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Communicating Discovery Science

ARTICLE

Promoting the Higgs boson as 'discovery science' news: exploring the boundary spanner functions of CERN communication professionals'

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Abstract

The announcement of the discovery of the Higgs boson at CERN marked a groundbreaking achievement in Mode 1 'discovery science'. We combined analyses of CERN strategic documents and organisational structures with ethnographic observations of, and interviews with, communication professionals. Our findings show that promotion of this 'Mode 1' discovery, in combination with the potential for longer-term 'Mode 2' innovation, was a strategic priority for CERN, but highlighted operational challenges for coordination between scientists and journalists. We conclude that CERN communication professionals played an essential boundary spanning role, brokering solutions and maintaining relations across borders and between relevant constituencies.

Keywords

Popularization of science and technology; Representations of science and technology; Science and media

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1 ▪ Context

CERN was established in 1954 by 12 founding Member States[1] and is host to a community of distributed 'users', principally particle physicists, computer scientists, and engineers, from different countries. Since its inception, when the CERN Convention was signed, this intergovernmental scientific organization has been committed to openness and transparency in disseminating science [CERN, 1953],

> "The Organization shall have no concern with work for military requirements and the results of its experimental and *theoretical work shall be published or otherwise made generally available*" [CERN, 1953, p. 6, our emphasis].

Communicating science through peer reviewed research outputs has been, and continues to be, a consistent manifestation of CERN's commitment to openness, demonstrated through its pioneering role in the Open Access movement. (LHC-related articles were open access from the start.)

The Large Hadron Collider (LHC) has been at the centre of CERN's experimental programme since it began operations in 2008. Exemplifying Weinberg's [1961] conceptualisation of 'big science', the LHC represents a major international collaboration. Significant public funding and contributions from many external organisations were required to construct the LHC, creating an imperative for public value to be justified through social and economic dimensions, "that flow from public policy and investment" [Wilsdon, Wynne & Stilgoe, 2005, p. 27].

Publication of open research outputs, in combination with educational initiatives, forms of engagement, and communication via news media, have been, and continue to be, channels through which CERN has sought to demonstrate the value of public investment in the LHC [CERN, 2021], e.g., through the establishment of a public visits service in the 1990s.

1.1 ▪ *CERN 'constituencies' for communication*

Publicly funded research institutes like CERN involve constituencies[2] that are strategically important, internally (CERN Users), and externally (funders, other scientific institutes, politicians, local communities, journalists, teachers and students, and members of the public). CERN communicates and engages with these constituencies for various reasons.

Borchelt and Nielsen [2014] argue that public relations play an important role within science communication, with an increase in the institutionalisation of public relations within scientific organisations. Externally, dissemination of CERN science to other scientific institutes and in the public sphere, e.g., via news media, helps to demonstrate public value, to establish, maintain, and repair trust, and to share scientific findings and approaches to physics research.

1. At the time of writing CERN is run by 23 Member States, that "have special duties and privileges. They make a contribution to the capital and operating costs of CERN's programmes, and are represented in the Council, responsible for all important decisions about the Organization and its activities", https://home.cern/about/who-we-are/our-governance/member-states.
2. The term 'stakeholder' is widely used in this context, but "may inadvertently perpetuate colonial narratives and reinforce systemic inequities" [Reed et al., 2024]. We have therefore used the term 'constituencies'.

Whilst CERN Users are key partners in external communication via news media, especially in relation to large experiments such as the LHC, the job of mediating these functions is primarily down to teams of communication professionals.[3] In this instance, this involves the CERN's Communications Group. This paper aims to shed light on the 'boundary spanner' role of CERN's professional science communicators in 'brokering' the announcement of the Higgs boson in 2012 and the 10-year celebration in 2022.

1.2 ▪ *Communication professionals as boundary spanners*

Meyer [2010, pp. 118, 122] highlights the emergence and significant growth in 'knowledge brokers', calling on researchers "to analyze more thoroughly their practices, the brokering devices they use, and the benefits and drawbacks of their double peripherality [...] that is, from the fact that they are partially connected to the two worlds they bridge".

Neal, Neal and Brutzman [2022] conducted a systematic review to explore the terms 'brokers' and 'intermediaries' and 'boundary spanners'. They identified an archetypal definition of boundary spanners by Bednarek et al. [2018, p. 1176],

> "[...] we define the practice of boundary spanning as work to enable exchange between the production and use of knowledge to support evidence-informed decision-making in a specific context and boundary spanners as individuals or organisations that specifically and actively facilitate this process".

When conceptualising public information officers as boundary spanners in the context of medical research Ankney and Curtin [2002, p. 232] emphasise the functions of a "relational mediator", maintaining connections between key constituencies and establishing networks, clarifying perceptions, ideas, and requirements between actors with different forms of agency.

Dunwoody and Ryan [1983] anticipated Meyer's [2010] theoretical conceptualisation of double peripherality, arguing that the boundary spanning role is complex because, by its nature, it involves connections across sub-cultural professions, where the aims, challenges and terminology are different and potentially in conflict.

In this paper, we explore the boundary spanning and brokering functions of CERN Communication professionals in negotiating between the 'two worlds' of particle physics and journalism.

1.3 ▪ *Making discovery science news: the announcement of the Higgs boson*

The discovery of the Higgs boson at CERN marked a groundbreaking achievement in 'discovery science', adding to the Standard Model of Particle Physics, and contributing to scientists' understanding of the fundamental building blocks of the universe [ATLAS

3. Communication professionals may work for universities, institutes, experimental facilities, and laboratories such as CERN, others for well-resourced academic journals, others still for third party organisations, including PR agencies and news distribution platforms (e.g., EurekAlert!).

collaboration, 2012; CMS collaboration, 2012]. As a significant achievement in particle physics this is an example of 'discovery-science-in-the-making' [Latour, 1987].

Latour [1987] represents scientific progress as a Janus, a mythical creature with two faces. 'Science-in-the-making' represents one of the faces, knowledge under construction. This face is opposed by 'ready-made science', where knowledge has been 'confirmed'. In adding 'discovery' to Latour's concept of 'science-in-the-making' we are referring to Mode 1 knowledge production, characterised as academic, experimental, foundational, and discipline-based [Nowotny, Scott & Gibbons, 2003].

In the context of 'discovery-science-in-the-making', new knowledge, data, and/or theories are produced via Mode 1 epistemologies, involving contributions from experts (e.g., researchers and technicians), organisations registered to produce research (e.g., universities, institutes, experiments, and laboratories such as CERN), predominantly supported through public funding [Nowotny et al., 2003].[4]

Not all 'discovery-science-in-the-making' is newsworthy. For the purposes of this paper, we conceptualise news as a genre of media content that can be consumed online (via a range of digital platforms and outlets) and 'traditional' media (including television, newspapers and radio) [Schäfer, 2017].[5] News can be produced by professionals or 'amateurs', the latter incorporating forms of citizen journalism [Allan, 2009]. The news we focus on in this paper is produced for mainstream outlets by professional journalists. It is defined in practice through the application, by professional journalists, of 'news values' [Allan, 2009; Harcup & O'Neill, 2001].

As a sub-genre of news, science news includes,

> "[…] significant explicit scientific content, namely a reference or references to scientific findings, scientific research, scientific procedure, science as an intellectual activity or scientists in their professional capacity" [R. Holliman et al., 2002].

There is a well-established relationship between the publication of science in high-impact journals and the selection and production of science news [Väliverronen, 2021; Weitkamp, 2014; Weitkamp & Eidsvaag, 2014; Peters, 2013, 2011; Trench, 2009; Richard Holliman, 2004; Kiernan, 2003; Miller, 1999; Wilkie, 1996; Nelkin, 1995]. This process is 'brokered' by communication professionals who review, filter and select and reconstruct 'science-in-the-making' for newsrooms by producing 'information subsidies' [Gandy Jr., 1982]. In this paper, we explore CERN Communication professionals' boundary spanning role in conceptualising and producing information subsidies in support of the Higgs announcement.[6]

Reporting of the announcement of the Higgs boson featured as breaking news with global front-page coverage between 2nd and 8th July 2012 [Incelli, 2018]. Such was the significance

4. In contrast, Mode 2 epistemologies involve varied forms of representation and sharing, discovery science focuses on forms of scholarly publication, notably academic journals [Nowotny et al., 2003].
5. We note arguments about the decreasing influence of 'traditional' forms of science news (television, radio, and newspapers) due to the popularity of digital tools and technologies [e.g. Väliverronen, 2021].
6. Research demonstrates that press releases support science organisations in getting new science into the public sphere via news reports [Weitkamp & Eidsvaag, 2014].

of the Higgs boson announcement in 2012 that CERN organized a retrospective, 10 years later [ATLAS collaboration, 2022; CMS collaboration, 2022]. In this paper, we compare how CERN's strategic and operational priorities for communicating 'discovery science' changed between 2012 and 2022.

2 ▪ Methods

This paper re-analyses data collected during the announcement of the Higgs boson, 1–6 July 2012, followed by two further periods, November 2012, March 2014 [Dorey, 2016].[7] An iterative, mixed methods approach was adopted, combining ethnographic observations, semi-structured interviews and document analysis to triangulate data [Jensen & Holliman, 2009], offering 'complementary assistance' across datasets [D. L. Morgan, 1998].

Document analysis offered insights into CERN's strategies and policies for prioritising and supporting research communication, and organisational structures for delivering these objectives. This method is versatile, supporting analysis across a range of texts [H. Morgan, 2022]. 'Purposeful sampling' was deployed [Flick, 2018]. Selected documents included at least one reference to strategic objectives or operational planning for communication about the LHC or Higgs boson.

The following documents were analysed:

- Communication Strategy, 2012–2016;
- LHC Communication Plan, 2006;
- Strategic Communication Plan, 2009;
- Annual Report, 2012;
- Code of Conduct, 2010;
- Social Media Guidelines, 2014;
- Staff Rules and Regulations, 2007, updated 2013;
- Press Releases and Media Packs, e.g., "Observation of 'Higgs' like Boson", "Open Access Initiative Launched at CERN".

Most of the documents were obtained following searches of the CERN Document Server.[8] Other documents were identified through the interviews and ethnographic observations with members of the Communications Group.

The document analysis included a review of CERN's organisational structures, identified from CERN strategies and plans, providing context for governance, function and connections [McNulty, Zattoni & Douglas, 2012]. This process, undertaken by one coder,[9] combined elements of content analysis and thematic analysis [Bowen, 2009]. Documents were read to gain an overview of their content and relevance to the study. This was followed by close

7. No strategically significant research communications were planned in November 2012 and March 2014, hereafter described as 'steady-state operations'.
8. The Document Server, https://cds.cern.ch/?ln=en, further demonstrates CERN's commitment to openness.
9. The analysis was conceptualised and applied within the context of a PhD project, therefore involving the supervision team.

reading of the texts, identifying relevant quotes and passages of text. Texts were arranged into categories, coding the data to identify themes, including openness, organisation, scientific mediation and communications.

Emergent findings derived through the document analysis were explored through ethnographic observations and interviews [Schensul, Schensul & LeCompte, 1999]. We report here on observations and interviews with six 'key informants' [Lokot, 2021], each working in the CERN Communications Group between 2012–14. These individuals were selected to represent the communication functions that the group undertook during this period:

- Head of Communications
- Head of Press
- Social Media Manager
- Internal Communications Manager
- Web Manager
- U.K. Communications and Innovations Officer

An 'observer as participant' role was undertaken for the observations [Gold, 1958], involving in situ structured field notes, complemented by rich descriptions produced at the end of each day [Mulhall, 2003]. Some meeting presentations were recorded; slides were made available to the lead researcher (JD).

Observational data was mainly collected at CERN's Meryin Site, Switzerland. Initial observations were carried out during the Higgs update, 1–6 July 2012 when the Communications Group was working in a 'heightened' state, preparing pre-planned media events, press releases, and acting as brokers between CERN Users and journalists. Fieldnotes were taken during these observations. Press Releases and media packs were also collected for analysis.

Further observations were carried out with the Communications Group in November 2012, when the group was working in a 'steady state', i.e. there were no planned media events.

In addition to these observations the lead author attended meetings between the Heads of Communications from High-Energy Physics labs around the world, communicators from physics institutes in CERN member states, and meetings between CERN's Heads of the Communications and Engagement teams for the LHC experiments. (This included a meeting with the InterActions collaboration,[10] and a joint meeting between the European Particle Physics Communication Network[11] (EPPCN) and the International Particle Physics Outreach Group.)

Field notes were taken during meetings. Detailed summaries were written at the end of each day. Presentations within these meetings were audio recorded and the slides made available.

In March 2014, six senior members of the CERN Communication Group were observed across a working day, 9am-5pm, observing and recording routines. Data took the form of

10. The InterAction Collaboration consists of Heads of Communication at the world's major particle physics laboratories and funding agencies, https://www.interactions.org.
11. CERN established a network of communication professionals, the EPPCN, which is made up of representatives from CERN Member States.

descriptive field notes, using a template. Products of participants' activities (Press Releases, Social Media posts, etc.) were collected for analysis. Summaries were written directly after each observation, with an initial analysis informing interview protocols for semi-structured interviews. Interviews were held the day after the observations. Interviews were recorded and transcribed in full; 'denaturalised' transcripts were produced for analysis [Oliver, Serovich & Mason, 2005].

Data analysis of the observation and interview data combined elements of content analysis and thematic analysis [Bowen, 2009]. Themes were derived from iterative interrogations of the datasets, informed by deductive (theory-driven) and inductive (data-driven) analyses [Silverman, 2005]. Texts were categorised under themes through open, axial and selection coding [Cohen, Manion & Morrison, 2011], involving a back-and-forth interplay with the data, as codes and concepts were (re)checked to identify similarities, differences, and patterns [Dorey, 2016].[12]

Two coders reanalysed these data, through a deductive (theory-driven) approach, exploring the press office function within the concept of a 'boundary spanner' [Ankney & Curtin, 2002]. The themes offer insights into:

- Promotion: CERN's strategic commitment to publicising discovery science and innovation over an extended period.
- Organisation and coordination: how positioning and coordination of communication functions informed the Higgs announcement.
- Boundary spanning practices: how CERN Communication Professionals prioritised, coordinated and delivered the Higgs announcement.

The supervision team for the initial study [Dorey, 2016] included a member of CERN's Communication Group and two academics. To produce this paper, we have reconvened that team with the lead researcher and introduced a new contributor, a recent member of CERN's communication staff. Together, the CERN Communication Staff have drawn on their experiences of professional practice, in combination with the lead author's ethnographic, interview and document data, to explore similarities and changes at CERN between 2012 and 2022.

3 ▪ Results and discussion

Findings and interpretations have been organised by theme.

3.1 ▪ *Promotion of discovery science and innovation*

Promotion of the LHC was a strategic priority in the first *LHC Communication Plan* [CERN, 2006], which sought to: 1) generate maximum news coverage about the LHC prior to its launch, and throughout its operation as a demonstration of open research; 2) establish CERN and the LHC as forces for long-term innovation.[13]

12. [Dorey, 2016] identified openness, digital scholarship and communication practices as themes in the initial study.
13. Subsequent strategic plans had similar aims [e.g. CERN, 2011, 2008].

> "The aim of the LHC communication plan is to gain maximum benefit in terms of public image for CERN and particle physics world-wide through the unique communications opportunity presented by the start-up of the LHC in 2007, and first results coming some months later."
>
> [CERN, 2006, p. 4]

CERN sought to demonstrate the value of public investment in the LHC's 'Mode 1' discovery science, in part, by consistently promoting the potential for 'Mode 2' innovation.

> "You need this virtuous cycle of basic research, driving innovation, driving applied research, driving innovation that then drives basic research again. If you break this virtuous circle, you start losing something. If you don't invest in basic research at some stage you start losing the basis of applied research. The two are intimately interconnected."
>
> [CERN's Director General, Rolf-Dieter Heuer, quoted in Jung, 2012]

We argue that this strategic positioning, to partly justify investment in CERN's Mode 1 discovery science through the potential for Mode 2 innovation, reflects wider changes in the system for publicly funded research. Gibbons [1999] offers a succinct account of the developing relationship between universities, governments, industry and society from the mid-1940s to the millennium, arguing that the conditions under which knowledge was produced and accounted for during this period changed profoundly, pivoting towards what can be characterised as a 'knowledge economy' underpinned by 'Mode 2' epistemologies.[14] In justifying the public value of the LHC in this way, CERN's core messaging reflected these changing epistemological conditions.

Journalists were an important audience with the objective of generating news coverage about the LHC to demonstrate openness throughout the research process. To illustrate the point, around 1000 accredited journalists representing more than 300 outlets were at CERN for the LHC First Beam Day in September 2008 [Gillies, 2008].

Ethnographic observations, combined with interview data, showed that CERN communication professionals actively managed these relationships prior to, during and following the announcement of the Higgs boson, e.g. for the first 7 TeV collisions, which were,

> "[…] covered by print, radio and television news around the world. At least 2,200 news articles were published in print and online on the same day […] More than 100 journalists from 68 media outlets in 18 countries attended the event at CERN. […] The link to the press release announcing the first 7 TeV collisions was clicked on 58,000 times" [Gillies, 2010].

CERN communication professionals saw benefits in brokering long-term relationships during 'steady-state operations', establishing and maintaining a 'trust portfolio [Borchelt & Nielsen,

14. Concerns have been raised about the shift away from Mode 1 forms of knowledge production, "The kinds of work that academics have suggested is under threat in U.K. universities include curiosity-driven, 'blue skies' research…" [Smith, Bandola-Gill, Meer, Stewart & Watermeyer, 2020, p. 2].

2014], and sensitizing journalists in advance of the next newsworthy announcement. In this sense, CERN's 'steady state' communication strategy conflicted with standard news values, which tend to favour short-term events over longer-term and periodically re-surfacing narratives [Miller, 1999].

The 2012–2016 *Communications Strategy* [CERN, 2011], which was in place during the announcement of the Higgs boson discovery,[15] sought to capitalise on increased visibility to generate and sustain political, financial and societal support for CERN's high-energy physics research programme [CERN, 2011]. This strategy also reflected changes to research systems in favour of greater dialogue between science and society [e.g. Wilsdon & Willis, 2004], outlining how CERN communication professionals and researchers should engage with, and benefit from, wider societal constituencies, i.e., beyond journalists and news.

Eleven audiences were identified as strategically important during the announcement of the Higgs boson (Table 1).

Table 1. Audience/activity matrix [adapted from CERN, 2011].

Activity	Community										
	1. CERN	2. Public	3. Local	4. Media	5. Sponsor	6. Alumni	7. Edu	8. Culture	9. Kids	10. Industry	11. Job seekers
Website	+	+	+	+	+	+	+	+	+	+	+
Social media		+		+							+
Spokesperson		+		+							
Press Office		+		+				+			
CERN Courier	+			+						+	
Internal Comms	+										
Brochures		+	+	+	+	+	+		+	+	+
Annual Report	+	+		+	+	+		+			
Photo/Video	+	+	+	+				+		+	+
Graphic design	+	+	+	+	+	+	+	+	+	+	+
Events		+	+	+	+	+	+	+	+	+	+
Exhibitions	+	+	+				+	+	+	+	+
Newsletters					+	+					
Corporate info support	+	+	+	+	+	+	+	+	+	+	+
Copy editing	+	+	+	+	+	+	+	+	+	+	+
Translation	+	+		+	+	+	+	+	+	+	+

Table 1 shows that 'media' (read journalists) retained their status as a strategically significant audience, with many activities aimed at this constituency. Data from the ethnographic observations and interviews showed that journalists remained core to the CERN Communication Group's 'trust portfolio' [Borchelt & Nielsen, 2014]; activities were designed specifically for them,

15. Details of how this strategy was operationalised are described in the following sections, 'Organisation and Coordination at CERN' and 'Boundary spanner practices'.

> Interviewer: "Would you say there's an audience you target more than others?"
> Interviewee: "We put a lot of effort into journalists, I mean both through Press Releases and through site visits and setting up events for them as well as just briefing them [...] in the lead up to big events I will phone many, many journalists and talk to [...] journalists about [...] what's coming up, so that they [...] have time to get their stories right. [...] There are a number of journalists [...] who I speak to quite regularly about what's happening here and will tell them things on and off the record as necessary and can trust them absolutely implicitly not to do anything with that information."
> (Interview: Head of Communications, 22.11.12)

As Blöbaum [2014] explains, trust plays an important role in the relationships between journalists and individuals and organisations outside of newsrooms. The relationships built by CERN communication professionals with journalists in their role as boundary spanners maintained this 'trust portfolio' [Borchelt & Nielsen, 2014]. Much of this work took place during 'steady state' operations, establishing and maintaining relationships with journalists, e.g., during the LHC shut down from 2013,

> "We wanted to bring the most important commentators from our Member States[...]. We organised every two weeks a slot where they could visit [...] That has generated stories, even though that's not what it's all about. The whole point is to familiarise them with what's here. People have moved on and changed, people have come in since the last time we did it. Most of the time they are journalists and they find stories and go home and tell them. So that has helped."
> (Interview: Head of Communications, 04.02.14)

The benefit of building relationships was highlighted during the interview with the Head of Press, who briefed a local journalist circa 2014 about CERN's tentative long-term plans, including a study into the feasibility of a new 80–100km circular collider, now known as the Future Circular Collider (FCC).

> "It's just a study to see what is feasible, how much it would cost to do that, but still as soon as you start such a process you can't hide it, not in the time of social media [...] we don't want people to think we are starting to dig holes, new tunnels of 80km yet [...] we invited a local journalist [...] we know him very well so we know it should be serious. I pushed for that because I know journalists copy from what they read elsewhere so I want to have at least one good article out in a serious thing, so if the others want to write something they will read this first"
> (Interview: Head of Press, 03.02.2014)

The relationship between the journalist, who received exclusive, targeted, newsworthy information directly from a reliable source, and the CERN communication professional, was symbiotic and built on trust. Acting as boundary spanners, CERN communication

professionals sought to reduce the potential for misinformation and 'churnalism' [Davies, 2008], opening up a space for upstream engagement about the public value of this new discovery science facility [Wilsdon & Willis, 2004].[16] In doing so, they drew on the 'double peripherality' of their specialist knowledge of high energy physics and news [Meyer, 2010].

As Borchelt and Nielsen [2014] describe, regular, trustworthy interactions are crucial to gaining, maintaining and repairing relationships between priority constituencies and a scientific organisation. The diversification of constituencies extended this boundary spanning work for CERN communication professionals, in combination with a greater range of channels through which to communicate and engage.

3.2 ▪ *Organisation and coordination*

The organisational structures and culture of an institution influence how its members communicate [Hoogervorst, van der Flier & Koopman, 2004]. We explored the organisation and coordination of CERN communication professionals as boundary spanners, how this influenced the flow of information to journalists, and whether the epistemological conditions of discovery science affected these processes.

CERN is one of several international research organisations investigating particle physics. It is devolved in aspects of its governance and committed to the principles of openness. Knorr-Cetina [1999] described CERN's organisation and component experiments as a 'post-traditional communitarian structure', with distributed responsibility and authority, whilst Boisot [2011] characterised CERN's experimental collaborations as 'adhocracies'.[17] Culturally, establishing priority in physics has been highly competitive [Gaston, 1971].

This context was acknowledged by a collective of communication professionals prior to the start-up of the LHC.

> "The media have a central role in telling the story of research in particle physics. We need to put aside our differences and keep our eyes on the big picture if we are to make the most of this vast resource [...] In the past, there have been occasions when our field has devolved into warring camps, reading each new press article with suspicion, quick to take offence at every real or imagined slight or bias. It's time to change this model. [...] We can set a tone of respect and admiration for all projects and experiments that lead to discovery – or one that begrudges every word of praise for others' work" [InterAction collaboration, 2006].[a]

a. The InterAction Collaboration consists of Heads of Communication at the world's major particle physics laboratories and funding agencies, https://www.interactions.org.

Significantly, this group of communication professionals spanned national borders, cultures and institutions to promote discipline, collegiality, and cooperation across international

16. Planning for the FCC is ongoing, with a feasibility study scheduled for publication in 2025. Public value of this facility is partly demonstrated in economic returns, e.g., "Estimated benefit–cost ratio of 1.66", https://home.cern/science/accelerators/future-circular-collider.
17. Mintzberg and McHugh [1985] define adhocracies as complex and dynamic environments, with unique and complicated outputs, involving highly trained experts working in multidisciplinary teams working in decentralised, specialised units.

particle physics laboratories and with newsrooms with a view to improving research communication.

Further contextual challenges to organisation and coordination were documented in the *2012–2016 Communications Strategy* [CERN, 2011].

> "This proposed communications strategy identifies and addresses some key problems in the way that CERN's communications function is currently managed and resourced. At the core of these problems is the fact that communications activities are distributed and uncoordinated" [CERN, 2011, p. 19].

Associated risks focussed on misinformation, missed opportunities and reputational harm [CERN, 2011].

Organisational cooperation involved CERN's Communication and Education Group, IT Communications, CERN Member States and the LHC experiments. Observations of, and interview data with, the Head of Communication highlighted the challenges of managing multiple roles and functions,

> "My job involved advising the DG [Director General], ghost writing for the DG and being the spokesperson for the lab, as well as running the Communication Group. My section leaders had a great deal of autonomy, so their teams were not so closely tied to the DG."
>
> (Personal communication: Head of Communication)

CERN's organisational structures in 2012 for communication can be characterised as an adhocracy (Figure 1).

The boundary spanner function of CERN communication professionals was crucial in designing and coordinating the timing of announcements, and discipline in respecting this schedule, for the announcement of the discovery of the Higgs boson.[18]

Observations showed that embargoed information subsidies (electronic press releases) were scheduled in particular ways, e.g., under embargo for journalists when a paper was published in an academic journal and featured in the journal's press release. This was not the case for the Higgs Update Seminar in 2012, where the press release was issued at the agreed time without embargo, although certain key journalists were briefed before the announcement.

Coordination and discipline within CERN were significant. In 2012 CERN personnel totalled 14,592,[19] each of whom had access to digital technologies, which could be used to 'leak' scientific information. To counter this, the Communications Group circulated the procedure outlined in Figure 1, alongside guidelines on the use of Web 2.0 technologies, to CERN users [CERN, 2008]. Blogs were categorised as "scientific", " internal", and "private"; within the scientific category, the guidelines emphasised that,

18. Previous research, e.g., [R. Holliman, 1999] on the now discredited announcement of life on Mars in 1996, has shown that leaked information can result in chaos and misinformation.
19. CERN Personnel Statistics 2012, https://cds.cern.ch/record/1571169/files/CERN-HR-STAFF-STAT-2012.pdf.

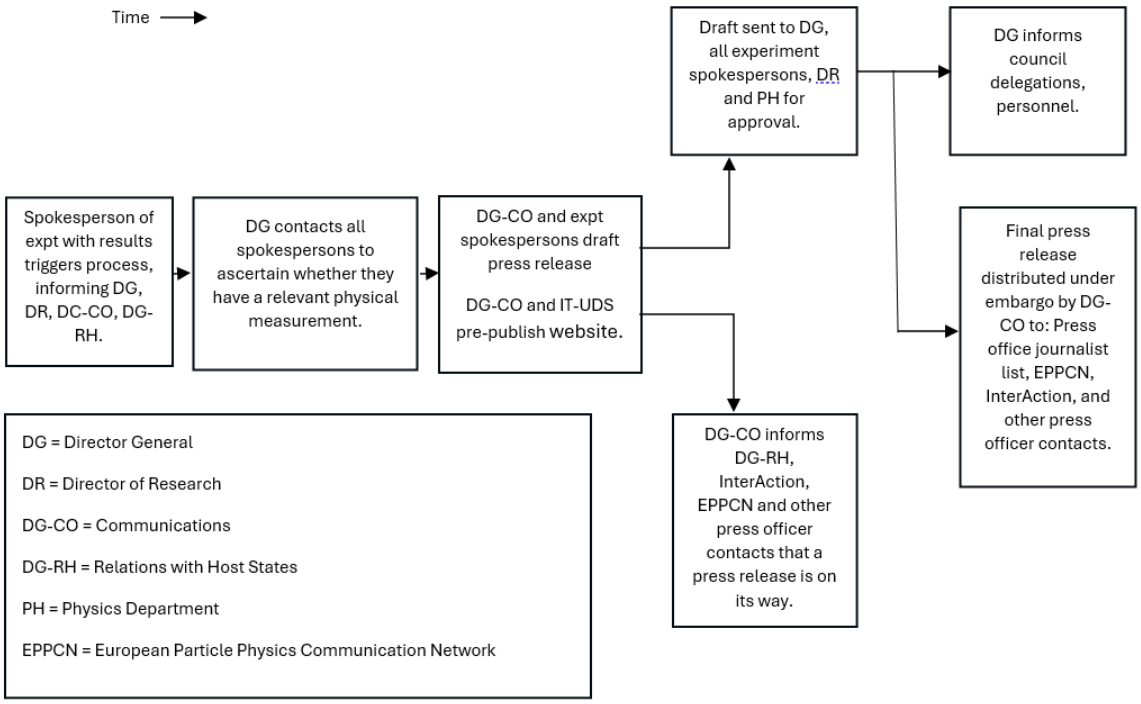

Figure 1. The internal coordination of the relationship between the CERN Communications Group and experimental facilities, demonstrating the points at which communication professionals performed boundary spanner functions [CERN, 2008].

> "Nothing should be discussed or shown that has not yet been approved. Furthermore, bloggers should kindly refrain from posting discussions on just-approved CMS results until the collaboration has officially presented them first" [CERN, 2008, p. 48].

These guidelines, introduced following an earlier incident at Fermilab,[20] also called on CERN users to refrain from discussing internal matters on blogs, e.g., operational issues, procedures and the content of private meetings [CERN, 2008].

> "The experiments have their own guidelines [for blogging], and this was triggered by a particular blogger [...] He started blogging things that were not mature, and his collaboration wasn't ready for him to release them, so they weren't considered to be mature results. [...] these got picked up and reported as fact [...] So that led to the introduction of guidelines in all the experiments."
>
> (Interview: Head of Communications, 22.11.12)

The distributed and devolved nature of the organisational structures at CERN was beneficial to the validity and reliability of CERN research findings, because each experiment explored the confidence of findings autonomously in the first instance, then through anonymous peer

20. Fermilab is America's particle physics laboratory, https://www.fnal.gov.

review as manuscripts were submitted to academic journals. In contrast, the nature of CERN as an adhocracy, combined with the desire of researchers to establish priority, raised challenges for the Communication Group. Coordination across the various organisational units, with communication professionals promoting discipline within an agreed process for releasing information (Figure 1) was key to managing the announcement of the Higgs boson.

3.3 ▪ *Boundary spanning practices*

Analysis of the observations and interviews showed communication professionals acting as boundary spanners [Ankney & Curtin, 2002], playing the role of broker between CERN personnel and journalists. The previous sections have shown that this role was significant during 'steady state' operations and in the lead up to the Higgs discovery announcement. This section combines data from ethnographic observations, interviews and document analysis to demonstrate how this earlier groundwork was challenged during the highly pressurised global announcement of the Higgs.

The Higgs discovery was announced on 4 July 2012 through a 'hybrid' scientific seminar as part of ICHEP 2012;[21] a CERN press release was issued on the same day.[22] Countering the advice of CERN communication professionals and representatives to the European Particle Physics Communication Network (EPPCN),[23] who wanted to issue CERN and EPPCN press releases at the start of the seminar, CERN management embargoed these information subsidies until the first experiment had presented its results.

The decision to embargo press releases of this global announcement presented challenges to those working in different time zones, for example,

> "We had a fundamental question at the very beginning, do we sit and wait for the seminar to finish, knowing full well what is going to be said, or do we say this is a media event and get someone to say, 'what they are about to tell you is this' [...] So we cheated, but we told CERN we were going to cheat and we had a very careful consideration with the physics groups as well."
>
> (Interview: U.K. representative, 30.11.12)

In the U.K., there was an event with a 'live feed' from CERN. The then Chief Executive of the U.K.'s Science and Technology Facilities Council announced news of the Higgs discovery before the press releases were issued. As a result, journalists in CERN Member States picked up the story from U.K. news, and not from the country-specific press releases that had been prepared by EPPCN delegates in each Member State.

21. The 36th International Conference on High-Energy Physics was hosted in Melbourne, https://indico.cern.ch/event/181298.
22. The CERN Communications Group coordinated embargoed information about the Higgs announcement for a wide range of constituencies in advance of the seminar, briefing local journalists, preparing of information subsidies, and organising media events.
23. CERN established a network of communication professionals, the EPPCN, which is made up of representatives from CERN Member States. Together, the CERN Communication Group and the EPPCN coordinated the Higgs announcement. EPPCN representatives prepared country-specific press releases and agreed unanimously to issue them at the start of the seminar. This decision was not accepted by CERN management.

This decision caused issues in other CERN Member States, e.g., news organisations in Finland and Norway saw the U.K. reporting. The Norwegian EPPCN representative analysed coverage later and reported that while daily outlets in Norway covered the story, none initially reported that Norwegian scientists were involved. Later, after the Norwegian press release had gone out at the agreed time, Norwegian news outlets started to talk about Norway's role in the discovery.[24]

As CERN's Head of Communications describes, this strained relationships with other journalists.

> "[The U.K.] announced it before we did. That caused problems for other people. It meant they couldn't tell their story the way they wanted. [...] One journalist said, 'It was great, but it was a mess because we played the game, we respected your embargo, and it was very frustrating to see this spoken about everywhere else before we were allowed to say anything'."
>
> (Interview: Head of Communication, 30.11.12)

This example highlights the importance of cooperation between CERN communication professionals and those representing the EPPCN in delivering timely, coordinated communication. These boundary spanners drew on their professional expertise to anticipate the potential for the embargo to be broken and advised CERN management when to issue the press release.

As a result of the broken embargo, communication professionals acted as boundary spanners to repair relationships.

> "[...] because boundary spanners interact with different groups, and each group has different expectations, including how the person should act, the values he or she should possess, and what interests he or she represents, role conflict remains one of the most difficult problems [...]" [Ankney & Curtin, 2002, p. 232]

The importance of creating, maintaining and repairing relationships was observed at meetings involving communication professionals from international physics labs, CERN Member States and representatives of the LHC experiments.

4 ▪ Celebrating the 10^{th} anniversary of Higgs announcement

In this section, we compare CERN's strategic and operational priorities for communicating 'discovery science' between 2012 and 2022. We have structured this contribution around reflective questions including, did the strategic focus of CERN communications shift for the announcement of the anniversary of the discovery in 2022, has the communications architecture and positioning of the communications team changed, and has the boundary spanning function evolved significantly?

24. Research has highlighted the significance of national perspectives as news values in the context of international discovery science projects [R. Holliman et al., 2002].

By the time of the 10^{th} anniversary of the Higgs boson discovery in 2022, several contextual factors had changed, not least the status of the scientific announcement which we characterise for the 10^{th} anniversary as 'discovery-ready-made science' [Latour, 1987] because, in effect, the science behind the 2012 Higgs announcement had been subjected to extended peer review and 'confirmed'.[25] Another important change concerned the post-LHC future. While mentioned in pre-LHC start-up communications, the proposed Future Circular Collider had become a key communication objective by 2022 with dedicated messaging [CERN, 2021]. As is often the case with investment in 'big science' [Weinberg, 1961], lead times for major new facilities are measured in decades.[26]

The relationship between media producers (including communication professionals and journalists) also evolved over this ten-year period, with greater emphasis on scientists' direct contributions to communication [Barel-Ben David, Garty & Baram-Tsabari, 2020], audience participation [Schäfer, 2017], and the use of Web 2.0 technologies for 'polyvocal'[27] communication and engagement [Habibi & Salim, 2021].

In contrast to earlier priorities [CERN, 2011, 2008, 2006], CERN's 2022 strategy was structured around three themes: 1) celebrating a discovery, the Higgs boson, that changed the field of particle physics, reflecting on this 'confirmed' finding as "discovery-ready-made-science" [ATLAS collaboration, 2022; CMS collaboration, 2022]; 2) knowledge gained over the 10 years following the discovery; and 3) preparations for a post-LHC collider future [CERN, 2021].

Whereas pre-LHC start-up communications strategies used language such as 'raising awareness' through the 'unique opportunity' presented by the LHC start-up [CERN, 2006], subsequent documents evolved to 'build on the platform created by the public impact of the LHC start-up' [CERN, 2011, 2008]. The strategy in place in 2022 [CERN, 2021] placed a stronger emphasis on 'fostering engagement', evident in the exploitation of the opportunities for 'polyvocal' exchanges mediated through Web 2.0 and by brokering scientists' direct contribution to public communication on these platforms. As examples, the 10^{th} anniversary celebrations included a travelling exhibition,[28] public events,[29] combined with moderated discussions with experts in high-energy physics across social media platforms.

Although already an important element of CERN's communications, the requirement to communicate impact on society and the economy through innovation and technology grew steadily between 2012 and 2022. Even though the focus of the 2022 anniversary was "discovery-ready-made-science", communicating the relevance of the Higgs boson to everyday life was a component of the communication strategy.[30]

25. Ziman [2000, p. 182] reminds us that "Philosophers constantly insist that scientific knowledge is provisional, but they seldom remind us that, even though it is continually expanding, it is very patchy in its coverage. This is not just a regrettable weakness, which can be forgiven because it will in due course be made good. It is a fundamental epistemic characteristic of academic science, closely connected with its social structure and cultural practices".
26. This is also the case for investment in other forms of Mode 1 'big science', e.g., space science.
27. Recent conceptualisations of engagement have rejected the notion of 'two-way' dialogue between scientists and the public in favour of 'polyvocal' conceptualisations involving a wider range of constituencies [Richard Holliman et al., 2024].
28. Multiple posters illustrating the different aspects of 10th anniversary of the Higgs boson's discovery event, https://cds.cern.ch/record/2811785?ln=en.
29. For example, Particle Fever continues…the Higgs boson was just the beginning, https://indico.cern.ch/event/1163480.
30. For example, How does the Higgs boson impact everyday life?,

Not everything changed, of course; nurturing relationships with professional journalists continued to be a core function,

> "While CERN is preparing messaging around three themes [...] the anniversary also presents critical risks in terms of messaging and external visibility that could bring sensitive questions from journalists. [...] it is essential to prepare [to] mitigate the risks and leverage the opportunities that these questions present. The topics can also be seen as an opportunity to provide messaging around the value of high-energy physics in terms of scientific, technological, economic, and human capital as well as international cooperation."
>
> (Media Training Brief for CERN Management prepared by the Head of Media)

Involving regular interactions with journalists, the production of information subsidies, and training for CERN Users, communication professionals continued to maintain the 'trust portfolio' [Borchelt & Nielsen, 2014], acting as brokers between CERN Management and journalists.

Organisationally, changes were made. Through the start-up phase, CERN communications was based in the Director-General's office; the laboratory's education and outreach functions were handled separately. This changed in 2016, when these functions were merged into a group entitled Education, Communications and Outreach (ECO) in the newly created International Relations sector. The name reflects the strategic change in emphasis. Within this new organisation, the 10^{th} anniversary of the Higgs discovery was developed with communication, outreach and education components. Seven target audiences were identified: the CERN community, the wider particle physics community, decision-makers (CERN's Member and Associate Member States), local communities, citizens, teachers and students, and journalists. Many communications and outreach functions continue to be decentralised, with teams in the experiments and several departments. To strengthen coordination, the central role of the ECO group in defining and implementing CERN's communications and outreach programmes was codified in the 2021–2025 Communications Strategy [CERN, 2021].

Collaboration across CERN and with the InterActions and EPPCN networks was core to the communication and outreach strategy for the 10^{th} anniversary. In 2012, discipline around releasing information was the main concern. In 2022, although timely and concerted communication of the anniversary was important, the focus of the collaboration was on agreeing on common underlying messages and a core package of communication assets that could then be adapted by the Member States in a timely manner, to highlight Member States' contributions to the discovery. In this way, we argue that the boundary-spanning roles of the distributed communicators was extended and strengthened.

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https://home.cern/science/physics/higgs-boson/why.

5 ▪ Conclusions

We have studied CERN's strategic approach and the operational practices of communication professionals in communicating Mode 1 discovery science about the LHC, in combination with the potential for associated Mode 2 innovation. Together, the communication of Mode 1 and Mode 2 epistemologies helped to justify the public value of this 'big science' initiative [Weinberg, 1961].

We found that the operationalisation of this strategic priority required coordination by CERN communication professionals in the context of an organisational structure that can be characterised as a decentralised 'adhocracy' [Boisot, 2011]. This context had benefits for the progress of discovery science but presented challenges for communication professionals working in a 'boundary spanning' role as relational mediators [Ankney & Curtin, 2002] in the context of 'double peripherality' [Meyer, 2010], brokering relations across CERN Users, newsrooms, cultural norms and international borders.

CERN's commitment to early and routine communication, in combination with work to establish relationships during 'steady state' operations, was key to maintaining and repairing relations with journalists, CERN Users and representatives from Member States during and immediately after the Higgs announcement. Early work by communication professionals in the years prior to the announcement of the Higgs laid the foundations for the highly pressurised announcement. However, this timely, coordinated approach was challenged: 1) by scientists' desire to establish priority during the pressurised conditions of the Higgs announcement and the demands of 24/7 global news; and 2) the ease by which information can spread via digital technologies. CERN communication professionals played an essential role in establishing procedures and promoting discipline to counter these challenges, also brokering and repairing trusted relationships between researchers, journalists and representatives from Member States. These connections, and the relationships that resulted, were born of CERN communication professionals' role as 'boundary spanners' within a Mode 1 research system for high-energy physics.

In conclusion, we argue the 'boundary spanning' function of CERN communication professionals, between internal and external groups, specifically between scientists, research institutions and journalists working for a range of international news organisations, were crucial in developing, maintaining and repairing the 'trust portfolio' around this discovery science [Borchelt & Nielsen, 2014]. We hope that these findings offer lessons to other Mode 1, 'big science' endeavours, e.g. space and planetary sciences and large experimental facilities.[31]

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31. Examples include the U.K.'s STFC-funded National Campuses and National Laboratories, https://www.ukri.org/who-we-are/stfc/facilities.

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