«Grønne, bærekraftige sommerjobber»

Real-time monitoring of diffuse emissions

Preliminary business plan

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Table of Contents

Executive Summary

The metal production and processing industry in Norway has a history of having a negative environmental impact on the nearby community. Particulate matter through emissions from industrial plants is an issue, both visually and environmentally. It is also linked to health and safety questions, both real and perceived.

Emissions from industrial installations are subject to regulations, and technologies are in place to ensure strict environmental compliance in the optimal exhaust locations. With the advances in technology to monitor and manage these emissions, the environmental, legislative and industry focus will inevitably shift towards *diffuse* emissions – the emissions that come from inside and outside activities through openings in roofs and walls. However, measuring diffuse emissions has shown to be a challenging task.

DetecDiff is a concept and enterprise that addresses the industry concern about measuring diffuse emissions by providing a service that automatically detects and registers diffuse emissions through video analysis technology. This is combined with measurements and analysis of diffuse emissions, obtained with the use of a spectrometer carried by a drone. This provides the industry with insight into their diffuse emissions, so they can work on containment and improvement of industrial practice, while also providing effective and no-hassle measurements for documentation purposes.

This concept is as a starting point designed towards the needs of the metal production and processing industry in Norway, as several industry actors have expressed a need for better solutions for measurement of diffuse emissions. We have identified two actors that provide diffuse emission measurement for this industry. Several companies also perform some kind of diffuse emission measurement and analysis on their own sites.

DetecDiff is positioning itself to be the leading industry expert on diffuse emission alert and measurement. The company will design, offer and operate diffuse emissions monitoring equipment and diffuse emission analysis. The product will be offered as a subscription service to the end customer.

Product design and R&D will be performed in cooperation with partners in the hardware and software (Video Analysis) fields.

We believe that the product offer will drive demand – once there is a commercially available solution for the notification and measurement of diffuse emissions, this will in turn increase adoption rates for the system. An important part of the sales and marketing strategy will therefore be to create a successful Proof of Concept solution, firstly in the form of an emission alert pilot, and later as trial products for prospect customers.

DetecDiff’s capital requirement for product development is significant and involves considerable software development. The feasibility of the project depends on getting access to funding support.

Mission Statement and Description of Business

Mission Statement

To give companies the means to develop clean and environmentally-friendly practices by providing real-time diffuse emission data and diffuse emission measurements.

Business Concept

Real time monitoring of diffuse emissions through analysis of data from digital cameras (multispectral analysis) and analysis through the application of big data analytics and machine learning techniques. By gathering data and observing trends, quantitative measurements of diffuse emissions can be performed during a defined period of time.

Potential customers consist primarily of mining and metal production and processing companies in Norway.

By monitoring diffuse emissions, companies can determine which processes lead to diffuse emissions and compare different operational practices to minimise their emissions. This optimisation will ensure that the companies will be able to meet regulations in the future, when measuring equipment technology improves and government and industry regulations inevitably catch up. Experience shows that information about diffuse emissions also can be coupled with production process parameters and routines, for further improvement. Together with the ongoing trends in digitalisation, this will provide valuable information for the companies, in the form of aggregate data that can be combined with process parameter data for insight and improvement.

Concept

A video emission detection system that detects diffuse emissions and provide real-time alerting, future planning opportunities and documentation. A drone is used for more precise measurements at the location of the emissions providing coverage of all locations, including hard-to-reach spots. Greater insight into diffuse emission patterns ensure that measurements are performed timely and economically.

This detection system and drone-assisted sampling is packaged into one product offering sold as a subscription-based service to companies who want to be able to detect and document their emissions.

Figure 1: Visualisation of the concept. Emission data is gathered by cameras and then processed by a software algorithm to generate real-time alerting and reports for a given time resolution for the company in question[1].

[1] Source: Own composition including photo: Øyvind Bratt, Rana Blad. All other figures are free stock images.

The Problem

Air quality and the challenge of diffuse emissions

Air quality is a challenge for governments, regulators, citizens and the industry itself. Emissions from industrial activities are subject to regulations, and technologies are in place to ensure strict environmental compliance in the optimal exhaust locations, such as chimneys etc. With the advances in technology to monitor and manage these emissions, the environmental, legislative and industry focus will inevitably shift towards *diffuse* emissions.

Diffuse emissions are defined as the many smaller or dispersed sources of pollution released into soil, air, or water, whose aggregate effect on those media can become considerable and for which collecting reports from each separate source is impractical (European Parliament, 2009). In practice this often means dust emissions due to outdoors production processes and handling and unloading of materials, in addition to diffuse emissions due to production itself (see Appendix A1 for processes that generate dust).

The metal production and processing industry in Norway has a history of negative environmental impact on the nearby communities. Particulate matter from industrial plants is an issue, both visually and environmentally. It is also linked to health and safety issues, both real and perceived. The companies involved are interested in measures that can help solve this problem but measuring the diffuse emissions is a challenging task. More information about the emissions is valuable and can give insight in which processes generates diffuse emissions. This information provides a starting point in the work of improving the processes and minimizing the emissions to create a better environment for everyone.

Emission permits granted by Norwegian authorities[2] take these diffuse emissions into account, and state that diffuse emissions are to be limited to the greatest possible extent, through use of best available practice. Some companies have emission permits that expire in 2020, and stricter demands are expected in future emission permits.

Industry practice for measurements of diffuse emissions today

Existing measurement techniques of diffuse emissions are problematic regarding representativeness, repeatability and quality assurance. Measurement is time-consuming, and the results are often not immediate. The companies have the responsibility of estimating their own diffuse emissions and no measurement standards exists for doing so. Therefore, various estimation techniques exist with varying accuracy. The simplest method is described as assuming a concentration of particles, estimating the volume of the plume and then extrapolating the results over the course of the year to get the total yearly amount of emissions.

Manual measurement at emission spots

Some industry actors try to quantify diffuse emissions by measuring particulate emissions in places where diffuse emissions are suspected to occur, like in openings in the roof or walls. These measurements, performed manually, are taken 2-3 times a year: One measurement consists of a total of eighteen hours measurement spread over three days. The results are

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[2] Can be found at https://www.norskeutslipp.no/

then extrapolated to estimate an average yearly yield. One problem with this method is that turbulence in these openings make accurate measurements complicated. Access to these places where diffuse emissions occur is often difficult and sometimes impossible. A lot of activities that lead to diffuse emissions also happen outside of the industrial buildings and will not be included in this kind of measurement.

Visual Characterisation and Video Imagery

Some industry actors use video imagery to determine the presence of diffuse emissions and identify the sources. By doing this they can identify when and where the emissions are happening. The resulting footage is inspected manually. In an on-going project they are trying to use motion-detecting software to do this process autonomously. This method has the advantage of using readily available technology. There are several disadvantages: Rigid data protection legislation hamper the use of visual inspection, or even recording video; motion detecting software is thrown off by sun glare and background movement. The camera in use can work during different kinds of weather conditions like rain or snow during both day and night. The camera cannot quantify the emissions, only determine if they are happening or not, and the probable source.

Such visual inspection can still be advantageous for minimizing diffuse emissions: one company we have been in contact with used data gathered by video to compare emissions during different temperature settings of an industrial process. By doing this they found a better temperature range which leads to reduced emissions and improved product quality compared to past practice.

One industry actor tries to measure diffuse emissions through visual characterisation, where an operator uses cameras on the industrial site to compare emissions against “calibrated” imagery, which corresponds to measured or calculated particulate matter. The operator delivers a status update every two hours.

Precipitation bucket

Another company uses the Norwegian Institute for Air Research (NILU) standard precipitation buckets to measure the dust. The buckets are placed on various sites around the business as well as a couple of places outside the business. This method does not determine the source or nature of the emission.

Solution offering

The Technology

Camera and emission-detecting software

Cameras that are capable of gathering information during various weather conditions and low light (for example Hikvision DarkFighter[3]) are installed at strategic locations around a business or industrial area. The cameras provide high resolution and great dynamic range in colour (preferably 4k resolution, 10-bit colour). For cases when businesses are near each other, a camera can also be mounted on the inside of each business to more accurately determine the source. The concept combines different locations to determine the source of the emissions as well as the total volume.

A software algorithm scans the data output from the camera, looking for emerging dust clouds in the image and outputs an alert when detected. This continuous video scanning of the environment lets the software see when and where the emissions take place. The software uses machine learning and is trained to recognise diffuse dust emissions at the same time as it filters out unwanted events like people, vehicles, sun flare and vapour. The software algorithm is fed with footage of diffuse dust emissions in different weather conditions from an entire year to perform in snowy and rainy situations. It is also trained to handle different lighting scenarios like low light during night. The sensitivity of the video detection software is capable of adjusting itself automatically. When it has not detected any activities in a longer period, the sensitivity increases. When it already has detected diffuse emissions, and there is a lot of dust in the area, the sensitivity decreases automatically to avoid repeated alarms (see Appendix A1 for similar technologies).

Real time alert and data gathering

The analysis is done in real-time with a notification system that allows the company in question to be aware of the emissions as they occur. The system will also generate a report based on a given time frame that can be used as documentation of the emissions.

The notification system will be flexible, so each customer can tailor it to best fit their needs. This will be done by offering software that allow for sending notifications on several platforms, such as computers and handheld devices. In this way, the customer can decide which solutions they want to use depending on how they want to receive the notifications. One example of use is a control room setting, where the operator can monitor diffuse emissions simultaneously with other aspects of the industrial process. The operator can thus discover connections between the ongoing processes and the diffuse emissions. A flexible alert system makes it possible for several people to receive alerts on different platforms, for example: the system can notify the head engineer through his computer, the shift leader through his smartphone, and the process operators through a monitor in the control room.

Quantitative measurement technology

For precise measurements, a drone equipped with measurement gear is sent to the location of the emission. By recognizing emission cycles and patterns, suitable time windows for drone measurement can be determined, ensuring that measurements are taken at

[3] https://www.hikvision.com/en/Products/Network-Camera/4-line/Darkfighter-Ultra-Low-light-Camera/DS-2CD4A26FWD-IZ(H)(S)

representative times. This will give a more precise estimation of the total diffuse emissions than what is practiced today. At some locations, stationary IoT-connected sensors can be an addition to drone measurement for providing continuous high-resolution data.

Drone

DetecDiff will use a drone that is big enough to carry the measuring device to perform measurements (for example Tarot 650[4]). The drone take-off mass (drone and measuring device) will most likely exceed 2,5 kg and the drone should be categorised as RO2 (Appendix A4). To operate a RO2 drone the operator needs to obtain a licence from the CAA Norway, this is done by taking an online course and an exam (Luftfartstilsynet, 2018).
Drones have the capability of quickly covering and reaching emission spots that are difficult or impossible to access for manual measurements.

Measurement

To perform measurements with drones, the sensor needs to be able to measure while in the air. The German company Palas GmbH has developed a measuring device called Fidas Fly 100 that can be integrated in a desired drone or another carrier system. The device is a battery-operated, real-time, compact and lightweight fine dust aerosol spectrometer, and measures PM1, PM2.5, PM4 and PM10. It has software that can present in different ways the measurement data of the particle size distribution and calculated mass or mass fraction. (Palas GmbH, 2018a). Palas GmbH also offers a package deal, Fidas Fly 200, where the measurement device is sold assembled onto an octocopter that has high operational safety and can be controlled both manually and automatically. Fidas Fly 200 has the same capabilities as Fidas Fly 100, but is also equipped with a data logger with flash storage and supports remote access (Palas GmbH, 2018b).

Since the Fidas Fly only presents data on the size and size distribution of the particles in the diffuse emission, it could be desirable to further develop the concept by supplementing these values with chemical analysis and information about the particle shapes in the emission. To perform analysis, it would be necessary to collect a sample of the dust in the diffuse emission, which would depend on sampling equipment that could be attached to a drone. When the sample is collected, it can be delivered to a laboratory that can analyse it to find the chemical composition and scan it to find the shape of the particles. SINTEF Molab has the equipment and personnel needed to perform these tests.

The visual data should be able to identify patterns that indicates if there are any clear sources of diffuse emissions. In some cases where conditions allow for it, stationary measurement devices could supplement drone measurements.

Storage

Due to privacy regulations (Appendix A4), video footage should not be saved for longer than seven days. Another consideration is the space needed to save large video files. To overcome these problems, the software algorithm gathers information for each company in a database of separate logs with information of time, whether there are emissions or not and an estimate of the volume of the emission for the corresponding time. This is saved in a

[4] https://www.uavsystemsinternational.com/product/tarot-650-ready-to-fly-drone/

cloud-based solution. In addition, a still image that documents the visuals of the situation is stored regularly as a visual reference. At events where there are emissions, the frequency of saved still images increases. To overcome privacy regulations, the system is capable of detecting people and automatically censor them in images that are stored. One example of this capability is a software developed by Epigram which automatically detects and removes people when they appear on a wildlife camera, ensuring privacy regulation compliance (see Appendix A1) (Epigram, 2018).

Report

The information stored in the cloud can be compressed and visualised in a report based on a time-frame that the customer chooses. Along with a picture of the emission, this can be used to document whether or not the company have had diffuse emissions in a certain timeframe. The information stored in the cloud is combined with measurement results for more precise documentation and estimation of the total emissions.

The Diffuse Emissions measurement market

Industrial plants that have visual diffuse emissions because of their production will be the market for this concept, as these plants can benefit from monitoring their emissions.

Industry Trends and Development

There are standards on how to measure emissions from point sources on industrial plants, and permits describing the allowed quantity of these emissions. When it comes to diffuse emissions, there is often a lack of or insufficient information on quantity and content. As of today, there are no standards on how to measure diffuse emissions, but there are some regulations on diffuse emissions. The industry expectations are that these regulations will be tightened, and that the government will demand measurement of diffuse emissions in near future.

The emission permits granted to mining and metal production and processing industry typically specify exact limits to diffuse emissions of particulate matter or other pollutants (Norwegian Environmental Agency, 2008). However, this is rarely enforced due to limitations in achieving feasible quantification with today's available technology. Permit holders are also expected to take measures to prevent or limit diffuse emissions but enforcement is not strict, owing to difficulties in identifying emissions as they happen or in a reasonable timeframe.

This attitude can be expected to change towards stricter requirements when a permit holder demonstrates for the Environment Agency an improved method of indicating emissions and in the long run of quantifying emissions[5].

Segmentation and Customer base

The mining, metal production and processing industries have challenges, both visually and environmentally, with particulate matter. Meeting with representatives from several industry actors, a need for better solutions for measurement of diffuse emissions was expressed. Accordingly, this concept is best suited for companies with industrial activities that produce diffuse dust emissions.

We have identified 16 metal production and processing plants and 6 mineral processing sites in Norway, not including aluminium producers (see Appendix A8). A marketing survey has been performed, probing diffuse measurement practices and needs, both present and future, in the metal production and processing industry (see Appendix A7). The results are encouraging, pointing to a general need for a better diffuse emission measurement concept. All the companies we have been in touch with have expressed interest in a solution for measurement of diffuse dust emissions. We estimate there are 30 plants that are potential customers of DetecDiff in Norway.

Today's practice of measuring diffuse emissions is an unwieldy process, as it requires measurements over a long time period. By automating much of the process and providing quick, well-timed measurements, we believe that we can reach a substantial share of the Norwegian metal production and processing industry. It should be noted that most of the

[5] Opinion expressed by employees in SINTEF Helgeland, SINTEF Molab, Miljøteknikk Terrateam

metal producing and processing plants in Norway are part of larger European or international companies that own many similar plants. This opens for possible expansion to plants outside Norway by first reaching the Norwegian plants that are a part of these companies.

Scalability

Diffuse emissions are not only a problem for the above-mentioned industry. Other industries also have challenges to face related to diffuse emissions of various kinds, and all of them will most likely be subject to more strict regulations in the future. By monitoring diffuse emissions, the companies can draw a better picture on how different practices and routines affect their environmental impact and production. Therefore, this concept may be expanded to provide valuable information for other types of industry like the petroleum industry and aluminium-producing and processing industry. Camera technology for monitoring non-visual emissions from for example the aluminium industry exists in form of multispectral cameras (see Appendix A1 for price and examples).

Competition

At present, the only independent providers of any kind of measurement service on diffuse particulate matter emissions in Norway are SINTEF Molab and Hardanger Miljøsenter. Additionally, Applica Test & Certification can provide the service but due to a perceived lack of demand does not currently perform these measurements.

The measurements are performed by collecting the total amount of particulate matter at a specific point over a given time and used for estimation as outlined earlier. This method does not vary in any significant manner between providers in the Norwegian market, and when brought to completion the concept might not initially have any competing solutions on the market.

SINTEF Molab is one of the largest industrial laboratory service and testing providers of Norway, offering a range of services to industrial, private and public clients. These services include field sampling, chemical analysis, material testing and analysis, environmental measurements, and environmental consulting.

Some actors, like Elkem, Eramet and Finnfjord AS, have internal routines for measurement or visual estimation of diffuse emissions. Both Elkem and Finnfjord representatives have expressed interest in diffuse emission measurement solutions that better address their needs.

Another actor worth mentioning is NILU, that does research on air quality. They have 40 years of experience and does measurements of air quality and chemical analysis for larger areas than an industrial plant. NILU’s activities are based on research and not focused on commercial solutions for diffuse emissions. Therefore, they are not considered a competitor today.

Business Goals and Strategy

Business Model

DetecDiff is positioning itself to be the industry expert on diffuse emission alert and measurement. The company will offer a complete system for diffuse emission alert and measurement and related reporting and data management services. The company will thus be responsible for actual hardware, software and reliable data communication and storage.

Product design and R&D will be performed in cooperation with partners in the hardware (equipment) and software (Video Analysis) domains. The latter falls into the domain of software developers with AI and video analysis capabilities. Suitable options for commercial partners with these capabilities include Detec and Araani.

Installation and integration of the systems will be performed in cooperation with a Systems Integrator. A suitable partner would be the local Avanti Engineering or Detec (see Appendix A1).

DetecDiff will perform diffuse emission measurements with the aid of drone and spectrometer, operated by a DetecDiff employee.

Dust samples will be analysed in cooperation with SINTEF Molab.

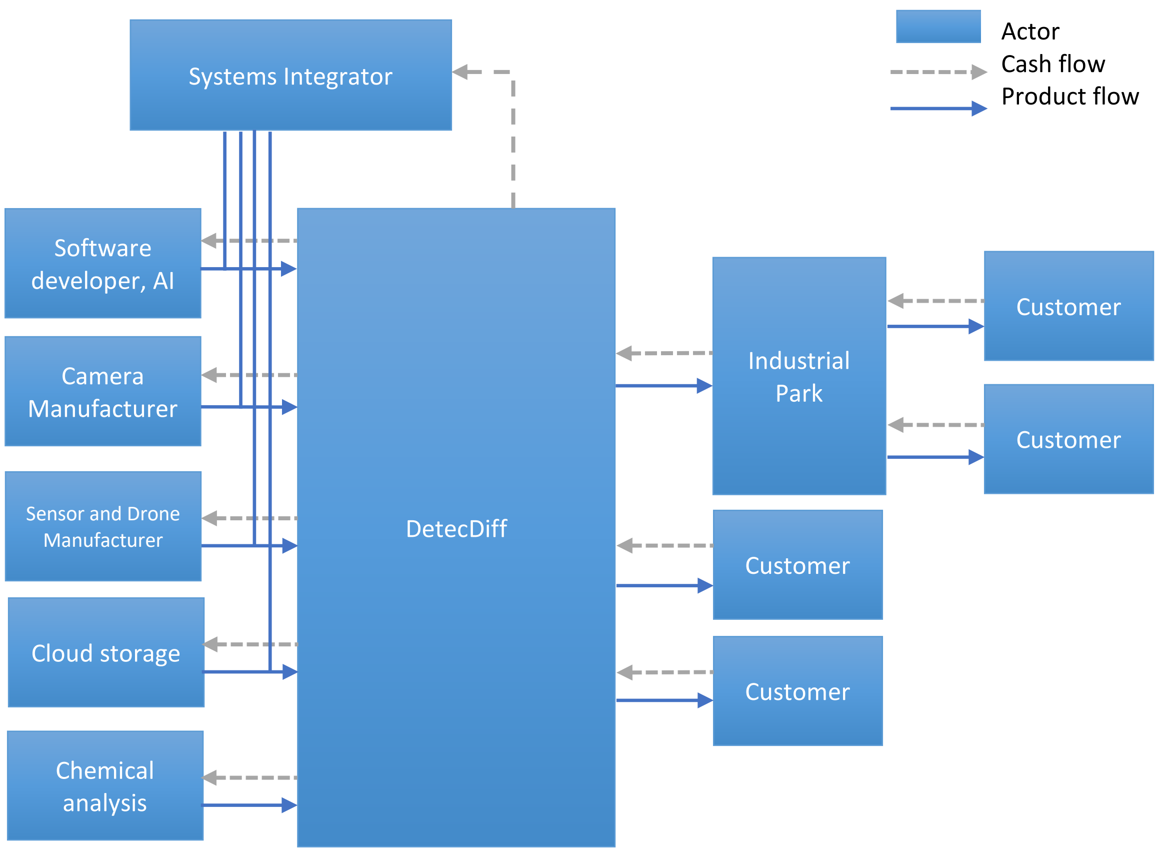

Figure 2: Business Model

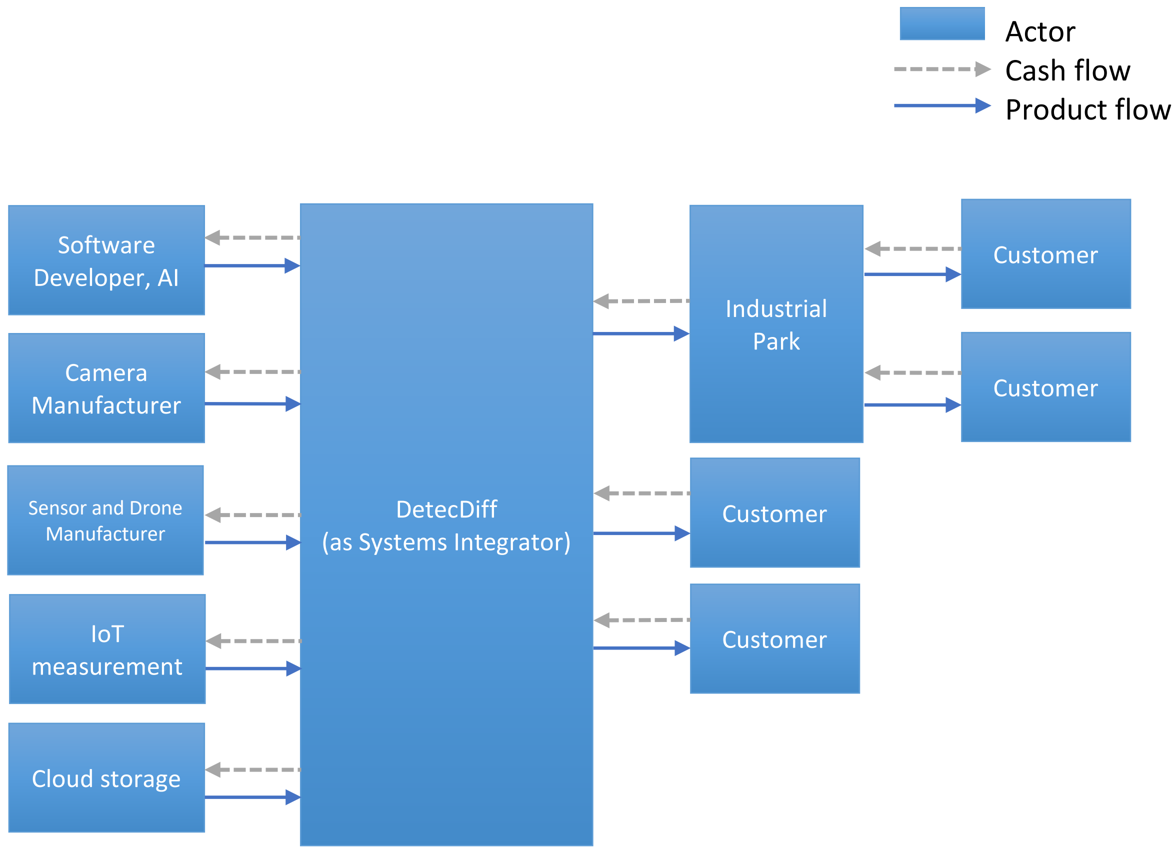

Figure 3: Future Business Model with DetecDiff as a Systems Integrator. Chemical analysis is also left out, for more information, see Product Development Goals and Strategy.

Price Strategy

The product will be offered as a subscription service to the end customer. There are two possible models for a subscription service:

1. The customer signs a three-year contract and is billed monthly throughout contract duration. The base product functions as a real-time emission alert system. This product will notify the end customer of the occurrence of diffuse emissions, pinpointing the place and time of the occurrence. Included in the subscription service is a monthly report based on the data stored in the database. The timeframe of the report can be adjusted according to individual customer needs.

2. The product is offered through industrial parks as value-added resellers. Industrial parks already provide services such as power, water, district heating, access roads, internet and phone lines, and may provide diffuse emission alert and measurement as an additional service. The measurement hardware is placed strategically at the industrial park, to allow for measurement of all sites contained within. Mo Industripark (MIP) is an example of such an industrial park, which contains several metal production and processing factories.

Measurements will be performed quarterly, or in other time intervals if needed. These measurements will be billed separately from the subscription service.

Sales and Marketing Strategy and Goals

We believe that the product offer will drive demand – once there is a commercially available solution for the notification and measurement of diffuse emissions, this will in turn increase adoption rates for the system. An important part of the sales and marketing strategy will therefore be to create a Proof of concept, firstly in the form of an emission alert pilot, and later as trial products for prospect customers.

The Norwegian Environment Agency (NEA) is a stakeholder in Norwegian environmental affairs, including pollution. We have a goal of keeping the NEA up to date with DetecDiff's achievements, capabilities and commercial availability. By establishing the availability of a commercial solution for measurement, this might lead the NEA to increase scrutiny on measurement and documentation of diffuse emissions, resulting in increased industry demand.

The customer segment consists of companies in the metal production and processing industry who are already procuring specialist services for measurement of diffuse emissions. Marketing will be directed towards decision-making units in companies which have diffuse particulate emission challenges. We have compiled a list of potential customers in the metal production, processing, and mineral industries (see Appendix A8).

We will first approach the metal production and processing companies located in Mo i Rana, due to their geographical proximity, cooperation during concept development, and due to already established relations with their decision-making units. By engaging MIP as collaborator and value-added reseller, we expect to be able to cover the whole industrial park.

Many of DetecDiff's proposed customers in Norway are part of European multinational corporations. Demonstration of successful product and collaboration in Norway will serve as entry point to the European market.

Expansion into other regions and business sectors is planned, and of these the mineral-based industry should be targeted first due to similar challenges that can be addressed with the DetecDiff solution.

Our goal is to have 14 customers by 2023 (~50% market share).

Table 1: Sales and marketing goals

Deadline	Task
January 2019	Proof of system concept trial at industry location (MIP)
January 2020	Delivery of service at MIP
August 2020	Delivery of service at Herøya Industripark
January 2024	Reach goal of delivering service to a total of 14 industrial clients

Product Development Strategy and Goals

DetecDiff will identify and secure manufacturing and product development partners in the European market. Suitable manufacturing and product development partners are being approached as we speak. Proof-of-concept development is of crucial importance for marketing and business development strategy.

DetecDiff is establishing contact with a software developer with AI capabilities, with the aim of engaging a key partner in the product development of Video Analysis software. Available partners are SINTEF Digital, Araani, Cognite and Cybernetica. Another possible key partner would be Detec, that have experience with implementing similar technology. Detec also has a history of cooperation with SINTEF Digital (Appendix A1).

An express product strategy goal is product innovation in the form of visual quantification of diffuse emissions. This rests on access to the following resources and expertise:

1. Accumulated data from video analysis coupled with measurement data
2. Big Data analysis resources
3. Measurement expertise

This innovation will make it possible to quantify diffuse emissions to a certain degree without performing on-site measurements. This will in turn expand DetecDiff's value offering to the clients, allow DetecDiff to increase its geographical range of operations (thereby servicing a larger segment) and lower DetecDiff's costs.

Table 2: Product development goals

Deadline	Task
October 2018	Partnership with VA software developer
January 2019	Proof of system concept at industry location (MIP)
January 2022	Use of multispectral cameras to monitor non-visible gases
January 2023	Proof of concept visual quantification of diffuse emissions

The data gathered can be used for further development of the product in cooperation with a mobile operator, for example Telenor, on integration of IoT connected air quality sensors (see future Business Model in Figure 3). This can provide more precise calibration of measurements or better data at locations exposed for emissions. Here, the mobile operator can act as a connectivity and device management provider (see Appendix A1). In the future business model, chemical analysis is also phased out, because the software should be able to recognise patterns and eliminate the need for chemical analysis.

To see the complete timeline of future development, see Appendix A9.

Business Development Strategy and Intellectual Property

Market research for suitable partners in Norway will be performed. After implementation in the Norwegian market, future expansion in the European markets will be considered. This depends on performing market research studies in European markets, to assess market demand for DetecDiff’s solutions.

Business structure and organisation will be determined. The software developer’s role in business structure needs to be clarified. The software developer controls key resources for new product development and establishing communication and access of information between DetecDiff and the software developer is imperative for successful product development. Securing the software developer’s engagement in the project may be best achieved through establishment of a joint venture where the software developer owns a stake in DetecDiff.

A Norwegian patent of the process, or part thereof, should be considered to protect DetecDiff’s competitive advantage as first mover in the diffuse emissions measurement market. Video detection of diffuse emissions may not be patentable due to the existence of video smoke detection, which may fall under the definition of closest prior art. A method for visual quantification of diffuse emissions may be patentable, which further asserts the importance of developing such a method.

Preliminary searches in patent databases Patentstyret and Espacenet, with keywords found in Appendix A10, have not turned up any patents likely to be infringed by DetecDiff. Further investigation can be done by SINTEFs partner Bryn Aarflot, that specialises in IPR services.

Financials

DetecDiff's capital requirement for product development is significant, seeing that it is still in a concept phase. It is also hard to estimate, as it involves considerable software development[6].

Assumptions and Comments

The assumptions and cost estimations that are as a basis for the income statement and cash flow forecast are given in Table 3.

Table 3: Assumptions and comments in cash flow forecast

	Assumption	Comment
Full Time Equivalents Needed	2 per year	Split between R&D and G&A
Average cost FTE	1 000 000 NOK	Assuming 1 per year
Emission measurement specialist costs	1 100 NOK per hour	During proof of concept stage
System integrator and hardware setup cost	10 000 NOK per assignment	
Camera	6 500 NOK per camera	4 cameras per single plant, 12 per industrial park
Drone and emission measurement spectrometer	313 000 NOK	
Drone operator training and certificate	55 000 NOK	For one employee
Office in co-working space	12 000 NOK per quarter	
Car lease	10 500 NOK per quarter	
Travel expenses	5000 per trip. Number of trips increasing with expansion of customer base	
R&D	2.50 MNOK	
Pricing		
For industrial park	200 000 NOK per quarter	3-year contract
For single actor	60 000 NOK per quarter	3-year contract
Additional measurement		
In industrial park	70 000 NOK per measurement	
For single plant	20 000 NOK per measurement	
Grants and support	4.66 MNOK	40% of total expenses the first 4 years

[6] https://azati.com/how-much-does-it-cost-to-utilize-machine-learning-artificial-intelligence/

Income and Cash Flow Statement

Table 4 shows estimated income and expenses for 2018-2022. Detailed cash flow for operations is listed in Appendix A6. First year with positive net income is 2021.

Table 4: Income and Cash Flow Statement

	2018	2019	2020	2021	2022	2023
Sales						
Total Revenue		0	1 620 000	2 640 000	3 280 000	3 920 000
Cost of Goods Sold	339 000	0	156 000	26 000	52 000	52 000
Gross Profit	**-339 000**	**0**	**1 464 000**	**2 614 000**	**3 228 000**	**3 868 000**
Operating Expenses						
Research and Development	250 000	1 000 000	1 000 000	250 000		
General and Administrative expenses	577 500	2 090 000	2 121 600	2 141 600	2 186 600	2 231 600
Total Expenses	**827 500**	**3 090 000**	**3 121 600**	**2 391 600**	**2 186 600**	**2 231 600**
Net Income Before Taxes (EBIT)	**-1 166 500**	**-3 090 000**	**-1 657 600**	**222 400**	**1 041 400**	**1 636 400**
Cash Flow						
Accumulated cash w/o External Funding	**-1 166 500**	**-4 256 500**	**-5 914 100**	**-5 691 700**	**-4 650 300**	**-3 013 900**
External financing	**466 600**	**1 236 000**	**1 311 040**	**967 040**	**678 440**	**0**
Accumulated cash w/ External Financing	**-699 900**	**-2 553 900**	**-2 900 460**	**-1 711 020**	**8 820**	**1 645 220**

Cash Flow Projections

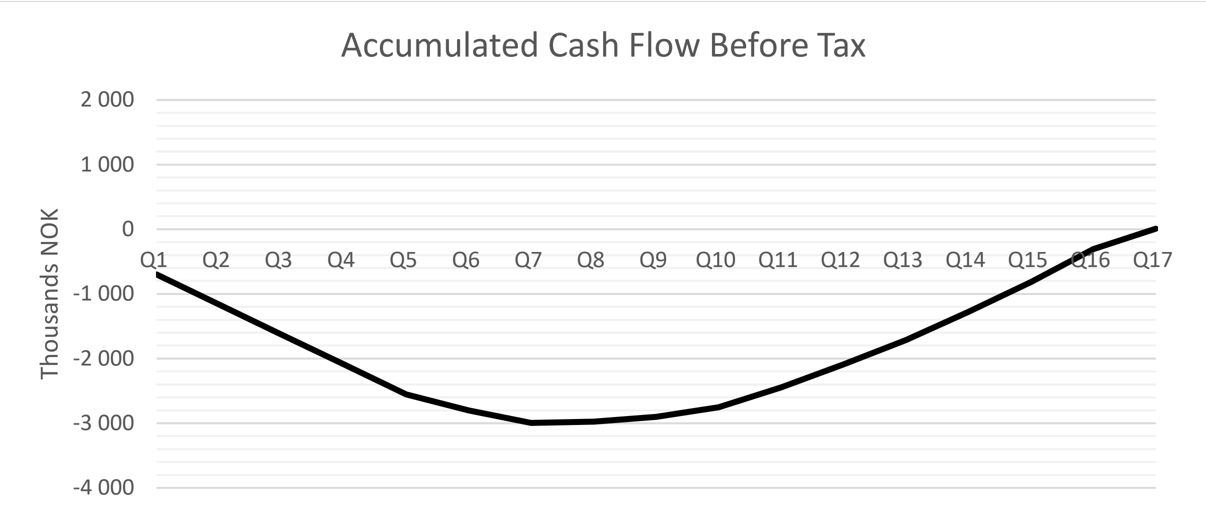

Figure 4: Accumulated cash flow before tax

Funding

In this project, funding will be crucial to gain profit. A list of relevant national and European funding schemes can be found in Appendix A5. Of these, Miljøteknologiordningen, Innovasjonskontrakter and Horizon 2020 is of particular interest. We would also recommend contacting the Norwegian Environmental Agency for advice and funding.

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Appendix

A1 Literature and technology

Processes that generate dust

The origin of the dust that the diffuse emissions consist of comes from may vary between the different metal producing and processing plants. Generally, metal is produced at very high temperatures, and the result is that some components in the melt will volatilise and enter the gas phase. The dust appears when the off-gases are cooled. This can happen inside of the furnace, when the furnace is tapped, or when the melt is poured between containers in the processing outside of the furnace.

When the metal is tapped from the furnace, there is often a vent that collects the exhaust and the dust, which then goes through a filter where the dust is collected. The tapping process is known to generate exhaust and dust, and measures are taken to collect this dust by using a vent and a filter. The same is often done at other processes known to generate dust, for example refining the metal. At other processes it can be difficult to have a vent, and the off-gases and dust goes up into the air and becomes a diffuse emission as it leaves the plant. These processes often involve pouring or casting of the melt, which means that the surface of the melts is larger as the metal is poured, resulting in a larger surface that reacts with air and produces exhaust and dust.

Artificial intelligence and image analysis

Artificial intelligence and machine learning is a growing field. As an example, a power company in Trondheim has hired students to use drone footage their power masts in order to detect various faults like woodpecker holes (Braathen, 2017). The students are developing a software that is able to detect these faults automatically through analysis of the images and machine learning. This way, the power company saves hours of manually work and inspection of these images. The results also show that the software is also able to detect faults that are not easily visible for the human eye. The students have started a company that has a goal of continuously monitoring, calculating and reporting of these kinds of faults. The company is called Sevendof AS (Sevendof AS, 2018).

In 2010, T.X.P. Zhao et al. published an article about an algorithm that uses satellite images to detect heavy dust and smoke plumes (Zhao et al., 2010). This algorithm could be used to early detect the outbreak of potentially hazardous dust storms that are bad for the environment. The challenge was to make the algorithm capable of detecting thinner dust and smoke plumes. In 2015, X. Li et al. published an article about a neural network-based system that used satellite images to detect smoke from forest fire. Through training and learning, the results showed that the algorithm was able to automatically detect both thick and thin smoke above land as well as over the ocean (Li et al., 2015).

Araani is a company that has developed and patented a video smoke detection method where an algorithm is trained to automatically detect smoke from fire and distinguish it from dust and vapor. Conventional smoke detectors need contact with the smoke to detect it, which can be a problem in large industrial buildings with high ceilings. The conventional method can be slow to react. Araani's software allows companies to use high resolution surveillance cameras to detect fire at early stages before a conventional fire detector would. The video detection method is also more reliable than conventional smoke detectors which can trigger false alarms. False fire alarms can in many industrial settings be very costly since the production needs to be stopped. The software automatically adjusts its sensitivity to increase the performance. When extreme activities take place, the software automatically lowers its sensitivity to prevent unwanted alarms. When nothing happens for a while, the sensitivity is increased, for example during weekends and holidays. The cameras with the built-in software send an alarm to the control room as well as an image to be monitored (Claerhout, 2017). On Araani's website, there are many video examples where the software automatically detects smoke that is barely visible for the human eye (Araani, 2018).

Another company that offers fire detection based on machine learning is Detec. They have developed an algorithm in cooperation with SINTEF Digital that processes data from thermal cameras to detect heat generation. Instead of cameras inside an industrial plant, they use overview cameras to have control over larger areas, like multiple buildings or even districts. The system offers an alert to the local fire department at an early stage. It combines thermal cameras to detect heat generation and a controllable PTZ (Pan-tilt-zoom) cameras that work both day and night so that an operator (fireman) can judge the risk of fire through Detec Next's user interface. This way, the fire department can consider an emergency before any action is taken. The software is developed for Norwegian weather conditions in cooperation with SINTEF and the Norwegian fire brigades. The software is capable of ignoring heat sources that are under control, like barbecues. Their system also has a way of dealing with privacy through advanced user management and limited access to the PTZ camera. Detec offer a complete package solution with everything from cameras, software, hard drives and databases that is ready to use as well as installation and advising (Detec, 2018)

Epigram is a company that helps their customers with understanding and adopting machine learning. They have in cooperation with Norwegian Institute for Nature Research (NINA) created a system that uses image technology to detect and classify animals on cameras in the wild. The software recognises for example a lynx and a deer to distinguish between the two. The pictures are sorted after species to make it easier for researchers to handle the incoming data. The image technology automatically detects humans and deletes pictures containing person sensitive data with people in them. This is an important part of the privacy of hikers. The system saves hours of works for the researchers that can concentrate on the information in the pictures, not sorting and deleting (Epigram, 2018).

Visual estimation techniques of dust

In the US, the US Environmental Protection Agency has developed standards for various industries on opacity. These standards require the use of Reference Method 9 or Reference Method 22 (US Environmental Protection Agency, 1993). These are methods on how to determine the level or frequency of visible emissions done by trained observers. The standards are from 1993.

(Du and Rood, 2009) has developed and tested a technique based on digital photography to determine the plume opacity. This is done during daytime as well as nighttime, and the report states that they are able to meet Method 9's requirements in both scenarios. To do this, they have developed a contrast-based and a transmission-based model for quantifying the plume opacity.

(Auvermann et al., 2013) has developed a method for measuring ground-level fugitive dust emissions from open-lot animal feeding operations by using digital cameras and contrast-based detection. By comparing the contrast of high-contrast objects at known distances on both upwind and downwind locations, one can detect such fugitive emissions at a low cost. They expect to predict PM10 concentrations within 20% accuracy of TEOMs which provides real time mass concentrations of particulate matter.

Laser measurements of diffuse emissions

One can also use optical remote sensing through laser to measure fugitive dust. E.D Thoma et al. describes a method to measure the fugitive emission flux with a multipath OP-TDLAS that is more cost efficient than an OP-FTIR. They use both vertical and horizontal retroreflectors along with a VRPM plane-integrated computational algorithm to directly measure the emission flux of methane through a two-dimensional plane, as shown in Figure 5 (Thoma et al., 2005).

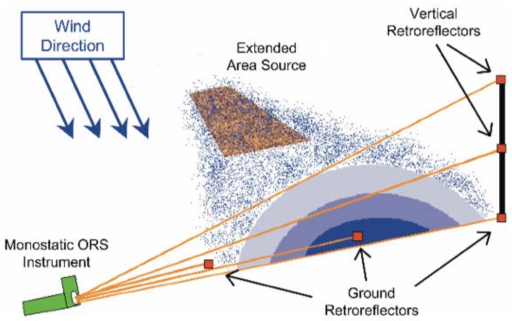

Figure 5: The setup used by E.D. Thoma et al. to measure mass emission flux (Thoma et al., 2005).

A method proposed by R.A. Hashmonay et al. use a setup with dust monitors in different heights to measure the vertical gradients of PM10 and PM2.5. These data are combined with wind monitors at the height of the dust monitors to measure the direction and speed of the wind. The data from the dust monitors are used to calibrate a laser at ground level, see Figure 6. They call this “an advanced test method for measuring fugitive dust emissions” (Hashmonay et al., 2009).

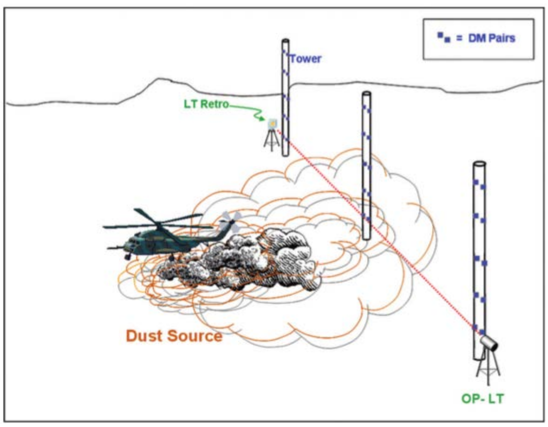

Figure 6: The advanced test method for measuring fugitive dust emissions from (Hashmonay et al., 2009)

Wireless sensor networks for air quality monitoring

S. Mansour et al. describes monitoring system for industrial and urban areas (Figure 7) that is easy to implement and offers event subscriptions, real-time alerting and long-time strategic planning. The system features a decision support system that analyses the data combined with historical data to predict future air quality. This can be used to for example optimised resource utilisation (Mansour et al., 2014).

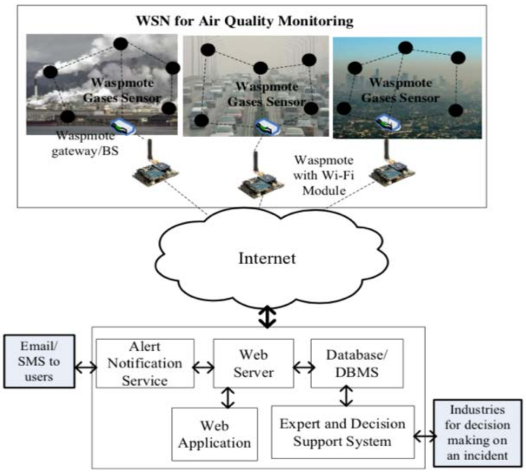

Figure 7: Air quality monitoring system developed by S. Mansour et al. (Mansour et al., 2014)

The mobile app, Air Matters (Air Matters, 2018), sends push notifications to the user's phone about the air quality in their local area. This is convenient for groups that are sensitive to pollen or people living in polluted cities like Beijing. From the information given by the app, the user can determine whether to use a mask or preventing the user from exercising outdoors. Air Matters specifies their measurements stations and data provided by luftdaten.info. On this website, there is a shopping list and instructions for assembling and installing online sensors for PM2.5 and PM10 measurement (OK Lab Stuttgart), available for everyone.

A study has been performed on such wireless sensor networks for monitoring air pollution (Leonhard Reindl, 2015), distinguishing between vehicle-based sensors, stationary sensors and community-based sensors. The article describes twenty state-of-the-art wireless networks for such measurements. As an example of stationary sensors, the article uses a conceptual deployment of sensors in Cambridge, Massachusetts (Murty et al., 2008). This concept was a project under development in 2008 where the sensors was proposed mounted on street light poles. As for community-based sensors, a system proposed in (Jiang et al., 2011) was based on mounting sensors on users. By the use of smart phones, the idea is to acquire, analyse and share air quality information. Another type of network, with vehicle-based sensors, is described in (Hu et al., 2009) where CO_2-sensors are mounted on vehicles to monitor the pollution over a large geographic area.

In February 2018, GSMA published a value generation guide for mobile operators based on advances in sensors, IoT platforms and mobile communications technologies. The report describes the challenge as well as business opportunities with customer segments and value propositions that comes with monitoring of air quality technology. A number of different roles and business models that mobile operators can adopt is proposed, including data product business, partnering business, platform business and 'new product' business (Figure 8). The different business models are referring four case studies that show how mobile operators can deliver IoT and analytics/big data services to address local air quality challenges (GSMA, 2018).

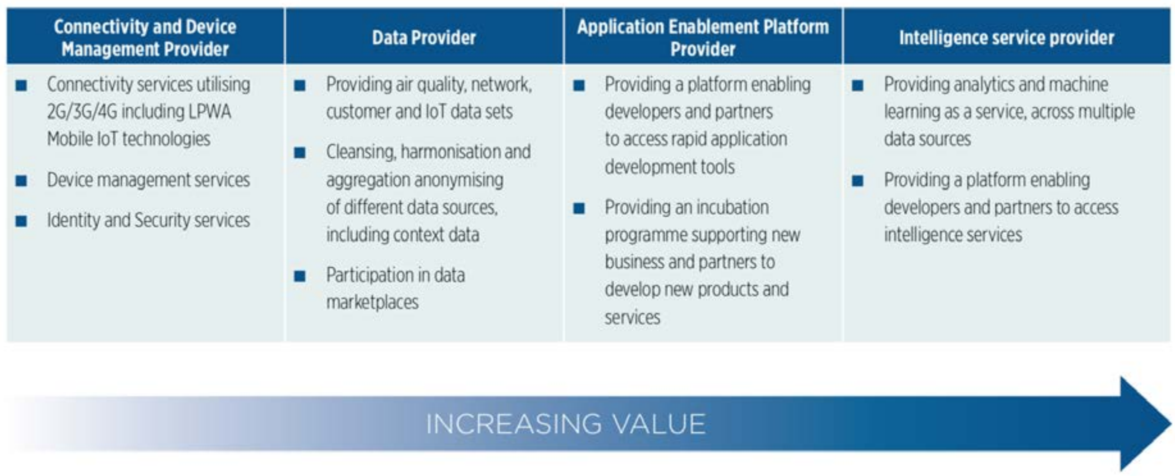

Figure 8: Business models and mobile operator roles in Air Quality Monitoring services (GSMA, 2018).

Multispectral cameras

In 2015, T. Lopez et al. describes a way of quantifying volcanic ash and SO_2 from a volcano eruption with a multispectral thermal camera (Lopez et al., 2015). In this article, they use an a priori particle size distribution model to achieve the total mass of ash for the size fraction below 50 µm. This allows them to quickly estimate the eruption size. The camera could be used for continuously monitoring and alerting nearby communities at larger eruptions. The errors are estimated to be around 20-50% for semi-transparent ash and 20% for SO_2. Future work will be focused on robust validation of total ash and SO_2 masses and fluxes and possibly better results for opaque plumes.

The company Parrot Drones SAS has developed a multispectral sensor originally for agriculture and inspection of crops that can fit all kinds of drones (Parrot Sequoia, 2018). MicaSense is another company that develops a rugged multispectral camera built for drones, at a slightly higher price than Parrot's (MicaSense, 2018).

A2 Osterwalder

Innovation Norway

Company Name: DetecDiff **Date:** 06.08.18

Navn på bedrift: **Dato:**

8 *Key Partners*
Partnere

- Software Development partner
- Drone and sensor supplier
- Systems Integration partner
- Data storage partner

7 *Key Activities*
Kjerneaktiviteter

- Monitoring of diffuse emissions
- Measurements of diffuse emissions

6 *Key Resources*
Ressurser

- Video Analytics software development
- Systems Integration
- Measurement tools and expertise
- Drone operation

2 *Value Propositions*
Verdiløfte

- Platform for insight into and measurement of diffuse emissions
- Provide aggregate data for best practice development

4 *Customer relationship*
Kunderelasjon

- Subscription service and contact through regular measurements

3 *Channels*
Kanaler

- Direct contact with DMU

1 *Customer Segment*
Kundesegment

- Metal producing and processing industry in Norway
- Mineral processing industry in Norway

9 *Cost Structure*
Kostnader

- Video Analytics R&D (rough estimate 2,5 MNOK)
- Measurement tool and drone (total 313 000NOK)
- Cameras (4 per customer, 6500 NOK per camera)
- Systems Integration (>100 000 NOK per year estimate)

5 *Revenue Streams*
Inntektsstrøm

- Subscription 800 000/240 000 NOK per customer per year (industrial park/single plant)
- Measurements 280 000/80 000 NOK per customer per year (industrial park/single plant)
- Est. Grants 4.7 MNOK

Figure 9: Osterwalder canvas (Source: Innovation Norway)

A3 Analysis

Stakeholder analysis

Table 5: Stakeholder analysis

Stakeholder Name	**Contact Person** ***Phone, Email, Website, Address***	**Impact** ***How much does the project impact them?***	**Influence** ***How much influence do they have over the project?***	**What is important to the stakeholder?**	**How could the stakeholder contribute to the project?**	**How could the stakeholder block the project?**	**Strategy for engaging the stakeholder**
MIP	Jan Gabor	Medium	High	Move towards a vision statement value creation through focus on environmentally friendly and energy-efficient solutions	Communicate with customers; logistical support; economical support; ownership of project as joint venture	Withdrawal of support	Monthly meetings
SINTEF Molab	Eigil Dåbakk	High	High	Capture emerging market of diffuse emission measurements	Ownership of project as joint venture	Withdrawal of support	Monthly meetings
Celsa	Per Johan Høgberg +4795935371 perjohan.hogberg @celsanordic.com	High	High	Emission control in a more restrictive political environment re: diffuse emissions; move towards "green" vision statement	Economical support; describe needs and goals	Withdrawal of support	Involvement in project development; Quarterly meetings
Alcoa	Maren Seljenes Bøe	Low	Low	-"-	Economical Support; describe needs and goals	Withdrawal of support	Involvement in project development; Quarterly meetings

Elkem	Jørgen Hjelle	High	High	-“-	Economical Support; describe needs and goals; technical support.	Development of competing solution	Involvement in project development; Quartely meetings
ACT	Monica Paulsen, Marianne Steinmo	Medium	Medium	Radical innovations in the industry Include local businesses in business	Provide meeting space for involved parties. Involve local companies.		Keep informed
Rana Kommune v/ Rana Utviklingsselskap	Allan Berg	Low	Medium	Public environmental concerns; Positive attention towards region	Tbd	Tbd	Keep in touch
Datatilsynet		Low	High	Privacy regulation concerns	Information about privacy law, regulation	Regulation	inform and show interest in keeping in line with privacy law
Rana Blad		Low	Medium	Sell newspapers Community engagement	Positive coverage Local Influence		Keep informed, Approach environmental concerns diligently Focus on local wealth creation
KPH	Monica Paulsen	Medium	Medium	Innovation and development in Helgeland	Networking, grant access, consultancy re: tax issues	No interest in blocking the project	Quarterly meetings; Project updates
SINTEF Digital	Helene Schulerud on Image Analysis +47 920 86 326	High	High	To have DetecDiff as a customer	Development of software algorithm	Not developing software algorithm	Pay for development of software
Detec	John Ekrem john.ekrem@detec.no	High	High	To have DetecDiff as a customer	Implementation of system	Not implementing system	Pay for system implementation

Avanti Engineering		High	High	To have DetecDiff as a customer	Implementation of system	Not implementing system	Pay for system implementation
Araani	Pieter Claerhout pieter.claerhout@araani.com	High	High	To have DetecDiff as a customer	Selling/leasing their software to DetecDiff	Not giving DetecDiff access to software	Address IP concerns Focus on new market possibilities for Araani
SINTEF / SINTEF Helgeland	Jack Ødegård	High	High	Insight in industrial challenges and by knowhow propose the good solutions	perform relevant R&D and ensure its industrial implementation (Innovation)	Restrict the needed knowledgebase	Continuous dialogue with industry stakeholders and promote relevant public support/funding mechanisms

PESTLE

Table 6: PESTLE Analysis

Element	Factor	Business Impact
Political	Greater focus on environmental impact	Increase in industry demand
Economic	Economic downturn, results can make industry prioritise environmental measures lower than today	Decrease in industry demand
Sociological	Greater environmental awareness and concern Greater awareness about negative consequences of particulate pollution	Pressure on industry to take visible steps towards emission reduction
Technological	Cheaper sensor technology Greater IoT sensor availability Data processing (AL/ML)	Increased competition
Legal	National and European regulations with greater focus on reducing particulate emissions Greater emphasis on reporting and documenting emissions Data protection laws Drone regulations get stricter	Greater industry demand for diffuse particulate measurement solutions Demand for solution that complies with Norwegian and European data protection laws, today and in the future Demand for solution that complies with local drone legislation; use of certified operators
Environmental	DetecDiff is dependent on the existence of industry that has issues with diffuse particulate emissions	Broad environmental concern, and lacking environment-friendly practice in industry, will both have a positive impact on DetecDiff's value offering

SWOT

Table 7: SWOT analysis

Strengths	Weaknesses
No competitor offers a product as integrated Skilled, knowledgeable staff in Molab with excellent industry contacts	Lack of proprietary technologies Lack of capital Unclear demand
Opportunities	**Threats**
Untapped market Emerging need for diffuse emission measurements Unclear regulatory environment Media coverage in Rana Blad Pilot/ proof of concept coverage in Teknisk Ukeblad and industry magazines	Competitors Customers develop internal solutions

Risk Evaluation

Table 8: Risk evaluation

Risk	Probability	Consequence	Actions
Poor performance against industry requirements	Medium	High	Focus on R&D activities and partners Focus on access to capital through funding
Sales progress more slowly than projected, resulting in liquidity challenges	Medium	High	Focus on marketing activities
Production costs increase significantly	Low	Medium	Procure alternative suppliers
Stronger competitors steal technology	Low	High	Seek legal advice Patent protection steps
Not being able to secure partnership with Video Analysis competence	High	High	Procure external contractor Seek partnership with academia (NTNU etc)
Willingness to pay is lower than expected	Medium	Medium	Reconsider business model Seek other segments (Offshore; other emissions) – R&D
Proof of concept project turns out unsuccessful	Medium	High	Focus on R&D activities and partners Focus on access to capital through funding
Failure to win funding	Low	High	Seek alternative capital
Industrial sites reduce emissions drastically	Low	Medium	Shift focus towards documentation of non-emissions

A4 Laws and regulations on camera surveillance and drones

Relevant regulations for camera surveillance are «Forskrift om kameraovervåking i virksomhet» (Lovdata, 2018).

Relevant regulations for commercial drone usage are "Forskrift om luftfartøy som ikke har fører om bord mv." (Lovdata, 2015).

Commercial usage of drones in RO2 category

To operate a RO2 drone the operator needs to obtain a licence from the CAA Norway, this is done by taking an online course and an exam (Luftfartstilsynet, 2018). The drone cannot be higher than 120 meters above the ground. The drone also has to have a system for fail-safe, meaning that it supports autonomous landing when connection to the pilot/operator is lost. For more information, see "Forskrift om luftfartøy som ikke har fører om bord mv.".

A supervisor on camera surveillance

When is it allowed?

To use camera surveillance, one has to have a clear reason to do so. It must be limited to a certain purpose and at the same time be necessary. The interest of using camera surveillance must be more important than the privacy of the people that are being monitored. There are more strict rules for collecting sensitive information related to for example ethnicity, religion and race.

Where is it allowed?

The camera surveillance must be performed at the business' own property. A business cannot monitor their neighbour's property without permission.

How should it be conducted?

The video cannot show more than what is relevant for the purpose, and the surveillance must be limited to the situations where the need is largest. If the camera is equipped with zoom and controllability, it must be reasoned.

How can the footage be used?

The business must have routines for who can watch the footage when situations occur, and how the personal data should be handled.

Information and deletion

The business must inform that camera surveillance is happening and who handles the information. This can be done by for example a sign. When the information is used proactively, the footage should be deleted with a reasonable interval. This time is usually one week, but the regulations can open for longer. This is clarified in (Lovdata, 2018).

Data security

The handling of data must satisfy the requirements for information security. The data must not get in the wrong hands, not get lost and must be accountable (time and place). When data is stored in the cloud, it must be secure and separated from other customers' data.

Authentication is important if the data is to be used outside the business. The data handling system must also support logging so that one can track activities from the past. This can be done by creating usernames and passwords for the involved users. The traffic also needs to be encrypted.

A5 Potential funding support

Table 9: Potential funding support

Name	What	How	Amount
Innovasjon Norge - Finansiering	Small and medium-sized companies New businesses and modernisation of existing businesses Greatest opportunities for businesses in the districts	Loan Guarantees Grants	
Innovasjon Norge – Koinvesteringsfond for Nord-Norge	For investors that will invest in young, innovative businesses in the north of Norway	Support for investors	
Innovasjon Norge – Såkornfond	For businesses in early stage with international ambitions Takes higher risks than other types of funding. Invests in businesses at the idea stage	Investment support	
Innovasjon Norge - SkatteFUNN	For projects that create value from new ideas		Up to 20% tax deduction on R&D
Innovasjon Norge – Innovasjonskontrakter	R&D cooperation between a business that develops a new solution and a business that uses the new solution Supplier – pilot customer relationship For high risk projects	Grants	

Innovasjon Norge - Miljøteknologiordningen	Public funding for the construction of pilot- and demonstration plants that exhibit new, more sustainable technological solutions than the currently conventional and used standards.		
Horizon 2020	For EUs priority on climate, environment, resources and raw materials Collaborative; need at least 3 partners		70-100% of project costs (typically 2-10 million Euros)
Forskningsrådet - FORNY	Programme for innovation and increased commercial application of public funded research Prioritise projects with high expected commercial and/or social return		Avg. 3.5 mill NOK
Forsknigsrådet - BIA	Funds projects that can create value for the business itself and the community		
Enova	Supports development of energy- and climate technology Their goal is to bring Norway towards a low emission society The funding goes to forward-looking measures that helps to reach the goal	Investment support	

A6 Cash Flow Forecast

Table 10: Cash flow forecast

	2018	2019				2020			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Cash Receipts									
Subscription						200 000	200 000	400 000	400 000
Measurement						70 000	70 000	140 000	140 000
Total sales	**0**	**0**	**0**	**0**	**0**	**270 000**	**270 000**	**540 000**	**540 000**
Grants and support	466 600	309 000	309 000	309 000	309 000	345 520	309 000	347 520	309 000
Total Cash receipts	**466 600**	**309 000**	**309 000**	**309 000**	**309 000**	**615 520**	**579 000**	**887 520**	**849 000**
Cash payments									
Product costs	339 000					78 000		78 000	
R&D									
Software development	250 000	250 000	250 000	250 000	250 000	250 000	250 000	250 000	250 000
G&A									
Wages	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000
Coursing costs	55 000								
Office Infrastructure	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Car Lease	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500
Travel Expenses								5 000	
Subcontractor services						13 300		13 300	
Total Cash Payments	**1 166 500**	**772 500**	**772 500**	**772 500**	**772 500**	**863 800**	**772 500**	**868 800**	**772 500**
Net Income Before Taxes	**-699 900**	**-463 500**	**-463 500**	**-463 500**	**-463 500**	**-248 280**	**-193 500**	**18 720**	**76 500**
Accumulated Cash Flow Before Tax	**-699 900**	**-1 163 400**	**-1 626 900**	**-2 090 400**	**-2 553 900**	**-2 802 180**	**-2 995 680**	**-2 976 960**	**-2 900 460**

	2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Cash Receipts												
Subscription	460 000	460 000	520 000	520 000	580 000	580 000	640 000	640 000	700 000	700 000	760 000	760 000
Measurement	160 000	160 000	180 000	180 000	200 000	200 000	220 000	220 000	240 000	240 000	260 000	260 000
Total sales	**620 000**	**620 000**	**700 000**	**700 000**	**780 000**	**780 000**	**860 000**	**860 000**	**940 000**	**940 000**	**1 020 000**	**1 020 000**
Grants and support	314 320	211 000	228 720	213 000	230 720	215 000	232 720					
Total Cash receipts	**934 320**	**831 000**	**928 720**	**913 000**	**1 010 720**	**995 000**	**1 092 720**	**860 000**	**940 000**	**940 000**	**1 020 000**	**1 020 000**
Cash payments												
Product costs			26 000		26 000		26 000		26 000		26 000	
R&D												
Software development	250 000											
G&A												
Wages	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000	500 000
Coursing costs												
Office Infrastructure	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Car Lease	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500
Travel Expenses		5 000	10 000	10 000	15 000	15 000	20 000	20 000	25 000	25 000	30 000	35 000
Subcontractor services	13 300		13 300		13 300		13 300		13 300		13 300	
Total Cash Payments	**785 800**	**527 500**	**571 800**	**532 500**	**576 800**	**537 500**	**581 800**	**542 500**	**586 800**	**547 500**	**591 800**	**557 500**
Net Income Before Taxes	**148 520**	**303 500**	**356 920**	**380 500**	**433 920**	**457 500**	**510 920**	**317 500**	**353 200**	**392 500**	**428 200**	**462 500**
Accumulated Cash Flow Before Tax	**-2 751 940**	**-2 448 440**	**-2 091 520**	**-1 711 020**	**-1 277 100**	**-819 600**	**-308 680**	**8 820**	**362 020**	**754 520**	**1 182 720**	**1 645 220**

A7 Marketing survey

Mail sent to relevant metal producing companies:

Vi jobber med et konsept som skal greie å detektere og måle utslipp (hovedsakelig støv). Med «diffuse utslipp» mener vi i denne sammenheng alle utslipp som ikke blir fanget opp av renseanlegg og som går gjennom åpninger i tak og vegger, samt spredning fra utendørs aktiviteter.

Vi retter oss hovedsakelig mot metallproduksjon- og prosesseringsindustrien. Vi er i kontakt med diverse smelteverk og relaterte bedrifter i Helgeland, men vil gjerne få et innblikk i bedrifters praksis over hele landet.

I denne sammenheng forsøker vi å kartlegge bedriftenes behov angående måling av diffuse utslipp, og lurte på om dere i <bedrift> kunne svare på noen spørsmål angående måling av diffuse utslipp.

1. *Måler dere diffuse utslipp? Hvis ja: Hvor ofte?*
2. *Hvor mye betaler dere for en måling av diffuse utslipp?*
3. *Tror dere at det blir skjerpede krav for rapportering av diffuse utslipp I framtiden?*
4. *Ville en løsning som advarer bedriften automatisk om når diffuse utslipp skjer være aktuell for dere?*
5. *Ville en løsning som automatisk måler diffuse utslipp være aktuell for dere?*

This was sent to the following companies on 18. July: Boliden Odda, Eramet Porsgrunn, Ferroglobe Mangan Norge AS, Finnfjord AS, Glencore Nikkelverk AS, Holla Metall, Stavanger Steel AS, Washington Mills.

Additionally sent to the following on 27 July: Rana Gruber, OMYA Hustadmarmor, NorFraKalk, Verdalskalk, Norcem Brevik, Norcem Kjøpsvik.

A8 List of relevant industrial companies in Norway

Table 11: List of relevant metal producing companies in Norway

Bedrift	Produkt	Hvor	Kontakt	Annet
Boliden Odda	Sink	Odda	info.odda@boliden.com	Boliden har 4 andre utenlandske verk
Celsa Armeringsstål AS	Armeringsstål	MIP, Rana	hans.skjaeran@celsanordic.com	Celsa har 7 andre smelteverk i utlandet
Elkem Bremanger	Ferrosilisium	Svelgen, Sogn og Fjordane	+47 57 79 61 00 Kontaktskjema: https://www.elkem.com/no/contact/?site=121#contact-location	Har ikke oppgitt epost, kontaktskjema ser ikke ut til å fungere
Elkem Rana	Ferrosilisium	MIP, Rana	+47 75 13 55 00 jorgen.hjelle@elkem.no	Annet: Elkem har et femte verk i Kina
Elkem Salten	Silisium	Sørfold	Kontaktskjema: https://www.elkem.com/no/contact/?site=617#contact-location	Har ikke oppgitt telefonnr eller epost, kontaktskjema fungerer ikke
Elkem Thamshavn	Silisium	Orkanger	+47 72 48 82 00 Kontaktskjema: https://www.elkem.com/no/contact/?site=608#contact-location	Ikke oppgitt epost. Kontaktskjema fungerer ikke
Eramet Kvinesdal	Silikomangan	Kvinesdal	+47 38 35 72 00	Har ikke oppgitt epost
Eramet Porsgrunn	Raffinerte manganlegeringer	Herøya Industripark	+47 35 56 18 00 elke.kummer@erametgroup.com	Epost fått per telefon Annet: Eramet har flere (20-ish) verk i utlandet
Eramet Sauda	Ferromangan	Rogaland	+47 52 78 50 00	Har ikke oppgitt epost
Ferroglobe Mangan Norge AS	Ferromangan og silikomangan	MIP, Rana	75123500 ole.jorgen.ostensen@ferroglobe.com	Ferroglobe har flere (25-ish) verk i utlandet
Finnfjord AS	Ferrosilisium	Finnfjord	firmapost@finnfjord.no 77 87 05 00	
Glencore Nikkelverk AS	Nikkel	Kristiansand	post@glencore.no	Glencore har 7 andre verk i Europa, og flere på verdensbasis

Holla Metall	Silisium og microsilica	Kyrksæterøra	+47 72 4506-00 post.holla@wacker.com	Holla er en del av Wacker (Silicones), som har 8 andre verk i utlandet
Stavanger Steel AS	Stål	Jørpeland	post@stavangersteel.no +47 51 74 34 00	
TiZir Titanium & Iron AS	Titandioksid og råjern	Tyssedal	+47 5365 2500	Har ikke oppgitt epost
Washington Mills	Silisiumkarbid	Orkdal	wamas@washingtonmills.no +47 5365 2500	Washington Mills har flere verk i utlandet

Table 12: List of some relevant mineral companies in Norway. List is incomplete,

Company	Product	Location	Contact
Rana Gruber	Iron concentrate, special products	Mo i Rana	rune.johansen@ranagruber.no (plant manager) nancy.schreiner@ranagruber.no (HSE)
OMYA Hustadmarmor	Paper filler from calcite	Elnesvågen	harald.natvig@omya.com (HR)
NorFraKalk	Quicklime	Verdal	glenn.hakon.bekkeli@norfrakalk.no (executive manager)
Verdalskalk avd. Hylla	Quicklime, slaked lime	Verdal	arnt.martin.storli@kalk.no (driftssjef)
Norcem Brevik	Cement	Porsgrunn	jorunn.gundersen@norcem.no (HSE)
Norcem Kjøpsvik	Cement	Kjøpsvik	annika.steien@norcem.no (external environment)

A9 Gantt diagram of proposed future development

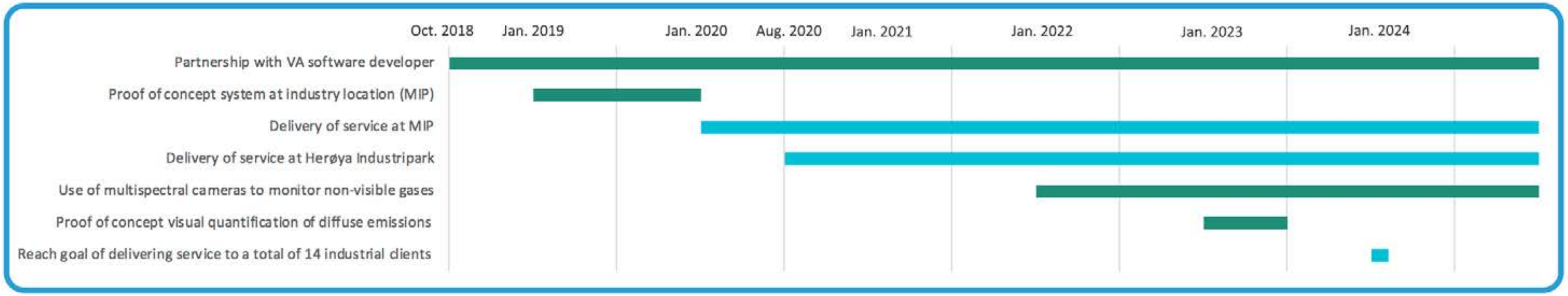

Figure 10: Future development

A10 Keywords used in patent search

Patentstyret

Keywords used in patent search:

Videodeteksjon
Video deteksjon
System for varsling
Video støv
Støv deteksjon
Støvdeteksjon
Utslipp deteksjon
Utslipp varsel

Espacenet

Keywords used in patent search (title and abstract):

Drone and spectrometer
Optical and emissions and measurements
video and emissions and measurements
video and diffuse and emissions
video and diffuse and emissions and measurements
dust and measurement