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Applying Crowd Risk Mitigation Technologies in Urban Sport Events: A Case Analysis of the Collegiate Football Event in Indianapolis, IN

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Abstract

In recent years, the need for advanced precautions for mitigating the risks imposed by events, which involve high volumes of people in shared spaces, has multiplied. The occurrence of COVID-19 pandemic has further altered event practices, spaces, and event attendees' mindsets in large-scale events. Proper crowd management not only seeks to prevent acts of violence and injury, but in today's event environments; efforts should be consciously applied to reduce the spread of respiratory infections such as COVID-19. As the events industry continues to evolve and face new limitations, ways in which event organizers respond must evolve as well. Smartphone technologies are opening new ways for event organizers to communicate with and monitor attendees. This case study explores current crowd management strategies, analyzes the gaps in widely used models, and finally proposes event management technologies trending in the field.

Keywords: Risk Management; Event Smart-phone Applications; Crowd Management; Mobile Sensing; Sport Events

Introduction

Crowd management has been a key challenge for event planners – they try to attract as many attendees as possible while ensuring the safety and quality of the event experiences (Mowen et al., 2003). The onset of the pandemic has placed even more concentration on crowd management in events, given the essence of social distancing in preventing the spread of the infections. Therefore, effective crowd management practices directly impact the safety and satisfaction of event attendees, the credibility and trustworthiness of event organizers, and the overall health of the host destination.

The importance of crowd management efforts must not be understated. In some cases, proper crowd management efforts in the pre-planning stage can be a matter of life or death for some attendees (Green, 2016). Some event organizers - even event brands, their major stakeholders, and entire host cities - have been shamed and tainted with ideas of death, irresponsibility, and incompetence because of failed crowd management efforts. In extreme cases, event operation plans erroneously fail to mention any sort of contingency for surging crowds (Macaya, 2021; Patel & Kasakove, 2021). Finally, situations of continual crowding such as overtourism, exacerbates environmental damage of the host destination from high levels of pollution (Johansson et al., 2012).

Responses to failed crowd management practices expand beyond simply increasing security staffing at events. There is a list of technologies that have already been deployed in managing crowds: surveillance cameras, heat maps, drones, prediction modeling software; yet these technologies only offer pre-event insights, provide limited coverage and information, or have further risked attendee safety (Brown et al. 2013; Hirth et al., 2021; Martella, 2017; Mowen et al., 2003; Solmaz et al., 2014). Advancements in crowd management practices are absolutely necessary to prevent additional event tragedies from occurring.

Accordingly, this study analyzes the case of the 2021 Collegiate Football Event in Indianapolis. IN, discusses the options, and develops an action plan for applying crowd risk mitigation technologies in urban sport events. In doing so, the findings of this study provide new

insights into crowd management during the pandemic times and offer practical implications for event planners and other practitioners.

Study Context

On January 7, 2022, over 110,000 fans, 2,000 volunteers, football teams, training crews, media crews, venue staff, and event operations staff will flock to the center of Circle City to mingle with Indianapolis's 857,642 residents (nearly 30,000 residents in the city's Mile Square alone) to kick off the National College Football Playoffs (Kollar, 2021). Although fans will have activities spread throughout the city at iconic spaces like Bankers Life Fieldhouse, Georgia Street, Pan-Am Plaza, Lucas Oil Stadium, Monument Circle, and the White River State Park; they will be met with the winds and temperatures of Indiana's winter, pushing the majority indoors. While events such as the College Football Playoffs are necessary to the economic and tourism development goals of cities like Indianapolis, the crowds they bring pose a long list of risks to everyone involved. Attendee safety, event and venue owner liability, resident quality of life, and the destination's environment must be accounted for when planning the event's crowd risk mitigation plan.

Conceptual Background

Crowd Management in Events

Riskful crowding can occur when the volume of people is too high, or movement of people is too slow for the adequate flow through the physical space. This type of crowding poses safety risks. Inconvenient crowding occurs when queue lines for vendors, services, or attractions exceed the expected wait time of visitors. Waiting times longer than 8 minutes pose negative impacts to event experience, attendee satisfaction, and income maximization (Alvarado-Valencia et al., 2017; Martella et al., 2017). Behaviors of individuals within crowds can further escalate crowd volumes or dangerous movement patterns. Besides the norms, a wide variety of elements need to be considered when developing crowd management strategies for major urban sport events such as the College Football Playoffs. These elements include both external factors such as the sporting environment, urban population growth, and the mega-event trend, as well as logistical factors like the different crowd management techniques.

External Factors

Sporting environment

Each type of sporting event draws its own crowds. In the case of college football, fans are known to gather and party in large numbers. Team pride, alcohol, and social media play a role in advancing violence or unruliness at the games (Iboshi, 2017). In the 2016 season for college football alone, records show 3,778 fans were ejected and 1,102 fans were arrested. These numbers only account for 60 Football Bowl Subdivisions out of 128 that sent numbers into KGW for the investigation. Records further show that some games' extent of crowd management was deploying 1 state trooper for each 1,000 fans and the use of surveillance cameras in the control room. A quote from sport psychologist Brian Baxter captures the environment's effect on fans well: "You just lose yourself to the group… Morals kind of erode, your individual responsibility erodes, and you are more likely to do something you would never do" (Iboshi, 2017).

Urban Population growth

According to the United Nations, nearly 55% of humanity (4.3 billion people) lives in cities today. By 2030, about 60% of the world's population will live in urban areas, and 70% by 2050 (United Nations, 2021). When the density of people becomes too high; crime, incidence of injury and illness, severe traffic delays, and pollution also increase often more than proportionately through the interaction of populations (Johansson et al., 2012). As urban populations grow, density of the event locations is already at high risk levels prior to the addition of tourists. Resident and visitor interactions grow negative as each competes for the space through crowding and traffic experience.

The Mega-Event Trend

As if urban cores are not overwhelmingly dense as is, the industry's trend and push for mega events further exacerbates the issue. Maximizing event impacts through ancillary events brings more people for longer amounts of time. Additionally, city-wide events can bring large volumes of tourists who are unfamiliar with the host destination. Maneuvering around a small venue with adequate signage is feasible, but once the venues begin to grow in scale and the displays of signage become more difficult, tourists get lost or circulate in fewer areas.

Logistical Factors

Traditional Crowd Management Technologies

The traditional crowd management strategies normally take place during an event and rely heavily on communication technologies that are pre-determined in the event planning process. For example, turnstiles count the numbers of people entering and exiting an event, but they have no control over in-event crowding behaviors. Barriers are used to mold crowds or block off access to unauthorized areas. Barriers sometimes are disregarded or become dangerous blockades in mass evacuations and unexpected crowd volumes (Martella et al., 2017). Once crowding occurs; megaphones, audio systems, and static screen displays are used to send communications to attendees. Noticeably, each of these technologies have some crowd dispersing power, but are not fully effective especially for city-wide events. Audio strategies only reach so far and can be drowned out by the nature of the event. Large screens, while at first thought seem like an effective way to communicate through changeable signage, actually draw crowds. Additionally, Sharma et al. (2016) recommend that a comprehensive crowd management system should include (1) planning and infrastructure support at the planning stage, (2) crowd monitoring and control during an event, and (3) data analysis for key decision-making.

New layer to Crowds: COVID

Events are now held to a new level of responsibility for crowd risk mitigation due to the COVID-19 pandemic. Events have been linked to the rise in cases for host destinations. A case in the Netherlands saw a drastic spike where there were 13,836 influenza-related hospitalizations in the 2017/2018 influenza epidemic, and carnival fell about 1 week before the peak of these hospitalizations (LUMC-COVID-19 Research Group, 2020). For the well-being of the host destination and all visitors involved, new crowd risk mitigation technologies (CRMT) instead of "management" strategies may be the key to in-person event continuation by supplementing travel confidence. In many cases, CRMT could be the difference between life or death for at-risk populations.

Event organizers are constantly forced to redesign current risk management procedures to ensure the safety of attendees, and ultimately, the longevity of events and host destinations. As host

cities evolve, new types of risks emerge, and technology advances; the types of crowd management strategies deployed must change accordingly. To achieve this, the root causes behind current ineffective crowd management practices must be identified. These findings will then shed light on the key features new technologies will need to have to perform more efficiently.

Applying Crowd Risk Mitigation Technologies (CRMT)

Not all types of crowding are bad. Studies find that crowds in event settings often indicates the popularity of the event and can be perceived positively (Mowen et al., 2003). Well managed crowds in meticulously planned events are acceptable. In fact, in the right environments, stable crowds are integral parts of the sense of community for event goers. Therefore, *crowds are not the problem; how well their behavior and potential negative impacts are planned for is.* Pre-event planning is the key to maximizing the economic and social benefits of crowds where appropriate. Pre-event planning is also the first to be blamed when damage or inconvenience actualizes during events. In fact, a qualitative study with 55 crowd management experts found that effective crowd management takes place 90% pre-event and 10% during an event. Figure 1 illustrates the makeup of an effective crowd management plan (Martella et al., 2017).

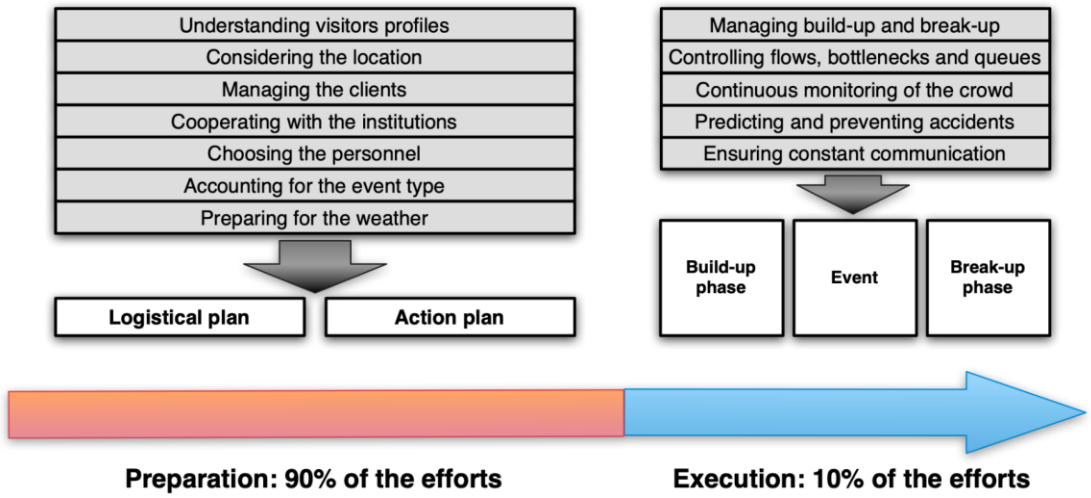

Figure 1: On Current Crowd Management Practices and the Need for Increased Situation Awareness, Prediction, and Intervention (Martella et al., 2017)

Event Design and Communication are critical elements that can determine the success of a crowd management plan in events (Martella et al., 2017; Van Winkle & Bueddefeld, 2020). Failures in event design can include inadequate amounts of signage, poor traffic flow, under-planned vendor mapping, and dangerous structure placement. Additionally, event design can be challenged by complex host environments like outdoor urban cores for unexpected high volumes of people, tall buildings/structures blocking routes and views, vehicular traffic, and weather. For communication, failures in current crowd management strategies can be traced back to absence of reliable communication methods between event staff and attendees, poorly designed signage, and the nature of interventions for violence and riskful crowding. These two critical components of crowd management strategies are echoed in industry studies on crowd management professionals' samples and event attendee samples.

Risk Mitigation Technologies is a term to refer to electronical resources used to prevent,

rather than manage, unfavorable outcomes from the nature of the labor and working environments in fields like healthcare, energy sourcing, and the construction industry (Wilson, 2004). For example, health and safety risk mitigation technologies such as visualization cameras augmented with artificial intelligence pattern recognition software to detect inanimate objects and people obstructing the safe movement of machinery at construction sites (Edwards et al. 2021). By applying this concept to event design and crowd management, the term Crowd Risk Mitigation Technologies (CRMT) is uniquely specified.

Adapting advanced Crowd Risk Mitigation Technologies to align with the needs of all parties involved is the only way to ensure the safety of attendees and the longevity of events and host destinations. Based on the root causes of crowding identified from the two main actors (event staff and attendees), the most effective crowd risk mitigation strategy would be one that dives down to the root causes of riskful crowding by improving organizer-attendee communications, advancing real-time crowd monitoring, and assisting the timing and nature of current intervention methods.

Examples of CRMT

While risk management has been an integral part of event design; 2021 has added new layers to the challenge, as well as new technologies to event designers' tool belts. Below are options for CRMT and a comparison of their ability to execute crucial tasks for advancing crowd management practices.

1. Develop a Location-based App (Mobile Crowdsensing)
    a. Develop an event brand specific smartphone application with Mobile Sensing through location-based Software Development Kits (SDKs) for real-time crowd risk mitigation from attendee and event management sides (Ewen, 2021). Access real-time maps illustrating movement and crowd densities, prioritize personnel dispersion based on most dense areas, coordinate live wait times for activations based on the location's density, send real-time updates to attendees in specific areas for less crowded service alternatives.
    b. Cons of this option include time and funds needed for its development. Development could last anywhere from 4-9 months and developers charge 20 to 30 an hour (Duong, 2021).
2. Last Years' Lessons + Pre-developed Event App Purchase
    a. Continue the use of traditional crowd risk management strategies. Deploy security personnel to address violence and place physical structures to ease traffic flow based on observations of the prior year's event. Purchase plans from pre-developed apps like Whova, CrowdCompass, or EventMobi to mitigate some areas of crowd-imposed risks. The app could ease entering and exiting crowd volumes by timed entry notifications and updates, provide manual updates on parking availability, feature a static map for vendor and activity locating.
    b. Cons for this option include lack of real-time, location-based services, and lack of personalization and control.
3. Heat Mapping (Static Crowdsensing)
    a. Invest in Static Sensing like Heat Mapping from companies such as GES. The smart phone tracking system is made up of floor sensors throughout the exhibit hall to detect MAC addresses from attendees' smartphone devices. The video tracking system is a series of temporary overhead cameras in exhibit hall ceilings, or on poles

in lobby areas. This could yield 2D models at less expensive price points and 3D models at higher price points (GES, 2021).

b. Cons:
    i. Static sensing suffers from several problems, such as insufficient node coverage, high installation/ maintenance cost, and lack of scalability. Physical equipment is subject to becoming outdated (Solmaz, 2014).
    ii. Must be reinstalled if the event moves to a new location next year.
    iii. Cameras only provide limited view (Martella, 2017).

4. Simulation Software
    a. Simulators such as FlexSim and SimWalk use computer-based modeling of any real-world environment and its interactions or processes. Simulations allow organizations in the industry to analyze and experiment with their processes or schedules in a virtual setting for fine-tuning real-world environments (FlexSim, 2021; SIMWALK, 2021).
    b. Simulations have been used in a broad range of environments from airports to sport event stadiums for their ability to illustrate possible scenarios pre-event for event teams to consider. They have been used to plan stadium evacuation plans, as well as help designers weigh logistical decisions for wait times, safety, and customer satisfaction. Unlike spreadsheet-based analysis and forecasting, simulation offers a quick and efficient way to adjust parameters and re-simulate, saving valuable time with quicker results. However, cons of this option include lack of real-time monitoring for mid-event crowd interventions. Investments in this technology would be solely utilized pre and post events.

Developing an Action Plan for the Collegiate Kickoff Event

In the case of the College Football Playoffs, investments in crowd risk mitigation technologies are necessary and timely. Hosting this specific city-wide sporting event for the first time in harsh weather conditions amidst a pandemic and tense social atmosphere at a time when sustainability is at the forefront of competitive edge conversations for events; emphasizes the need for streamlined organizer-attendee communications, fast event information access, and effective, holistic crowd monitoring technologies. Therefore, the development of a location-based app is the primary suggestion for organizers and destinations to invest in advanced crowd risk mitigation technologies.

Referring to the suggestions from crowd experts and event attendees for developing the ideal crowd risk mitigation technologies, a location-based app sufficiently meets all desirable features and much more. Brown et al. (2013) found that CRMTs such as geo-tracked mobile devices mitigate the crowding problem, and even increase visitor satisfaction and intent to visit and revisit. Dane et al. (2020) found that geo-location data revealed intra-event participation was limited by temporal restraints by tracking the flow and visitation levels of attendees; allowing event organizers to redesign event spaces for maximized profits while enhancing the attendees' event experience. Bustard et al. (2019) found that attendees demonstrate an increasing demand for real-time event integrative information, with more immersive and augmented experiences.

Backend management of a location-based app will increase awareness and reliable real-time crowd monitoring, improve communication channels between event organizers and attendee populations, collect advanced and real-time crowd behavior data, and assist in preventing accidents and enabling intervention without force. The front-end features of the app itself can be seen as

mobile, interactive, and personalizable form of signage. It's adaptable, versatile, innovative, and attractive. Continued use will lead to a wealth of knowledge for improving event facilities, attendee experiences, and crowd flow design.

Aside from the support from research, the idea of developing a location-based app may seem unattainable for some event organizers and cities due to current funding structures and education gaps in leading technology. A location-based smartphone application not only will advance the event planners' crowd management strategies to crowd risk mitigation strategies; but it speaks to the desirable themes such as health, convenience, connection, innovation, and sustainability. Because of this, investments in the app can be funded through grants relating to public health, regional development, sustainable tourism development, technology for humanities, and innovation. Additionally, research and actual implementation for mobile sensing in tourism is rapidly expanding. Applications of Mobile Sensing can be seen in theme parks, festivals, and sports events for advancement in crowd mitigation and attendee experience (Brown et al., 2013; Bustard et al., 2019; Dane et al., 2020). Through these studies, a list of features and suggestions for app implementation is featured below.

App Features, Integrations, and Implementation Strategy Recommendations Deep Dive:

I. App Features
   - A. Privacy Notice Page: what is used and what is not
   - B. Share Location Feature: "Find my Friend"
   - C. Live vendor queues and wait times for attendees (Similar to Google business live)
   - D. Itinerary Planner with GPS guidance
   - E. Live queue updates through notifications to attendees for internal ticketed events
   - F. Crisis report feature/hotline
   - G. Worker Chat Feature: log-in secured, backend feature for solutions and crowd control communications
   - H. Location-based notifications for incidents reported in attendees' nearby area
   - I. Live parking map
   - J. What's Happening Page: public feed for photo sharing
   - K. Front end display of highly populated areas (Crowdmapping feature)
     1. For attendees concerned about COVID and wanting to avoid crowds
     2. For those looking to find large gatherings and increase sociability

II. Implementation Strategies
   - A. Feature in registration email for convenient tick access, early event map access, vendor deals, or share for early ticketed event registration access if downloaded to promote app use
   - B. Host team and city merchandise on commerce page of app to promote use and ease of sales
   - C. Market to destination residents as tool for wayfinding daily life around events to increase crowd density accuracy
   - D. Send location-based recommendations to attendees in large queues for alternative attraction or vendor options with location provided to encourage event traffic flow and sales

The following implementation plan is a sample of time-organized tasks that the event organization committee will execute to successfully develop and implement a location-based event app.

Time to Event	Task Duration	Task	Notes
PRE-EVENT			
2-3 years out		Secure Event Bid	Event Organizing Committee and DMO
		App Developer RFQ and Quote	Committee outlines desired features for app on front and back ends
	(2-3 months)	Funding Development	Committee Finance locates grants. Duration depends on the close dates of open grant cycles of interest. Use quote and design plan from app developer in grant.
1 year out	(4-9 months)	Location-based App Development Process	Committee works alongside developers during the multi-phased process. Includes app prototyping, designing, coding, and testing.
8 months out	Ongoing up to event	Event Announcement and Marketing	Marketing dept. will begin communications of the event. App downloading is encouraged by early ticket access or experience discounts/packages.
2 months out	(1-3 weeks)	App training	Developers train event staff on usage and processes. Training will cover front end (user side) of app (10%), and back-end monitoring of crowd management dashboard and dispatch methods (90%)
DAY OF EVENT			
		Command Center Implementation	Command center (CC) monitors real-time dashboard of movement and densities at points of interest
	As identified	Density control	CC identifies high volumes of people in high-risk areas. Dispatches additional security team members and sends mobile communications to attendees in the form of attraction suggestions.
	As identified	Flow Control	CC identifies slow movement in queues for services or vendors. Event team contacts vendors to assess needs and plan of action.
	As reported	Crisis Response	If risks fail to be mitigated, situations reported in the app will be identified and linked to report location for event security in the area to easily locate and address.
	Ongoing	Satisfaction Reporting	Attendees tag locations in event and leave reviews
POST EVENT			
		Sentiment Surveys	Committee will distribute post event communications with surveys on technology use

	(2-3 months)	Data configuration	App developers will create a report based on location data and content analysis of attendee posts on app

Evaluation of the Plan

To ensure the benefits of implementing a location-based app is being maximized, event owners should set specific, measurable, attainable, realistic, and timely goals. These goals will serve as metrics of success and prerequisites for further investments.

Goal	**YR 1**	**YR 2**	**YR 3**	**YR 4**	**YR 5**
Effectiveness Analyses:					
Numbers, locations, and environmental factors of all reported incidents of injury or violence will be documented post event on a yearly basis for comparison to succeeding years to track app's crowd risk mitigation success.	X	X	X	X	X
Attendee Sentiment Analyses:					
Each year, post event, surveys will be distributed to attendees to evaluate each user-based feature of the event's location-based app. Results will be configured into scores, which will be used to assess the direct of app related investments and updates.	X	X	X	X	X
After impact is realized, benefits are maximized, and new investments in other interactions or technologies become optional; event owners and researchers will perform content analysis across social media and review sites for location-based app and projected technologies to contrast and compare investment options.				(X)	X
Event Industry Development:					
After impact is realized, every two years, event owners will provide researchers to mine location and attendee behavior specific data from the app to develop cases for additional event industry fields of research and innovations.			X		X

Other Considerations

Privacy

The concern for app user privacy is one that arises in every location-based app discussion. This area is under heavy research and debate. Enabling location data can be temporary, and personal identifying information can be left untouched. With the correct privacy protection measures, brand trustworthiness and loyalty, and technical planning; privacy concerns of app users may rest assured (Wang et al., 2020). Due to privacy concerns and the educational gaps for technology use in older generations, event designers may be hesitant to invest in location-based apps. If large amounts of attendees do not utilize the event's location-based app, numbers and data for crowd risk mitigation displays can be skewed or ineffective. This can be overcome through the event design process. User interface design, prototype design, app trial periods with populations that represent the target attendee audience are crucial to successful implementation. Educational gaps for collegiate target populations may be of less concern because of their general acceptance of technology (Talantis et

al., 2020).

Funding

Because of the large-scale investment needed for advanced apps, event organizers will need to develop project funding. Grants for USA Nonprofits, Agencies, Tribes, and IHEs for Digital Projects in the Humanities, and federal grants for risk mitigation, innovation, or sustainability should be considered in the funding model.

Conclusions

Through a review of the potential application of CRMT and an analysis of the scenario, this conceptual paper develops an action plan for applying CRMTs in collegiate events. First and foremost, a location-based app would serve as an event's multifunctional competitive advantage. A location-based event app would reduce the chances of risks actualizing at the event. This would build brand trustworthiness and brand loyalty as event owners demonstrate active measures for attendee wellbeing and safety. It would also reduce the possible out-of-pocket costs for legal settlements. Direct organizer-attendee communications would increase attendance confidence, increasing sales and revenue. Adopting modern technology into event practices engages and attracts audiences because of their conveniences, especially those of younger generations. Extensive CRMTs demonstrate an event owner's proactive commitment to attendee safety, increasing their chances for competitive venue securement. Participating in the app development and large project funding processes are valuable additions to the CV's and success metrics of event organizers.

Additionally, the implementation of a location-based app at College Football Playoffs will provide attendees with a large range of value. Most importantly, their health and safety will be positively impacted with assistance from the app's well-planned features. A live crowd map will enable attendees with compromised immunities to locate crowds and avoid them by accessing alternative routes when possible. Attendees looking for more ways to engage at the event can locate happenings in the live event map. If riskful crowding or dangerous situations do occur, attendees will receive immediate information directly to their personal devices through notifications from the Command Center.

Aside from value in health and safety, attendees' sense of convenience will increase with the implementation of a location-based app. The "Find my Friend" feature will allow attendees to locate their communities better in the challenging urban environment. While some smart devices (i.e., Apple products) already enable this feature, locations based on temporary event structure and updates on closed roads will be accurately displayed. Additionally, density configurations can be used to create displays for vendor wait times and locations so that attendees can plan their own unique itinerary based off of real-time data.

Furthermore, the role of event operations staff in an event can make or break the attendee experience. Advancements in the quality and depth of organizer-staff communications would result in better directed efforts of the front-line staff. The power of radios was revolutionary. Imagine the power of an app that includes direct communications alongside live environmental updates for improved mitigation efforts. Experience in technology use is a hard skill that would supplement portfolios of event operation professionals.

Lastly, vendors reap the consequences of event crowding at direct levels through attendee frustration and revenue impacts. The power of an app to send notifications to attendees on current queue times will decrease the negative impacts of crowding on vendors, as well as promote more

opportunities for sales during dead times. When attendees begin to recirculate in a few areas, cutting off sales opportunities for vendors outside of the area, Common Center can send notifications to attendees for specific vendor promotions to increase flow and revenue generated.

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