

Improving festival crowd safety measurability utilizing AI-enabled video surveillance analysis

Thesis subtitle

Master Thesis



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Date, year

By

Torben Albert-Lindqvist

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This thesis has been prepared over six months at the Section for Indoor Climate, Department of Civil Engineering, at the Technical University of Denmark, DTU, in partial fulfilment for the degree Master of Science in Engineering, MSc Eng.

It is assumed that the reader has a basic knowledge in the areas of statistics.

Torben Albert-Lindqvist - s233587

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Signature

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Date

Abstract

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Acknowledgements

Torben Albert-Lindqvist, MSc Civil Engineering, DTU
Creator of this thesis template.

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1 Introduction

1.1 Background and motivation

On June 30th 2000, nine young men lost their lives in a crowd crush during a Pearl Jam concert at Roskilde Festival in Denmark [1]. An uncontrolled surge, pushing the crowd towards the scene, caused immense pressure on the front most concert-goers, thrusting them against the barriers. The high-energy mass of people unknowingly trampled the victims, who succumbed under the pressure of the crowd. This incident is unfortunately not the only one of its kind, as crowd crushes continue to occur at mass gatherings around the world.

1.2 Problem definition

No matter the size of the event, crowd safety is a complex and multifaceted problem. No matter the extent of planning and preparation, the unexpected can still happen. Crowd safety professionals have an immense responsibility, as they are tasked with ensuring the safety of thousands of people. Large crowds are often unpredictable, and improper planning and/or response can lead to disastrous consequences. Fortunately, however, crowd safety professionals have a plethora of tools and knowledge at their disposal to help mitigate these risks and keep crowd dynamics within manageable bounds (see section 2.2).

Despite the available tools and established frameworks, current crowd safety management practices face significant limitations. A recurring theme identified through discussions with industry professionals is a heavy reliance on the experience and intuition of the safety team. Key decisions regarding venue layout, capacity planning, resource allocation (e.g., staffing levels and placement), and risk assessment of concerts often depend heavily on estimations derived from past events and anecdotal knowledge rather than objective, quantitative data specific to the event's context. While experience is invaluable, this reliance introduces subjectivity and potential inconsistencies. Calculations conducted for aspects such as stage layout or entrance/exit dimensions are often based on estimations made by the safety team, albeit these usually are adjusted to cover worst-case scenarios. Even these adjustments, however, are still limited by the imagination and, crucially, the past experiences of the safety professionals. This ultimately suggests that younger or less experienced teams may lack the extensive reference points available to seasoned experts, potentially leading to false assumptions and miscalculations. Consequently, the efficacy of safety planning can appear correlated with the cumulative experience within the team.

This complicated problem, has a seemingly simple and obvious solution: more objective data. At present, experiences and observations often go undocumented, as the safety team already has a plethora of responsibilities and tasks to attend to, not to mention the impossibility of having a full overview of the event at one given moment. Moreover, most music festivals are massively scalable operations, going from a relatively small team of full-time employees and contractors throughout the planning stage, to a massive team of volunteers during the event. In the example of Roskilde Festival, this culminates in a team scaled from over 100 employees to over 30 thousand. This drastic staff scaling certainly applies to the crowd safety department as well, potentially contributing to a lack of continuity and knowledge retention. This implies that immediately following the event,

or even after a given day, important observations and learnings from staff may be lost if not systematically documented. These factors effectively hinder a comprehensive, data-driven understanding of crowd behavior.

Furthermore, communicating the rationale behind safety decisions and requirements to other internal departments or external stakeholders can be challenging without clear, objective evidence. Provided that safety precautions are based on subjective assessments, conveying a need for specific resources or precautions can prove difficult. For instance, Roskilde Festival's safety team present a recurring challenge of convincing colleagues in the food and beverage department of concerns regarding the placement of food stalls or bars. Without the aid of clear evidence, Roskilde Festival's safety team occasionally find themselves dedicating valuable time and resources to justify their positions, at times even having to deviate from their core competencies to develop visual material to support their arguments.

These scenarios and limitations highlight opportunities for significant improvement, namely through the development and integration of technology capable of providing objective, measurable insights into crowd dynamics at music festivals. This thesis seeks to explore these opportunities, guided by the following hypotheses:

- Challenges in communicating crowd safety requirements and justifying decisions internally are often due to the subjective nature of current assessments, lacking objective, easily understandable evidence.
- The precision and efficacy of safety planning are constrained by a reliance on experience-based estimations rather than quantitative, historical data on actual crowd dynamics.
- The lack of a persistent, easily accessible digital record of crowd dynamics during an event limits post-event analysis, knowledge retention, and continuous improvement within safety teams.

1.3 Brief history of Fluxense

Together with two classmates, I founded a startup, Fluxense, in January 2024. Our initial plan was to solve the crowd safety challenges of music festivals, as presented in section 1.2, by developing an AI-enabled system for monitoring existing CCTV infrastructure to provide automated analyses of crowd behavior. We gained traction quickly, with several large festivals expressing their interest in our proposed product. Development began almost immediately, and we held our first prototype test at DTU's Commemoration Day, where we provided a live count of the number of people in the concert hall. The test gave great results, as well as valuable learnings, and became the first of many. The following summer was very busy, as we attended three of Denmark's largest music festivals – Copenhell, Roskilde Festival and Smukfest – to further test and develop our product.

After the summer, we stood at a crossroads. Our collaborations with the different festivals had revealed that each had their own unique requirements, and the value of our product was not as clear-cut as we had initially thought. We feared that crowd safety was not a large enough market for scaling our business, nor that a generalized product would be attractive in the industry. We decided to pivot, and began exploring other markets where our technology could be of use. We gradually moved away from our initial focus on crowd safety, and found business intelligence to be a much larger and lucrative market. Instead of monitoring crowds, our new product would track individual customers in retail stores, transportation hubs, amusement parks, and museums. We aimed to provide insights into

places/products of interest, dwell times, conversion rate, footfall analysis, etc., to help businesses optimize their operations.

As the autumn progressed, we began securing new collaborations in our target industry, and our value proposition became clearer. One important thing had been lost in the process, however: our motivation. We had started Fluxense with the goal of improving crowd safety at music festivals, as it was a mission we shared a passion for. Our new focus on business intelligence made sense fiscally, but didn't evoke the same feeling of purpose. Fluxense ended up dissolving in the winter of 2024/25, as we couldn't see ourselves in the startup's new reality, and struggled to find a common vision.

1.4 Scope and purpose statement

This thesis continues approximately where Fluxense left off before the pivot. However, rather than following the path laid out by the startup and striving to develop a scalable commercial product, the purpose of this work is to create a tool that directly aids crowd safety managers at Roskilde Festival. This is partially due to our already close collaboration throughout the entirety of 2024, as well as their expressed interest in continuing our collaboration through this leg of the project. Additionally, it is the largest music festival in Northern Europe, attracting over 130 thousand guests each year [2]. With considerable prestige in the industry, as well as a passionate dedication to improving crowd safety, Roskilde Festival is an ideal partner for this project.

It is important to note that the majority of crowd safety practices presented in this thesis are gathered through discussions with Roskilde Festival's safety team. While occasional references may be made to interactions or insights gained through collaborations with other festivals, these are included solely to illustrate the broader landscape and are not indicative of the project's applicability beyond Roskilde. These findings are also assumed limited to a Danish context, as all discussions with crowd safety professionals were with Danish festivals. Additionally, it was observed during these consultations that some prominent experts occasionally presented viewpoints that could be interpreted as subjective or opinionated. However, as the explicit goal of this project is to provide a functional tool for Roskilde Festival's specific operational environment, a critical evaluation of the objective validity of these statements falls outside the defined scope and is not deemed essential for achieving the project's objectives.

In summary, the purpose statement of this project is as follows:

To enhance Roskilde Festival's crowd safety management by developing an intuitive, data-driven platform that provides actionable insights into crowd dynamics (such as density, flow, and movement patterns), thereby improving planning, internal communication, and documentation for the safety team.

1.5 Objectives

Formalizing the hypotheses presented in section 1.2, the business objectives of this project are as follows:

- 1. Improve internal communication:** offer clear, visual, objective evidence to help the safety team communicate requirements and justify decisions to other departments.
- 2. Enhance safety planning:** provide quantitative, historical data on crowd dynamics to enable more accurate planning of layouts, capacities, resource allocation, and facility placement.

3. **Create reliable documentation:** Generate a persistent digital record of crowd dynamics for post-event analysis, debriefing, and knowledge retention.

1.6 Thesis structure

In their book, *Design Science*, Hubka and Eder characterize the design process as intuitive, iterative, innovative, unpredictable and reflective [3]. While these aspects are inherent to design, tackling complex engineering challenges requires more than intuition and creativity alone. To manage the process effectively, ensure thoroughness, and facilitate clear understanding and traceability, a structured approach is beneficial [4]. Therefore, the process needs to be organized, drawing upon established product design methodologies and frameworks to guide this project. Many such frameworks exist, offering different levels of detail and focus. This section will explore the most relevant frameworks, and propose a design and development methodology for this project.

1.6.1 Comparison of frameworks

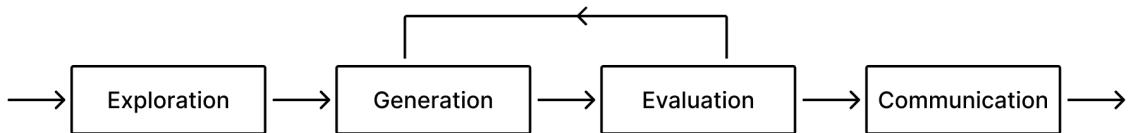


Figure 1.1: Cross' four-stage model of the design process

Cross [5] proposes likely the most simplistic, yet well-known framework: a four-stage model comprised of *exploration*, *generation*, *evaluation* and *communication* (Figure 1.1). Cross describes this type of model as descriptive, as it merely attempts to model the conventional, heuristic design process. More detailed models of this type exist, such as French's [6] "anatomy of design," (Figure 1.2) detailing four stages, most distinctly underlining the problem analysis and definition, as conducted in section 1.2. According to Cross, these models differ from prescriptive models, which offer a more systematic procedure, as well an emphasis on analyzing and understanding the design problem before generating solution concepts. Perhaps the most well-known of these is offered by Pahl et. al [7], and is based on the following design stages: *clarification of the task*, *conceptual design*, *embodiment design*, and *detail design*. Combining the aforementioned models, Ulrich and Eppinger present a rather comprehensive framework. Their process is based on the following stages: *concept development*, *system-level design*, *detail design*, and *testing and refinement* [8].

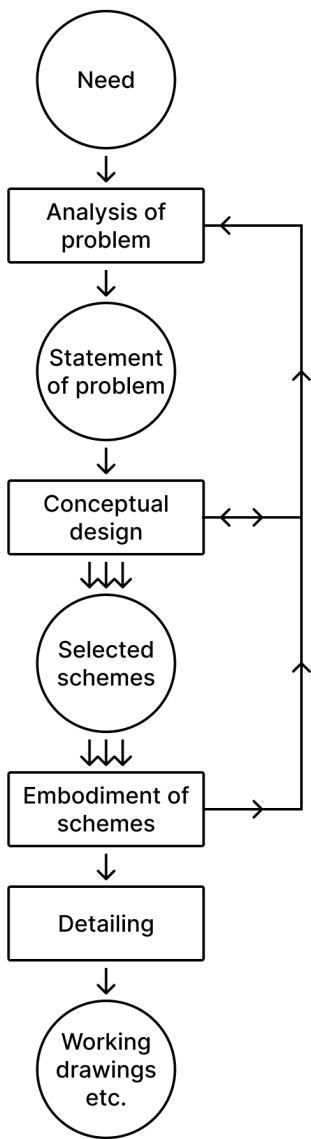


Figure 1.2: A block diagram illustrating the design process according to French. The circles represent stages reached, and the rectangles represent work in progress.

These frameworks provide varying degrees of structure and granularity to the design/development process, but all share the commonality of being highly engineering-focused. In engineering a physical product, a rigid, structured process is often necessary as each iteration must be designed, manufactured and tested. This is costly, both in effort and material costs. Therefore, the design and development process are divided and sequential. Software, on the other hand, is much more flexible, with iterations being a magnitude faster and cheaper to develop. This demonstrates a need for adapting the design/development process to the context of the product being developed. Conveniently, Ulrich and Eppinger present a multitude of adaptations to their framework, including what they refer to as "Quick-Build Products" and "Digital Products." Here the *detail design and testing and refinement* stages are omitted, and replaced with a cyclical design-build-test process. Whereas the linear, rigid processes described previously are labelled as "waterfall

methods”, this iterative process is most often referred to as *agile development*.

Agile development has many benefits in contrast to the waterfall approach, especially in the context of software development. As mentioned previously, the waterfall approach is ideal for engineering projects where prototyping is costly. When the cost of prototyping is negligible, however, agile methodology grants the flexibility to iterate quickly, and adapt to evolving requirements. Design and development are sequential in a waterfall model; here they are heavily intertwined. A strong example of this, as well as being the most popular implementation of agile development, is *Scrum*. Scrum defines the following stages: *sprint planning*, *daily stand-up*, *sprint review*, and *sprint retrospective*, with a sprint typically lasting 2-4 weeks [9]. This framework is ideal for large teams, as it ensures that all team members are aligned, and are able to coordinate their efforts efficiently. The daily stand-up is a particularly useful tool for larger teams, preventing overlapping work, or potential blockers from being overlooked. In smaller teams, however, this structure can be cumbersome, and potentially even counterproductive. Especially when considering this project, exploring a singular use-case as a solitary developer, the full-scale implementation of Scrum is evidently not necessary. Instead, a more adaptable and lightweight framework is employed.

In his book, *The Lean Startup*, Eric Ries describes a simple, yet effective agile framework, which he refers to as the *Build-Measure-Learn* loop [10]. This framework is designed for rapid prototyping and iteration, splitting each stage into *build*, *measure* and *learn*. *Build* involves developing a minimal product or feature, which is then tested with the target user(s) in the *measure* stage. The results of this test are then studied in the *learn* stage, where the product/feature is adapted based on these results. This process is then repeated, until the requirements are met. This framework is ideal for this project, as it is quite exploratory in nature, while still aiming to fulfill predetermined requirements.

1.6.2 Design and development methodology

Building upon the exploration of frameworks conducted above, the following design methodology is proposed for this project. The design stage follows an engineering approach, guided by Ulrich and Eppinger’s *concept development* and *system-level design* stages. Subsequently, the development stage is based on a more agile, entrepreneurial approach, as described by Ries. Standing in for the *detail design* and *testing and refinement* stages, Ries’s *Build-Measure-Learn* architecture is employed in order to facilitate rapid prototyping and iteration, albeit with a slight augmentation. The *measure* and *learn* stages are consolidated through periodic feedback sessions with Roskilde Festival, where implemented features are reviewed and emerging requirements are gathered. This eliminates the implied analysis between these two stages, as this project is developed in close collaboration with the target user, and its usage is not intended for a wider audience.

Chapter 2, **Concept Development**, ultimately selects and proposes a conceptual solution to the problem outlined in section 1.2. As defined by Ulrich and Eppinger, a concept is “a description of the form, function, and features of a product and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project.” [8] This selection is initially preceded by a thorough inspection into the intricacies of crowd safety management, as well as a review of potential solutions and existing products. A novel solution is thereafter presented, outlining requirement specifications, as well as its technical, legal, and financial feasibility.

Chapter 3 focuses on the **System-level Design**, including the definition of the product architecture, and a decomposition of the product into subsystems and components. The

full workflow from data collection to the resulting user interface is presented, followed by a detailed description of each sub-system, including the data collection, computer vision model, spatial mapping, metric extraction, and the user interface/frontend.

Finally, Chapter 4 presents the **Results** of the development stage, beginning with a showcase of the frontend, including an overview of the iterative feature selection conducted in accordance with the augmented *Build-Measure-Learn* framework. This is followed by a technical performance evaluation, describing the accuracy of the solution. The chapter concludes by revisiting the business objectives outlined in section 1.5, and evaluating the product's business value. This includes a summary of a workshop conducted with Roskilde Festival, where the final product was presented and tested by members of the safety team.

2 Concept Development

2.1 Revisiting the problem definition

2.2 Understanding crowd safety management

In order to develop a solution that supports crowd safety professionals, it is imperative to understand how they operate, and what tools they currently have at their disposal. Together with my co-founders at Fluxense, we conducted interviews with many crowd safety professionals from various different organizations, including Event Safety (Smukfest), smash! bang! pow! (Syd for Solen), Roskilde Festival, and Live Nation (Copenhell, Heartland) – see appendix A.1 for meeting notes. Throughout this period, it became clearer that crowd safety management is very complex, and is almost as much a philosophy as it is a science. Music festivals and events vary greatly in size, participant demographics, venues, and budget. Equally varied are the crowd safety professionals themselves, who appeared to have varying levels of experience, as well as distinct approaches to their work.

Most interestingly, the greatest discrepancy was seemingly between a focus on incident-prevention and incident-response, or "crowd safety vs. security", as according to Roskilde Festival's Director of Safety, Morten Therkildsen. A security-focused approach often involves less planning, as well as hiring third-party professionals to handle safety during the event. Safety-focused teams, on the other hand, spend most of the year leading up to their events meticulously planning initiatives to ensure the well-being and enjoyment of their guests. The distinction between these two protocols was apparent throughout Fluxense's collaborations with both Copenhell and Roskilde Festival. At their 2024 events, Live Nation had two full-time employees responsible for crowd safety at Copenhell, whereas Roskilde Festival had a team of 10+ full-time employees.

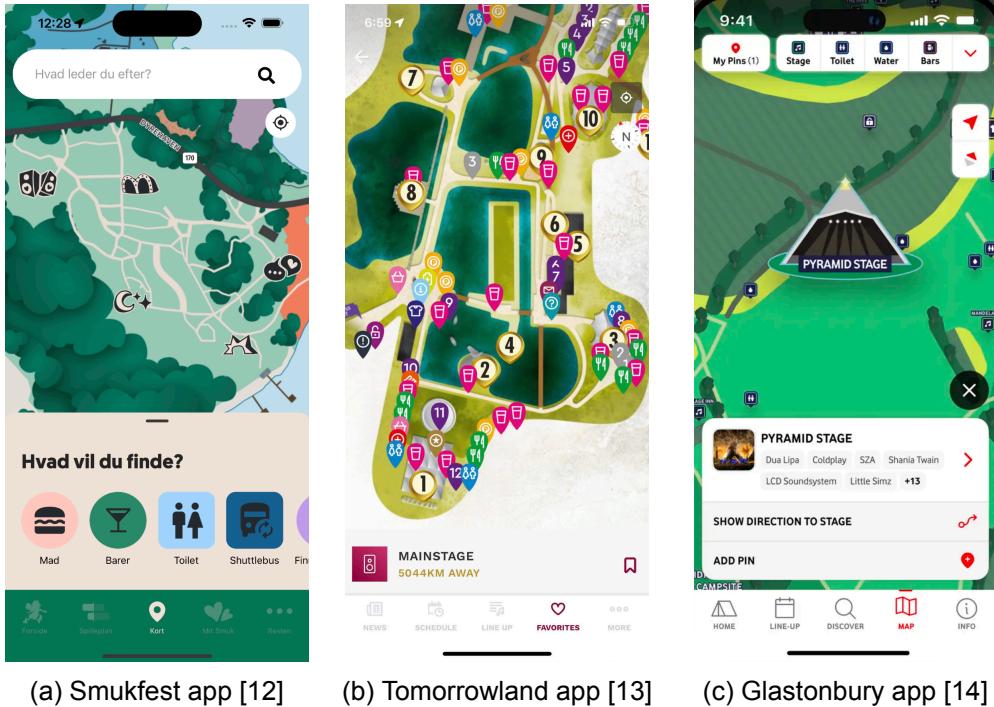
2.2.1 Existing frameworks and workflows

2.2.2 Key metrics

2.3 Comparing technical solutions

2.3.1 Global Positioning System (GPS)

Using GPS to track the location of festival-goers is a common practice, and likely the easiest to implement technology in this comparison. This is typically achieved by providing guests with a mobile app that uses their smartphone's GPS to track their location. Of course, this requires the guests to opt in to location tracking, as well as there being a sufficient reason for doing so. In almost all cases, this is attempted by including a map of the festival in the app, as visible in Figure 2.1. This feature, however, still functions without location tracking, and therefore doesn't guarantee users will grant data access. Even before this obstacle is met, there is the question of whether festival-goers will actually use the app. A study on Roskilde Festival 2015 by the Copenhagen Business School found that of the 60 thousand people who installed the festival application, 44 thousand opted-in to allowing anonymous tracking; yielding 38.678 unique users who were present inside the festival area [11]. This equates to slightly under 30% of the total 130 thousand attendees. In a crowd safety context, this is a significant limitation, as the location data gathered is not representative of entire crowds.



(a) Smukfest app [12]

(b) Tomorrowland app [13]

(c) Glastonbury app [14]

Figure 2.1: Examples of map features in music festival mobile apps (Smukfest, Tomorrowland, Glastonbury), often used to encourage attendees to enable GPS location tracking.

Beyond low adoption and potential privacy concerns, the technical limitations of GPS also hinder its utility for detailed crowd analysis. According to GPS.gov, GPS-enabled smartphones are typically accurate only to within a 4.9 m radius under open sky; however, their accuracy worsens near buildings, bridges, and trees [15]. While a 4.9-meter radius might seem acceptable for general location awareness on a festival map, this level of uncertainty significantly hinders the calculation of precise crowd dynamics metrics. Furthermore, the degradation of accuracy near structures is particularly problematic in festival environments, which often feature large stages, tents, and temporary structures – precisely where accurate monitoring is most needed. The effectiveness of GPS tracking is also contingent on factors outside the organizers' control, such as users keeping their phones charged and maintaining a stable mobile data connection.

Compared to infrastructure-based monitoring systems (like cameras or dedicated sensors), GPS relies heavily on user cooperation and device functionality, making it less suitable for generating the consistent, high-resolution data needed for proactive crowd safety management and detailed post-event analysis. Therefore, while mobile app GPS data can offer some high-level insights into general attendee distribution, its inherent limitations in accuracy make it insufficient as a primary tool for gathering crowd dynamics measurements.

2.3.2 Bluetooth beacons

Another potential solution for gathering crowd dynamics data involves utilizing Bluetooth Low Energy (BLE), a wireless communication technology designed for low power consumption. This technology is typically utilized in Bluetooth beacons – devices that periodically transmit signals that can be detected by nearby receivers, such as smartphones or dedicated hardware. These signals can be used to determine the proximity of beacons to the receivers, as well as location estimation through triangulation techniques, requiring

three or more receivers. This capability is increasingly utilized for proximity marketing, indoor navigation, and positional tracking, typically in retail environments [16]. It has also been effectively used for guest tracking in environments like museums, as demonstrated in a study at the Galleria Borghese, where visitors were given portable BLE beacons tracked by fixed receivers [17].

Finding examples of BLE beacons utilized at large outdoor events is more challenging, as the technology has its own set of drawbacks. Similar to GPS-based mobile apps, the effectiveness of Bluetooth beacon systems is significantly contingent on user cooperation. Beacons can be implemented either as dedicated physical devices or embedded within smartphone applications. The latter is simpler and cheaper, however motivating users to install an app is challenging, as discussed in section 2.3.1. The former approach has challenges of its own, as requiring event participants to carry a dedicated device demands a value proposition of its own, not to mention the overhead costs involved in developing, deploying, and maintaining the system. Given that beacon signals have an effective range of 30 meters without obstructions, a considerable number of receivers are necessary to ensure adequate coverage [16].

Ultimately, the most critical factor for crowd dynamics analysis is the technology's accuracy. A study conducted at a large exhibition in Japan evaluated the accuracy of trajectory estimation using Bluetooth beacons. They found that in 68% of instances, their positional estimates were accurate within a radius of 18 meters [18]. While still useful for certain applications like indoor tracking or general zone classification, this level of accuracy is significantly less precise than typically achievable with GPS (section 2.3.1). This limitation, combined with the dependency on user adoption and implementation costs, makes Bluetooth beacons a less favorable option for gathering crowd dynamics data at large outdoor events.

2.3.3 Camera solutions

Camera-based solutions leverage existing CCTV systems in conjunction with computer vision algorithms to analyze crowd dynamics. Utilizing video footage from these camera systems, novel advancements in machine learning and computer vision enable automated extraction of valuable metrics.

A primary advantage of this approach compared to GPS (Section 2.3.1) and Bluetooth beacon (Section 2.3.2) systems is its independence from attendee cooperation. Unlike solutions requiring festival-goers to install an app, enable location services, carry a specific device, or keep their phones charged, camera-based analysis operates passively. It gathers data from anyone within the camera's field of view, potentially offering a more comprehensive and unbiased view of crowd behavior across monitored areas. This circumvents the significant limitations associated with low adoption rates and opt-in requirements inherent in user-device-dependent methods.

(competitor analysis)

2.4 Proposed solution

2.5 Feasibility of solution

2.5.1 Technical feasibility

2.5.2 Legal feasibility

When dealing with CCTV footage, there are a number of legal considerations to take into account.

2.5.3 Financial feasibility

3 System-level Design

3.1 Product architecture

3.2 Sub-systems

3.2.1 Data collection

Data collection is the vital first step in the system, as it provides the raw data needed for all subsequent processing and analysis. This process involved on-site deployment of designated cameras, strategically positioned to capture the crowd dynamics of interest.

The selected cameras were Reolink RLC-520A, which are PoE-enabled (Power over Ethernet) and capable of recording 5MP (2560x1920 pixels) video at 30 frames per second. Powering the cameras required a separate PoE switch (Ubiquiti PoE++ Adapter), which was connected to a standard power outlet. Mounting the cameras was achieved with 3D-printed brackets, designed to securely attach the cameras to existing infrastructure, such as fences or poles. In cases where existing structures were not available, aluminum poles were brought to provide sufficient height in order for the cameras to capture the entirety of the desired area.

As agreed upon with Roskilde Festival's safety team, the cameras were installed around the Eos stage during the first three days of the festival, and subsequently moved to the Arena stage for the remainder of the festival.



Figure 3.1: Camera placement at Eos stage, with approximate field of view (FOV) indicated.



Figure 3.2: Camera placement at Arena stage, with approximate field of view (FOV) indicated.

3.2.2 Computer vision model

Annotation

3.2.3 Spatial mapping and GIS

3.2.4 Metric extraction

3.2.5 Interface/frontend

4 Results

- 4.1 Frontend showcase**
- 4.2 Technical performance evaluation**
- 4.3 Business value**

5 Conclusion

- 5.1 Summary of results**
- 5.2 Market expansion opportunities**
- 5.3 Technical challenges and lessons learned**
- 5.4 Technical improvements**
- 5.5 Closing remarks**

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A Appendix

A.1 Roskilde Festival meeting notes

A.1.1 February 16, 2024

Roskilde currently uses GPS phone signal to get overview of guest counts through their app. Updates every 15 minutes to get a signal. Greentel system, the function is called CrowdView.

Morten says there are many systems available, but all come with a disadvantage - in Denmark, they don't use many cameras, as they are expensive to set up. On top of that they need to move them and this ~~fu**~~s up the analysis done by cameras.

****Morten tested DCM****, they use a grid-like approach to calibration of cameras. It can tolerate some camera movement but not much.

- Greatest value of DCM is in his eyes is the after-analysis of events. For example to see how their barrier design influences flow.
- How fast can a scene get emptied, what is the flow of people from A to B. How fast can a scene fill up and what are the connections to the temporal aspects of the show (concert starting etc.)
- NOT interested in real time analysis - not even in front of stages, as there are plenty of people there present as ground crew and they can tell.
- Sometimes, the crowd issues happen outside of view of cameras (example of Ukendt kunstner concert at Arena stage) far away from stage

It is crucial to build this product/app/function in collaboration with educated crowd management professionals, and the accuracy of reporting is key. Following the current industry standards of flow estimation, density calculation in pre-planning of venues. Otherwise he will NOT use it.

DCM is used at Silverstone in areas where they know they have issues with crowd flow as an analysis tool.

Morten says, psychology of people has changed after corona - They go much more to concerts and they are more hesitant to stand close together.

****Festivals are scaling operations**** - during festivals they have a lot of employees, after festival everybody leaves and with that also knowledge of what was done last year. Creating documentation of layouts, crowd management plans and general analysis of how things were will be of great value.

The Police does security - preventing harm where there could be intent of harm
Roskilde does safety - Accomodating people so there is no harm in first place
Safety is about creating risk assessments for possible situations.

****Communication:**** two separate channels 112 for emergencies and 114 for internal communication. They use VHF and Whatsapp groups. Sometimes phone signal is an issue.

Mads Therkilsen is responsible for flow analysis, and early in researching how AI tools can help with crowd management. (feeding existing information about venues to the ...model..)

We will receive contacts to people from england doing Crowd Science. Keith Still - mathematician with focus in this field.

Takeaway is - analysis is more important than real time insights
RF meeting February 16, 2024

A.1.2 March 10, 2024

Crowd management and crowd safety is something some companies do, and some don't. In any case, to get licensed to make an event, you need to follow standard guides for a risk/event safety assessment that is submitted to the police. Issue is, the standard guide is very high-level and 'doesn't go in depth of what the actual safety plan is. Therefore, things are up for interpretation.

LiveNation 'doesn't plan, and they probably 'don't have the capacity or knowledge to do it either - their safety management is security focused, hiring people to manage things on the go on the ground as they develop. Sometimes, Roskilde offers some small planning if they are participating, however only internally.

Roskilde goes one step further by developing a Venue Manual for each stage/area of the festival. What they are interested in is understanding where people flow in from and mapping risks caused by these flows. They want to have a good understanding of what the flow of people over the whole venue is. People at every festival are different - at Roskilde they are younger, active, move around a lot and see many concerts.

UK is on the forefront of crowd management because they are a fucked up country with many problems, so they have to invest into it.

This summer, Roskilde only provides manpower on ground for Copenhell, no planning. Us making a plan for LiveNation / Copenhell since they don't have people that can do it?

Roskilde makes a **risk assessment for every single concert** - Starting with talking to bookers to understand what kind of a concert it will be (qualitatively speaking). After that, they research the band and do a **Band analysis** (what is the level of popularity/publicum attraction, what sound level they play at, what is the demographic). They try to see if they need to prepare for particular **crowd dynamics** (if the band causes moshpits or storming of the stages to happen etc.) **Crowd types are outlined by Berlongi** [-Crowd types (Berlonghi 1995/EMA 1999) | Download Table (researchgate.net)](https://www.researchgate.net/figure/Crowd-types-Berlonghi-1995-EMA-1999_tbl2_224911893)

They are building a database of bands and concerts to refer to. Word files with filled out features of the band/concert. Can we digitalize/log this data in our product?

Work flow:

Band Analysis > Risk Assessment > Concert Colour (red, green, yellow)

DJ sets are the most unpredictable.

Density mapping is very interesting. Where people leave and at what time, what direction. Setting up more cameras is only a problem when they are CCTV due to cost. Regular cameras is not a problem.

As planners, they have to decide based on their knowledge and intuition what densities are acceptable. There are EU guidelines, but in the end high

densities are okay as long as people are having fun at a good concert.

They look at live camera footage to see if there is a crowd collapse, if people are ...happy This is included in post evaluation.

Old collaboration with IBM was not good. They were trying to link data from cash registers, spending and concert types/bands to find correlation (Or was this what they wanted from them but didn't get???)

DCM - Cameras cant move to work. They have to be calibrated, and the data outputs you get from it depend on the inputs you give it for raising alarms = too much work for the event organizer, a lot of effort into setting up of the software.

Morten spends time looking at CCTV footage even after festivals.

What would you change if you had the product/analysis - Calculating number of emergency exits, which areas to close off and at what time. Staff allocation - better placement of people on ground in preparation of influx of crowds. Proving their theoretical knowledge with real data.

Roskilde spends approximately 600.000DKK every year on cameras. For places like Royal Arena, this is more of a one-time cost.

They follow the Event Safety Guide and the purple guide [The Purple Guide](<https://www.thepurpleguide.co.uk/index.php/the-purple-guide>)

[The+Event+Safety+Guide.pdf](Roskilde%20Festival%20c0150926974744a3a5d39167c77340a2/TheEventSafetyGuide.pdf)

For planning of Roskilde festival, they use GIS map tool (Its also used by the emergency response departments). They can import AutoCAD drawings. Its a map of all services in one place. When they go out and build on site, they pay a land surveyor to map out the whole venue with accurate GPS coordinates. This must be really fucking expensive to do for such a large venue!!!!

Moving onwards - Contact DTU about GDPR and-or non-disclosure agreement for data processing. Create data risk assessment for data processing. Roskilde contacts us back if they have a GDPR data agreement / data transfer agreement .

What problem is being solved by our product? No clear problem being solved. Feedback on redesign of barriers, Less staffing, and staffing on time where it needs to be.

Business talk from Morten - Do something cheap, place cameras yourselves, **do an analysis and offer a visual, understandable data visualization** - People struggle understanding the theory behind what they preach.

Steen is the name of the head of IT at Roskilde

RF meeting March 10, 2024

A.1.3 May 25, 2024

Meeting with Mads Therkildsen.

Roskilde proposes our involvement at the festival to be composed of two phases . Pre-festival during warmup days they would like us to analyze EOS. After opening of the big festival, Arena stage. We are open and flexible to analyze also other parts of the venue, maybe areas with Food and Beverages.

Mads asks to be sent the project description, and to understand better what our aims with the product are. Ideally in the future, we are coming, setting up cameras, taking them down and just giving a report on the analyzed areas, with minimum work effort needed from the organizers side.

The expectation is to get data/demand curves for the ingress and egress of people to the individual stages. Secondly, to get relatively accurate measurements into what the density of crowds is in the analyzed zones that follow Fruins levels of service. Estimate density based in people pr. m² etc.

It is interesting for Roskilde to get an idea about how a concert starting at Orange stage affects people moving from Arena to other areas.

Our contact people at Roskilde for the beginning will be Niels - working with CCTV systems and Adam from England who is a flow manager. We will setup a way to follow and learn from Adam while on ground working to understand the way they handle things.

We will receive risk assessments and concert schedules to understand key events.

RF meeting May 25, 2024

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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