management systems, particularly at airports. A practical example of U-space implementation is the port of Rotterdam, although it has not yet been officially designated as U-space airspace, it is already being treated as such.

Is the "detect and avoid" technology already developed?

The person notes that while there are pieces of technology available that could be used to build detect and avoid systems, there isn't yet a complete solution. Although there are means for collision avoidance, such as electronic communication between aircraft, these are not universally available. This makes collision avoidance complex, as it involves not only avoiding other aircraft but also other airspace users, weather conditions and ground obstacles. The International Civil Aviation Organization (ICAO) is working on standards for these systems, but translating them into regulations and industry standards takes time. The individual also emphasizes that the development of this technology is not solely the responsibility of the government but also of the industry. While the government can establish rules and designate test areas, the airspace belongs to everyone, and all parties must contribute to developing detect and avoid solutions.

Is the implementation of U-space and the associated regulations the final step in the process of BVLOS flying?

The person explains that in the EU Drone Strategy 2.0, published by the European Commission, the steps to be taken are outlined. Among them are the additional traffic rules, which are being developed under SERA. Additionally, there is no restriction for BVLOS flying in the current Regulation 947. The legislation does not hinder that. However, it is up to the inspectors of the ILT to grant a permit. It is important to further develop the BVLOS Roadmap. There are many practical challenges in implementing BVLOS operations, especially in urban environments.

How can developing the BVLOS Roadmap help in getting a licence from ILT inspectors?

The person explained that through the Roadmap, a layered approach is being taken where all parties involved, including ILT inspectors, can learn from the process. Test areas, such as Valkenburg and Woensdrecht, are being identified to conduct BVLOS experiments. Work is currently under way to create an airspace corridor from Valkenburg to the North Sea, allowing BVLOS implementation to be tested closer to operations. By working together and experimenting within the framework of the BVLOS Roadmap, all parties, including ILT inspectors, can learn from experience and contribute to the safe implementation of BVLOS operations.

Can you estimate when BVLOS flying will be operationally possible?

The person explains that it is difficult to give an exact date for when BVLOS flying will be operationally possible. They stress that a detect-and-avoid system is essential for practical implementation. However, not much progress has yet been made in this area. They estimate that it could take another two to three years or so to become reasonably operational, but this depends on the development of the market. The person points out that the industry is being challenged by initiatives such as Drone2Go to develop certain technologies needed for BVLOS flying. They also note that the lack of standards for detect-and-avoid is an impediment and that the process of establishing these standards is slower than expected. The implementation date has again been somewhat delayed, as the European system of industry standards down is also not moving very fast. This may delay the final implementation, but in the meantime, experiments can still be carried out.

Is it true that ILT is not always involved in initiatives around drones? Do we need to convince ILT to get more cooperation?

The person indicates that ILT may not always have been involved in initiatives around drones in the past, but this is changing. There was a phase when ILT could only act on licence applications and was

not allowed to have pre-contact with stakeholders. However, there is now more awareness within the organisation that they need to be more involved in other processes because of the experimental and innovative nature of drone initiatives. It is mentioned that Maarten, together with the licence inspectors at ILT, is working on a plan to achieve more involvement. These efforts are seen as a good complement to what is being done on the BVLOS Roadmap side. The person says that the growth fund is a good initiative, especially in terms of innovation, however, they also stress the importance of involving ILT in the entire process, including obtaining permits.

Have any political developments in the past influenced the agenda regarding laws and regulations on drones for Europe and/or the Netherlands, and could they happen again in the future?

The person explains that many of these developments are driven by industry demand, with initiatives such as the rise of air taxis seeking political support. Like Volocopter who want to fly to Paris with the Olympics. The person emphasises that regulation does not just happen, but is often the result of external pressure and expected market developments.

The person also illustrates how Europe was initially reluctant to develop drone regulations, but began to act when the importance of a common European market became clear. There is a mismatch between the rapidly changing drone world and the existing aviation system, which poses a challenge for adapting regulations and infrastructure. They conclude by stressing that developing a new system for drones is not only about technology, but also about revising existing aviation frameworks, which do not fit drones, which is a complex process that requires time and effort.

Is there a way to structure and optimise the process of decision-making and development of the BVLOS Roadmap?

The person explains that it is important to identify the right experts and assign specific roles to different stakeholders. For example, they cite an example of a previous experience with hydrogen as a fuel for drones, where involving the right experts would lead to progress since there were no hydrogen experts on the person's team.

They emphasise that it is not only about defining the steps to be taken (from experiment to operation), but also about determining which parties will play which role in the process. This includes various actors, such as operators, government parties like ILT and NVWA, and other organisations like the police and fire brigade. The aim is to ensure that all parties involved understand what role they play and what is expected of them, working together towards an operationally safe situation. This requires a detailed recording of the roles and responsibilities of each party within the roadmap.

E.9. Interview 9

Background description The person is employed at the Traffic Control Center Velzen, or VC Northwest Netherlands, and flies for the drone team.

How have discussions around the use of drones for incident management on the road evolved within RWS? The person says it is still being talked about very inconsistently. According to them, the use of drones for incidents is clear. However, they note that there are still definitely cases where OvDs still choose not to call the drone team. Like at the A9 where there was an accident. The VOA team wanted to investigate and it took a very long time. The OvD had not called the RWS Drone Team, so they asked the OvD why this was. The answer was that the police were keen to use a, their own, drone team for the VOA. However, that drone team was occupied. When they asked why then the RWS drone team was not called, the reply was that the Zulu would be deployed or something similar. The person cites this example to show that it does not always occur to the OvDs to call the RWS Drone Team. The person believes that the OvD should not wait for the police here, but take that decision into his own hands.

How have discussions around the use of drones for other use cases, such as the trial at the A7, been evaluated within road transport?

The person says they are still working on the trial of the deployment of the drone team during road works at the A7 Purmerend. The traffic centre NWN sees the added value. The person's team leader

is also very enthusiastic about the use of drones in road traffic. The test is still in progress so the person does want to share the results later. In addition, the person explains that there are still some issues for the drone team, such as arranging a drone bus for times when they need to monitor for longer, which does not always work out through their own budget. However, when they have to monitor for Arcadis as in the A7 trial, they can get a drone bus. This kind of thing could make the drone team's operation more elevated. The drone desk often has to decline request for monitoring since it officially falls outside of the scope.

E.10. Interview 10

Background description The person is drone coordinator of RWS and works for the department of operational development of shipping and water management.

What were the challenges for when managing marine incidents? The person answers that in incidents, there were oil spills that one could see poorly. The idea of using drones was suggested by some operators who believed that drones could give a better aerial view and get into hard-to-reach places such as under a bridge. This suggestion was eventually brought in to Smart Patrol, which had to further justify the idea to management. Smart Patrol was then given budget for drone activities for incidents. DGLM gave budget for boosting the drone market in the Netherlands.

How did discussions arise around the use of drones for road incidents, enforcement and other applications? The person explains that these arose from the observations and experiences of drone pilots and enforcers. The business case for enforcement is there but it is necessary to address the ethical issue around the use of drones for enforcement. Although there has been a successful pilot, no decision has yet been made on how to effectively implement and standardise drones for enforcement. For incidents on the road, they did the pilot Highway Patrol which showed that the response time is too low. The drone team may deploy drones for incidents on the road, but in practice this still happens too little in the eyes of drone pilots. The pilot was stranded on substantive issues, while monitoring and enforcement is quite applicable and stranded on ethical considerations and no decision has been taken on this yet.

Has the elaborated business case breakdown on the road actually been implemented? If not, is there any decision yet to be made on its implementation or are there other factors affecting the decision-making process? The person explains that that business case is not an issue at the moment. Drones can potentially help with breakdowns on the road, by verifying that a car is on the side, for example, from the moment the drone-in-the-box can be deployed on a large scale. The person thinks that those decisions won't come for another year after testing has been done to fly BVLOS for this application.

What is your opinion on the suggestion that the drone-in-the-box is more interesting for the Drone2Go partners than for RWS, how do you feel about that? The person indicates that the technology is interesting for everyone. However, implementing it will require adapting internal processes and readiness. The person emphasises there is not only a need to demonstrate the added value, but also to think about how to integrate it into existing work processes, including a uniform workplace.

Do you think drones are well incorporated within the policy or strategic framework of shipping or road traffic? The person thinks drone use is not explicitly included in these frameworks. The drones, of course, remain a tool. According to the person, such services are not incorporated in the strategic framework, but they have not read it for a long time.

Have drones been fully applied for road incident management? The person replies that apparently it has not been applied. It takes effort to convince people of the added value of the drone team. The highway patrol pilot didn't help. Examples are mentioned where the drone team was not used, sometimes because the drone team was often unavailable so people do not ask them. It is noted that there may be miscommunication between different parties, not only within RWS, but also with external partners such as the police. The importance of good communication, especially to OvDs, is stressed to make the use of drones more effective.

When approximately was the decision taken that drones could be used for incidents on water, and thus eventually on roads? The person estimates that the decision was officially taken in 2021. After that, efforts were first made to improve the organisation of the drone team, so lately they have been working on communicating the use of drones with OvDs. The use of drones started mainly with shipping, but there is now interest in using them for road traffic as well, especially from some drone pilots.

That decision-making moment in 2021, was it another moment when the Drones team was reviewed? The person says that every year the drone team looks at what tasks can or cannot be done, and this is discussed with the CEO Drones. However, there have been no major changes to this process in recent years.

Is there perhaps a need to take action, for example by implementing a drone-in-the-box solution, or by making road traffic management more aware of the importance of drones? The person stresses that there is currently too little data to show that drone (which might come out of a box) on the road is very useful. It is also noted that drone flight capabilities have improved in recent years, such as with RTK, transmitter mast and in CTR areas, which means that the drone team is now allowed to fly in more places, including at night and near airports.

Have any political or policy developments influenced the agenda in the past? The person stresses that the sector is always dependent on laws, regulations and policies. They point out that the U-space regulation should have been ready about 2 or 3 years ago, but is still not complete. This pattern of delay is also seen with the testing and experimentation framework, the development of which took three years before it was published. However, even after the framework is published, laws still need to be amended by the province of South Holland before it can come into force. The person expresses doubt about the feasibility of the drone strategy of policy by 2030. They note that no progress has yet been made on detection and avoidance technologies. Although they are willing to fund the development, clear frameworks that these technologies must comply with are still lacking. Moreover, they note that there are no requirements for airspace users without a transponder. Although it has been proposed to provide everyone with a transponder, this has not yet been incorporated into policy. There have been attempts from the industry to help. Several proposals have been handed over to ILT, but these have not yet been assessed, indicating stiff decision-making. Communication between DGLM and ILT was difficult in the past, as ILT did not want to position itself as an advisor, but stuck to its role as a regulator. Although this has now improved, the industry still depends on permits issued by ILT within the framework of policy.