

Institution: University of Salford		
Unit of Assessment: 12		
Title of case study: Salsa Sound Ltd.: Reinventing live sports audio		
Period when the underpinning research was undertaken: October 2011 – May 2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Ben Shirley	Senior Lecturer in Audio Technology	July 1993 – Present
Dr Rob Oldfield	Research Assistant	February 2010 – September 2013
Period when the claimed impact occurred: January 2017 – December 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact <p>With multiple microphones, fast-moving action and high expectations from fans, live sports broadcast is one of the most challenging and complex genres for audio engineers. The COVID-19 pandemic has created new challenges for broadcasters in producing live sport that engages viewers when no crowds are permitted in stadiums. Research at Salford has developed novel techniques to automate real-time sound-mix production as well as new technologies for virtual crowd production. Award-winning University spin-out, Salsa Sound Ltd., is exploiting these technologies through development of software tools that are used to create bespoke audio mixes for broadcasters including CBS in the United States and ‘fan-experience’ audio mixes for sports clubs such as Manchester City FC in the UK. Salsa Sound’s technology provided the first ever virtual crowd used in American sports broadcast and redefined the way that live sport sounds during the pandemic. The resultant audio is now broadcast to millions of sports fans worldwide, across 10 leagues and from 5 different sports in the UK and US.</p>		
2. Underpinning research <p>The impact described in the case study is underpinned by research in new immersive and object-based broadcast audio formats and in novel methods for automating and enhancing audio for live sports broadcast. Object-based audio (OBA) is a new method for transmitting audio in which sounds in a broadcast can be transmitted separately with coordinates and other metadata for mixing at the receiver in the home.</p> <p>Research on audio capture and reproduction for the European Union’s FascinatE project (FP7/2007-2013) was carried out by Salford’s research team, led by Dr Ben Shirley. The FascinatE project developed a complete end-to-end future interactive broadcast system. The premise was that the viewer should be able to choose their own view of any live event and be able to move their viewpoint either freely, or via an automated ‘virtual director’. Cases used in the project encompassed live sport (football), music (BBC Proms) and dance (Berlin Arena production). Audio research on the project, including OBA production, was led by Salford and predated OBA formats. Research in this area has been ongoing since October 2011 when a first test shoot was carried out at Stamford Bridge football stadium as part of the FascinatE project.</p> <p>The project oversaw the early development of the MPEG-H OBA format (format development on the project was led by Technicolor). Salford developed techniques to create discrete audio objects (with associated coordinate and identifier metadata) from multiple microphones at an event including for broadcast sport [3.1]. In addition, new methods were developed for rendering immersive crowd sound [3.2, 3.3]. This meant that (in the case of football) sounds of the ball being kicked and the whistle being blown would be accompanied by positional, level and</p>		

identifier metadata that facilitated immersive, engaging and stable mixes for multiple reproduction systems, including simple stereo, immersive systems, 360 video and virtual reality (VR) [3.3, 3.4, 3.5].

The research outputs tracked and monitored on-field activity using only audio received at existing broadcast microphones, without the need for video tracking, and utilised signal processing to identify important sounds. Research continued after the FascinatE project and neural networks were also employed to identify and classify salient sounds which were valuable to the broadcast sound mix. This is extremely challenging in the presence of so much acoustic noise in a packed football stadium. Algorithms were developed for automated mixing of broadcast microphones using these techniques, initially to automatically raise and lower the levels of pitch-side microphones based on knowledge of the location of salient sound events, and later to enhance important sound effects with processed and pre-rendered audio content in real time [3.6].

Further, Salford's research created audio objects at a micro level, formulating a novel definition of *short-term audio objects* where every individual ball kick or referee whistle in a football game could be treated as a separate object which could be processed independently and placed anywhere in a 3D sound scene for immersive experiences either with large screens or using head mounted displays and mobile devices. Immersive crowd and on-pitch sound reproduction was also developed in a hybrid system for multiple reproduction devices [3.1, 3.4].

The audio tools developed were tested during the FascinatE project (2010 – 2013), both offline (for sport) and live, in real time (for music and dance performances). The FascinatE project won The Engineer Award for Consumer Technology in 2011. Algorithms were further refined between 2013 and 2017 by the researchers on the project, and with support from the University's Technology Transfer Office, to create automated and enhanced audio mixes for current broadcast systems (OBA broadcast was still not yet available so the research outputs were leveraged for conventional broadcast). Patents have been acquired for these research outputs [3.6]. The resultant tools for automated and enhanced mixing of live football have been field-tested at live Premier League and FA Cup matches with BBC, BT Sport, Sky Sport, Dolby Labs, Arsenal FC and Manchester City FC. The techniques and technologies were further refined and adapted during the COVID-19 pandemic to provide virtual crowd for live sports where no crowd was present.

3. References to the research

3.1. Oldfield, R., Shirley, B., & Spille, J. (2015). Object-based audio for interactive football broadcast, *Multimedia Tools and Applications*, 74(8), pp. 2717-2741.

<https://doi.org/10.1007/s11042-013-1472-2>

3.2. Batke, J. M., Spille, J., Kropp, H., Kordon, S., Abeling, S., Shirley, B., & Oldfield, R. (2011). Recording spatial audio signals for interactive broadcast systems, *6th Forum Acusticum, European Acoustics Association (EAA)*, (27/06/2011 - 01/07/2011), Aalborg, Denmark.

<http://usir.salford.ac.uk/id/eprint/58932>

3.3. Thallinger, G., Shirley, B., Schreer, O., Thomas, G., Niamut, O. A., Macq, J., ... & Oldfield, R. (2011). Format-agnostic approach for production, delivery and rendering of immersive media, *Networked and Electronic Media 2011*. <http://hdl.handle.net/2117/13574>

3.4. Schreer, O., Macq, J. F., Niamut, O. A., Ruiz-Hidalgo, J., Shirley, B., Thallinger, G., & Thomas, G. (Eds.). (2013). Media Production, Delivery and Interaction for Platform Independent Systems: Format-Agnostic Media. John Wiley & Sons. ISBN: 978-1-118-60533-2.

<https://doi.org/10.1002/9781118706350>

3.5. Thomas, G & Schreer, O & Shirley, B G & Spille, J, (2011) Combining panoramic image and 3D audio capture with conventional coverage for immersive and interactive content production, *Best of IET and IBC*, 3, *Institution of Engineering and Technology*, pp. 8-13.

<http://usir.salford.ac.uk/32090/>

3.6. Oldfield, R. G., & Shirley, B. G. (2018, 2017). Assistive mixing system and method of assembling a synchronised spatial sound stage, US Patent 9,979,499; UK Patent GB2546456

All journal articles [3.1, 3.5] and conference papers [3.2, 3.3] have been subject to peer review.

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4. Details of the impact

The exploitation of immersive technologies by Salsa Sound Ltd. has led to commercial success for the spin-out and has benefitted a range of stakeholders, creating new revenue streams for global broadcasters and sports clubs as well as enhancing sports fans' experiences. The impact has been particularly pertinent in 2020, as broadcasters and clubs have sought new and innovative ways to bring the live experience to fans during the COVID-19 pandemic.

4.1. Commercial success of spin-out company Salsa Sound Ltd.

Salsa Sound Ltd. was formed as a University spin-out company in 2017 to further develop and exploit the IP generated during and since the FascinatE project. Patents have been obtained in the UK and US [e.g. 3.6] with other patents (Japan, EU) pending. Integration of the resultant product was carried out with Manchester City Football Club (MCFC), Sky Sports and NEP (the largest global outside broadcast company). Demonstrations of automated mixing were carried out to leading broadcast industry players at trade shows (International Broadcasting Convention (IBC) between 2015 and 2019 and the National Association of Broadcasters (NAB) in 2016).

Salsa Sound now employs two members of staff (headcount: 2; FTEs: 2) as of December 2020. Since the start of the COVID-19 pandemic in March 2020 and up until December 2020 Salsa Sound generated **additional revenue of [text removed for publication]** from its virtual crowd (vCROWD) software, which has been used on **300 broadcasts globally**, with audiences of **one million viewers** at many of the individual events [5.1]. This built on revenue from consultancy work [text removed for publication] and additional match funding on a Department of Culture, Media & Sport grant worth **GBP86,946** to work with BT and others to develop new forms of sport broadcast [5.2].

The company has won numerous awards for the technology including the Royal Academy of Engineering Enterprise Fellowship (2017), International Association of Broadcast Manufacturers Dragon's Den event (2018) and the City Startup Challenge (2019), sponsored by City Football Group, which funded a full pilot of the technology developed from the research with MCFC [5.1, 5.3]. This led to the **development of an 'automated fan experience mix'**, offering unique immersive audio highlights on the club's YouTube channel and **subsequent collaboration on introducing vCROWD** for games played behind closed doors during the pandemic [5.3].

4.2. Innovative technologies creating immersive audio for global broadcasters

Broadcasters are achieving **better, more consistent and immersive audio for broadcast sport** as a direct result of Salsa Sound's innovative technologies. In 2020 Salsa Sound were contracted by American commercial broadcast network CBS Sports, American sports network Big Ten Network, global transmission service provider Vista Worldlink, as well as City Football Group in the UK to exploit these technologies [5.3, 5.4, 5.5].

The first broadcast by CBS using Salsa Sound's vCROWD technology was 27 June 2020, drawing the **largest attendance ever in the National Women's Soccer League's history** (527,000 viewers) [5.5]. On using Salsa Sound's technology, the Vice President of Remote Production, CBS Sports confirmed that *'we were very pleased with the end result. The plan is to continue it for our NWSL coverage, and we will be looking at it for other soccer and football'* [5.5]. Since that game Salsa Sound's technology has been used in the broadcast of **108 live matches** (to December 2020), covering sports such as men's and women's soccer, men's (American) football, men's ice hockey as well as men's and women's basketball [5.1, 5.2].

Figures put together by Salsa Sound in December 2020 [5.2, 5.6] demonstrate the roll-out of its vCROWD virtual crowd usage in network broadcast across America:

American Football

- Big10 network American football coverage starting 24 October 2020 (Rutgers at Michigan State University) (*average 600,000 viewers per game*)
- CBS network American football coverage starting 5 September 2020 (*average 4,000,000 viewers per game*)

Soccer

- National Women's Soccer League (NWSL) Tournament First game, Challenge Cup on 27 June 2020 (North Carolina Courage vs Portland Thorns)
- Phoenix Rising (United Soccer League club) starting 25 July 2020 (Phoenix Rising vs Orange County)
- Chicago Fire, Montreal Impact and New England Revolution Major League Soccer teams starting August 2020 (*average 500,000 viewers per game*)

Ice Hockey

- Big10 network ice hockey coverage starting 15 November 2020 (Arizona State at Michigan) (*average 200,000 viewers per game*)

Men's Basketball

- Big10 network Basketball coverage starting 25 November 2020 (McNeese State at Nebraska) (*average 700,000 viewers per game*)
- CBS Sports (main network) basketball coverage starting 12 December 2020 (Notre Dame at Kentucky) (*average 1,450,000 viewers per game*)

Women's Basketball

- Big10 network coverage starting 11 December 2020 (Rutgers at Wisconsin)

Prime time viewing figures for the Big Ten Network after vCROWD was introduced **showed significant gains**, increasing by as much as **260%** during the week of 22 November 2020 [5.6].

4.3. Providing global sports clubs with immersive fan experiences to attract viewers

Sports clubs are benefitting from Salsa Sound's innovative approach to live sports audio by providing better, more immersive fan experiences and so are **driving traffic to their digital and other platforms** using automated and semi-automated audio mixes utilising Salsa's technology.

The first club to use Salsa Sound's technology was MCFC for a match against Liverpool FC on 21 April 2020 [5.3]. The game shown was one at which the researchers had been present as part of the City Startup Challenge pilot and was therefore one for which a fully automated fan experience mix had been generated during the pilot [5.3]. A replay of the game was shown on MCFC digital platforms across YouTube, attracting an initial **205,661 views**, as well as on CityTV and Facebook, across which MCFC have **11,200,000 subscribers** [5.3]. The automated mix was extremely well received by fans: *'Football without the boring tones of aged punditry. Sounds amazing, like I'm there again.'*; *'Crowd noise is ace @ManCity #CityzensAtHome feel like I am at the ground again'; 'Tell @SkySportsPL how much better it is.'* [5.7]

Once football restarted in 2020 without crowds in attendance, MCFC used Salsa Sound audio mixes for their highlights packages, the first of which achieved **4,450,000 views**, with **2,000,000 in the first 24 hours** [5.5]. By way of reference, broadcaster Sky's highlights of the same game achieved only 1,400,000 views in total. This is **attracting viewers to the club's platforms (and therefore advertising revenue)** and **driving subscriptions to their digital platforms** [5.4].

Independent research indicates that fans were **more likely to renew their City+ subscription because of Salsa Sound improvements** to the audio [5.8]. Development of the vCROWD solution for matches played behind closed doors during the pandemic *'uniquely allowed Manchester City to continue delivering authentic match highlights, despite the absence of fans from the stadium'* [5.3].

As a result of this successful launch Salsa Sound are in advanced integration discussions with MCFC to install the technology, hosted on a server at the stadium, for the 20/21 Premier League

football season once crowds return to the stadium. Other clubs in the US are now using Salsa Sound vCROWD technologies, including **MLS** and **USL soccer clubs**.

4.4. Creating the ultimate immersive experience for sports fans around the world

Salsa Sound's innovative sports audio solutions are now making games more immersive, exciting and enjoyable for fans of multiple sports both in the UK and the US. To capture feedback, MCFC commissioned independent fan research in 2020 to compare current sound with Salsa Sound immersive sound for matches [5.8]. Key findings were as follows:

- There is an **appetite among fans for new ways of watching football** with stadium sounds and removal of commentary
- **2 in 3 fans prefer the immersive sound** when they can compare to traditional sounds, with the heightened atmosphere and feeling of being at the stadium the key drivers for preferring the immersive sound, especially for non-UK based fans
- Over **three-quarters of fans** think that having the option for immersive sound makes **watching football a better experience**
- Fans are **more likely to keep their subscription** if immersive sound is available on the City+ platform [5.8].

City Football Group confirmed that *'the collaboration and responsive approach led to the delivery of real outputs that tangibly impact and improved the experiences of Manchester City fans globally'* [5.3].

Social media reaction to the new sound mixes in the UK and the US demonstrates the enthusiasm for the technology:

'[text removed for publication]: literal chills🥶'; '[text removed for publication]: What a game, remember it like it was yesterday! Hearing that at 4:38 sends shivers down my spine'; '[text removed for publication]: The feeling with my headset is so so amazing'; '[text removed for publication]: That sound of the crowd 15:30 and 18:51 🥰' [5.9]. 'Are there fans at this Army/Mid-Tenn St. game? If not, this is the easily best job I've seen any audio guy/gal do monitoring the fake crowd enthusiasm button' [5.10].

5. Sources to corroborate the impact

5.1. Viewing Figures and Revenue, Salsa Sound Ltd. (December 2020), detailing income generated on vCROWD software and viewing figures from broadcasts using vCROWD (4.1)

5.2. Income and Viewing Figures, Salsa Sound Ltd. (December 2020), detailing income generated since spin-out was established in 2017 (4.1) and viewing figures for major broadcasters using VCROWD software (4.2)

5.3. Testimonial: Head of Research & Insights, City Football Group Ltd. (March 2021), on the collaboration with Salsa Sound in developing an automated fan experience mix and vCROWD (4.1, 4.2) and impact of vCROWD during the pandemic on the club (4.3) and fans (4.4)

5.4. *[text removed for publication]* demonstrating contract awards from global broadcasters for use of Salsa Sound technologies (4.2)

5.5. Press Coverage: various articles highlighting success of Salsa Sound, particularly during the pandemic, available at <https://salsasound.com/#salsapress> (4.2)

5.6. Weekly Ratings, Big Ten Network, demonstrating the prime time gains in viewings once the vCROWD software was introduced from 24 October 2020 onwards, available at: <https://ctv.kwayisi.org/networks/btn/> (4.2)

5.7. Social Media: MCFC fan reaction to the automated mix used across its platforms (April 2020), available at: https://twitter.com/salsa_sound/timelines/1251565592936624129 (4.3)

5.8. Independent Survey, InSites Consulting (2019), commissioned by MCFC, with n=565 MCFC football fans with 2/3 preferring the immersive sound (4.3, 4.4)

5.9. Social Media: MCFC intimate audio fan reaction on YouTube (July 2020), available at: <https://www.youtube.com/watch?v=owYEHcwXOfc> (4.4)

5.10. Social Media: US fan reaction to vCROWD (September 2020), available at: <https://twitter.com/TheCousinSal/status/1302307779563069440> (4.4)