Institution: Edinburgh Napier University

Unit of Assessment: Unit of Assessment 33 – Music, Drama, Dance, Performing Arts, Film and Screen Studies

Title of case study: Pioneering real-time long-distance collaboration: new opportunities for musicians, audiences, education, and the audio industry.

Period when the underpinning research was undertaken: September 2012 - July 2020

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 Paul Ferguson	Associate Professor and PI	January 2001 - July 2020
Dr Dave Hook	Lecturer	January 2012 - present
Dr Zack Moir	Lecturer	August 2018 - present
Dr Ingi Helgason	Senior Research Fellow	February 2019 - present
Dr Ollie Mival	Senior Research Fellow	August 2014 - present

Period when the claimed impact occurred: January 2014 - December 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Edinburgh Napier University's (ENU) low-latency (LOLA) research group, led by Dr Paul Ferguson, has introduced UK and international education institutions, rural ensembles and leading orchestras to remote real-time rehearsal, teaching and performance over high-performance networks. Supported by AHRC, EPSRC and Industrial Strategy Immersive Experiences funding, the work has led to new partnerships with leading audio manufacturers Focusrite and Audinate, collaboration with Abbey Road Studios, live BBC World Service radio broadcasts, and innovative digital world firsts. This has supported new product research and development, input to new professional practice and future 5G development, stimulated new media production partnerships and resulted in real-time performances across 30 countries.

2. Underpinning research (indicative maximum 500 words)

Low-latency audio-only long-distance networked audio has been possible using JackTrip since around 2004, but systems incorporating video typically introduce 200ms to 500ms delay. In order for musicians to play together in time, the delay needs to be reduced to 50ms at least, with a figure of 11.5ms regarded as the ideal for real-time synchronisation (musicians hearing each other's performance at the same time as if they were in the same room). LoLa (a low-latency audio/video streaming system) is the product of a research partnership between Conservatorio Tartini and network engineers at GARR (the Italian national computer network for universities and research), designed to reduce the delay of audio/video transmission to the point that remote musicians can successfully play together. However, much work remains to be done towards the application of this system for meaningful employment of video to enhance the musicians' sense of engagement with one another.

In July 2012, in partnership with JISC/JANET (the UK's National Research and Education Network), ENU researchers carried out the UK's first real-time streaming trials of the LoLa low-latency audio/video streaming system between the UK and Italy. Ferguson's findings led directly to LoLa software changes to improve music quality **[O1]**.

In September 2013, ENU were invited by JISC to give the UK's first public demonstration of real-time live music performance by musicians from the Royal College of Music over distance at the first Arts and Humanities Streaming Workshop. Findings from this trial resulted in further research and testing which led to a demonstration at the 2013 TERENA TNC13 conference, where a trumpet player at ENU appeared 'virtually' on stage in Maastricht, the Netherlands, to

lead a jazz quartet performing live in front of the conference delegates. This proved to be a landmark test in this research field, that demonstrated how musicians separated by large distances could play together meaningfully and provide an engaging audience experience.

In 2013-14, ENU participated in a project consortium with partners from Conservatorio di Musica Giuseppe Tartini in Trieste, the Academy of Performing Arts in Prague, and three European National Research and Education Networks (NRENs); CESNET (Czech Republic), GARR (Italy), and JISC/JANET (UK). The aim of the project was to evaluate the use of the GÉANT (the pan-European data network for the research and education community interconnecting NRENs across Europe) Bandwidth on Demand (BoD) service, to support remote education and collaboration in music (eLearning) and remote access to cultural performances (eCulture). Although the user interface proved complex, requiring trained network engineers to operate it, the educational and collaborative impact of the activities enabled by the project was deemed significant **[O3]**.

In 2015 ENU carried out the UK's first use of LoLa with a commercial ensemble. The Hebrides Ensemble, together with composer Sir James Macmillan, gave a real-time interactive masterclass between Italy and the UK. Research emphasis was placed on the user experience and through the placement of loudspeakers and the use of a life-sized video of the horn player. Participants noted significant improvements in both audio and visual immersion which enhanced the possibilities of rehearsal between remote locations **[O2]**.

In collaboration with Soluis Sublime (creating '*next-generation immersive experiences and technology to transform the worlds of learning, work, and communication*'), ENU employed an immersive dome environment in order to significantly enhance the experience of a remote musician during real-time co-performance across long distances. The immersive environment promotes a sense of 'togetherness' and a shared experience of 'space'. This project involved the first use of eye-tracking glasses in real-time performance research **[O4]**.

Recent research has sought to clarify understanding and best practice in the field of remote recording and performance. ENU researchers have analysed existing online tools and resources for remote collaboration **[O5]**, and evaluated their use in practice with the Radio Science Orchestra at Innovation in Music 2019 (University of West London) **[O6]**, to ascertain best practice in practical application of remote performance software.

3. References to the research (indicative maximum of six references)
O1, and **O2**, have been cited and informed research beyond the institution. **O3** and **O4** followed competitive peer-reviewed funding, and informed major research networks.

- [O1] Ferguson, P. (2013). Using Low-Latency Net-Based Solutions to Extend the Audio and Video Capabilities of a Studio Complex. In: *Engineering Brief* 134(97). New York: Audio Engineering Society. https://www.aes.org/e-lib/browse.cfm?elib=16698.
- [O2] Ferguson, P. (2015). Real-time long-distance music collaboration using the Internet. In: Hepworth-Sawyer, R., Hodgson, J., Paterson, J. L., and Toulson, R. Book eds. *Innovation in Music II*. Book Chapter. Shoreham-by-Sea: Future Technology Press, pp. 174-178. **Submitted to REF2.**
- [O3] Ubik, S. and Allocchio, C. (2015). *Open Call Deliverable OCI-DS3.2 Final Report (eMusic)*. [Online]. Report. Amsterdam; Cambridge: GÉANT Limited. https://geant3plus.archive.geant.net/Resources/Open_Call_deliverables/Documents/eMusic_final_report.pdf
- [O4] UKRI. (2019). *ENSEMBLE Performing Together Apart: Enhancing Immersive Multi-Location Co-Performance in Real Time*. Swindon: UKRI. https://gtr.ukri.org/projects?ref=AH%2FR010080%2F1
- [O5] Moir, Z., Ferguson, P., & Smith, G. D. (2019). Real Time, Remote, Collaborative Recording Sessions: Music Production Without Boundaries. Book Chapter. In: Hepworth-Sawyer, R., Hodgson, J., and Marrington, M. eds. *Producing Music*. London; New York: Routledge. pp.194-208. https://www.taylorfrancis.com/chapters/real-time-remote-interactive-

recording-sessions-zack-moir-paul-ferguson-gareth-dylan-smith/e/10.4324/9781315212241-12
- [O6] Ferguson, P., Hook, D. (2021). Ground Control and Cloud Booths: Breaking geographical barriers to music production. Book Chapter. In: Hepworth-Sawyer, R., Paterson, J., and Toulson, R*. Innovation in Music: Future Opportunities*. London and New York: Taylor & Francis (Routledge). **Can be supplied be HEI on request.**

- [G1] European Commission Framework Programme 7 - GN3Plus. *eMusic: Using Géant dynamic circuits to support remote collaboration in musical education and eCulture*. **Ferguson, P.** (PI). October 2013 - August 2015. €32,000
- [G2] AHRC. *ENSEMBLE Performing Together Apart: Enhancing Immersive Multi-Location Co-Performance in Real Time.* **Ferguson, P**. (PI), **Helgason, I.** and **Mival, O.** January 2018 - December 2018. £58,000.

4. Details of the impact (indicative maximum 750 words)

The principal beneficiaries of this work have been musicians and commercial partners in the field of digital audio. The research has increased connectivity between geographically distant musicians, led to wider accessibility of collaborative performances, and reduced the necessity for travel and the resulting lower carbon footprint. The musicians who have benefited from this research include professional bands, soloists, and ensembles, but also musicians teaching and training at conservatoires across the UK, the USA, Australia, and Europe. The research has been shared with audiences through its inclusion in public events, through broadcast on the BBC World Service, and via the internet. The cultural impact of this shared sense of connectivity, spread through events such as the #IPlay4Peace concert, have been significant at a time when isolation has become the 'new normal', and performing music together has seemed too challenging.

Impact on Musicians

The masterclass held by the Hebrides Ensemble and the composer James MacMillan was the first application of this technology for this purpose in the UK by a commercial ensemble **[C1]**. Kate Whitlock, General Manager of the Ensemble described the collaboration with the University as having '*really a huge impact on the direction of the Ensemble'*. The event was attended by representatives from major arts organisations in Scotland. Fiona MacLennan, Carbon Reduction Project Manager of Creative Carbon Scotland, who attended this masterclass, described it as '*having significant potential for helping artists based in locations which are remote from each to work together with high quality visual and audio communication*' **[C2].**

The industry stakeholders group consultation, during ENU's AHRC ENSEMBLE project **[O4]**, selected the 2018 #IPlay4Peace Armistice Centenary concert as the primary vehicle to test the next phase in international networked performance. The resulting concert involved 40 countries **[C3]** and received a House of Commons Motion to Congratulate from the Rt. Hon. Frank Field MP **[C4].** The concert, which was streamed live currently has over 1,700 views on YouTube, and the edited video has been viewed 926 times **[C3].** Neil MacLennan, who led the project, described the ENU team's input as '*truly outstanding*' and attributed the success of bringing so many musicians together at the same time to the support of the team, which led to the project being repeated in 2019 and 2020 **[C3].**

The success of the Armistice project led Paul Gudgin, artistic director of the Durham Brass Festival 2016-19, to approach the project team to facilitate a 'Global Brass' concert and 'Global Jam Session', including musicians performing live in the Gala Theatre, Durham, joined virtually from Copenhagen for paying audiences in both sites. Gudgin described this event as hopefully '*spawning lots of other collaborations, whether in brass, jazz, classical or rock and pop'*. Tony Thompson, from the Festival's steering committee, suggested that this was a world first in terms

of brass bands **[C5].**

In August 2019, the BBC commissioned an 18th birthday special episode of 'Digital Planet', broadcast live on the BBC World Service on the 3rd September 2019, which connected the BBC Radio Theatre to studios at ENU so that musicians Andrew and Callum Huggan could perform together. Callum Huggan, Professor of Marimba and Percussion at Trinity Laban Conservatoire of Music and Dance said that the LoLa technology '*allows for the tangible atmosphere of being in the same room to be so realistic'* and observed that the technology '*allows us to be closer together than we would be in an orchestra*'. The presenter Bill Thompson observed the '*sense of presence that comes from having no lag at all*' in the duet. Andrew Huggan said that he forgot '*that the link is there*' and that he could see the technology '*having a real purpose for rehearsal purposes for travelling musicians*', saving a lot of travel **[C6].**

Infrastructure Impact

Work funded by and in collaboration with Jisc (formerly JANET) **[O3]** has provided a showcase for both LoLa and the UK's academic network at the launch of JANET6 and the 2018 and 2019 Jisc Digifest edtech conferences. The implementation of a multi-person immersive dome environment (IDE) on stage with an orchestra from the Royal College of Music allowed performers to appear virtually broadcast from Edinburgh. Ben Hutchens, a training consultant for Pearson's higher education digital resources, describes the performance as '*amazing*', and that '*Words can't describe how powerful the message was'*. Dominic Pates, Senior Educational Technologist at City, University of London, described the performance as '*Impressive stuff that demonstrated some of the potential of the Internet for higher education'* **[C7].** This close involvement of the team with academic network infrastructure has led to them advising fourteen institutions in the use of the technology, and directly supporting the first trials at the Royal Academy of Music, London, the Royal Scottish Conservatoire, Glasgow, and the Royal Birmingham Conservatoire.

From 2019-20, Ferguson was invited to be a member of the UK5G Creative Industries Working Group, providing policy recommendations into the UK Government's DCMS 5G Programme **[C8]** as a direct result of his work on this project and with applications in the commercial world of sound production.

Sound production and recording industry

The Rogue Orchestra, Scotland's first-freelance cross-genre session orchestra, have approached the team with a view to creating a competitive UK remote recording orchestra for music and film projects by international clients. Positive market research has led to feasibility testing for projects by PP Arnold and Paul Weller **[G2].**

Focusrite (world leading audio interface builders), Resurface ('*the world-wide marketplace for companies and individuals using professional audio mixing technologies'*) and the technical team at Abbey Road Studios, London, regard the keynote performance given by the Radio Science Orchestra led by Bruce Wooley, with Matan Berkowitz and Harry Docherty, live in both the University of West London and ENU **[O6]** as a key moment for networked audio and remote sessions. For Focusrite, the idea that every piece of technology employed '*was a current, off-the shelf software or hardware product'* was particularly remarkable **[C9].**

Recent work by the team has relied upon hardware from Audinate, manufacturers of Dante, '*the leading AV-over-IP solution in the world*'. Audinate have invited Ferguson to give online webinars explaining his approaches to using 'Dante over Distance' which has been viewed by significant number of professional audio engineers, leading to significant reach within the industry [**C10].**

5. Sources to corroborate the impact (indicative maximum of 10 references)

- [C1] Hebrides Ensemble. 2015. *Transmitting the twitch of an eyelid to Trieste.* https://conts.it/did/masterclass-e-seminari/masterclass-2015/lola
Email from General Manager of the Hebrides Ensemble.

- **[C2]** Creative Carbon Scotland. 2015. *Hebrides Ensemble runs a Digital Masterclass using LoLa system.* https://www.creativecarbonscotland.com/hebrides-ensemble-runs-a-digital-masterclass-using-lola-system/
- **[C3]** University of Aberdeen. 2018. *Remembering war with musical collaboration.* https://www.abdn.ac.uk/stories/remembering-war/index.html
Email from Project Leader.
- **[C4]** UK Parliament. House of Commons. 2018. *Taking First World War Commemoration into the Future.* (EDM 1883).
- **[C5]** 4barsrest. 2019. *Brave New World to be conquered with technological first at Durham BRASS Festival.* https://4barsrest.com/news/38150/brave-new-world-to-be-conquered-with-technological-first-at-durham-brass-festival
- **[C6]** BBC. 2019. *Digital Planet's 18th birthday show.* https://www.bbc.co.uk/programmes/w3cszbwy
- **[C7]** Jisc. 2019. *Innovate and inspire: immersive collaboration.* https://www.youtube.com/watch?v=qqNUABxKsWc
Pearson. 2018. *A journey back to the future: Jisc Digifest 2018.* https://www.pearson.com/uk/educators/higher-education-educators/course-development-blog/2018/03/a-journey-back-to-the-future-jisc-digifest-2018.html
City, University of London. 2021. *Learning and teaching, reimagined.* https://blogs.city.ac.uk/learningatcity/2021/02/25/learning-and-teaching-reimagined
- **[C8]** UK5G Innovation Network. 2020. *Working Groups: Creative Industries.* https://uk5g.org/about/working-groups/creative-industries/
- **[C9]** Focusrite. *RedNet Enables 'World-First' Cross-Border Interactive Performance.* https://pro.focusrite.com/case-studies/live-sound/rednet-enables-%E2%80%98worldfirst%E2%80%99-crossborder-interactive-performance
Abbey Road Studios. 2020. *Remote Session Tools: An Overview from our Technical Services Team.* https://www.abbeyroad.com/news/remote-session-tools-an-overview-from-our-technical-services-team-2702
Resurface. *Dante over Distance: Remote is a Reality* https://resurface.audio/dante-over-distance-remote-is-a-reality
- **[C10]** Audinate Marketing Operations. 2020. *Dante over Distance (Edited Webinar – May 12, 2020).* https://vimeo.com/423560184