

# Collaborative Tools and the LHC: *Some Success, Some Plans*

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**Abstract.** I report major progress in the field of Collaborative Tools, concerning the organization, design and deployment of facilities at CERN, in support of the LHC. This presentation discusses important steps made during the past year and a half, including the identification of resources for equipment and manpower, the development of a competent team of experts, tightening of the user-feedback loop, and the final design and installation of facilities at CERN. I also summarize current discussions to extend this progress to other services and present my own proposals for future development.

## 1. Introduction

During CHEP 2007 in Victoria, I introduced the recently formed RCTF (Remote Collaboration Task Force), chaired by CERN IT, and comprising LHC representatives, developers, and experts in the field of collaborative tools [1]. This committee was formed in response to recommendations of the LCG RTAG 12 Final Report [3], proposing the centralization of coordination under CERN IT, with oversight from the LHC experiments.

Since then, RCTF has overseen development at CERN, effectively implementing most of the key recommendations. This has included the signing of service-level agreements by ATLAS and CMS, specifying the installation and support of conference facilities at CERN. As much of the deployment is now complete, attention is shifting toward other possible agreements, including application support, lecture archival services, and facilities for detector and data monitoring. This note will briefly summarize a few of the successful implementations of both policy and material deployment, before discussing future plans and recommendations for focus in the coming years.

## 2. The LHC Challenge

Experimental particle physics took a major leap forward this past year with the commissioning of the LHC and its dedicated experiments. The energy and luminosity of the collider promise to usher in a new era of discovery, during which key questions concerning the form and limits of the standard model and/or any superseding theory can and must be resolved, one way or another.

The size and complexity of the detectors, required to handle the high energy and event rate of the LHC, take the field to a new level, with typical dimensions that are many times larger than any predecessor. The resources and effort required to design, construct and run these detectors have given rise to collaborations that are similarly larger, with more than 2000 physicists in each of the largest experiments. This increase in collaboration size, as well as the long duration of the experiments (3-4

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decades from design to construction through running), has brought about what is arguably the largest paradigm shift in the field, a dramatic increase in the distributed nature of the collaborations.

As an example, the ATLAS experiment currently boasts the participation of 2500 physicists, representing 169 institutes in 37 countries spread all over the world. These physicists, including 700 students, have actively participated in the design, construction and commissioning of the detector for the most part, from their home institute, and not at CERN. The high level of coordination required for the construction of such a large, complex, and intricately connected scientific instrument has placed new pressure for fast, reliable, high quality communication links between the participants. Periodic conferences, detector and computing workshops, weekly meetings, and impromptu gatherings have become the norm. Yet, international communication and travel costs require that new solutions be found to handle these rapidly increasing needs; old solutions simply do not scale.

### **3. Addressing the Challenge: A Brief History**

#### *3.1. Research & Development*

As is typical to our field, when there is a new problem, solutions have been proposed from within the HEP community. The VRVS [4] video conferencing system, for example, was developed during the LEP era to solve growing communication needs within that community. The primary goal was to create a flexible system that could address the unique constraints of HEP: participants located at end points with a variety of hardware and software environments, large bandwidth variations, different operating systems, and a variety of meeting scenarios, including desktop-to-desktop, meeting-room-to-desktop, meeting-room-to-meeting-room, plenary sessions, etc.

In addition, in the early LHC days, the WLAP [5] lecture archival project was put in place by the ATLAS Collaboratory Project [6] to address the non-synchronous communication and training needs of the collaborations, recording conferences, plenary meetings, tutorials and other key events. More recently, both CMS and ATLAS have embarked on initiatives to address the complex data and detector monitoring issues of the LHC experiments, facilitating the ability of our colleagues to view the status of our experiments from remote locations via dedicated, live displays [7][8].

Parallel to these achievements, CERN has pursued a variety of development, both within IT and in other divisions/departments, aimed at supporting the growing LHC collaborations. These initially included the installation of a few basic video conferencing facilities, an operator-based phone conferencing system [9], and a variety of software tools for handling document storage [10], creating mailing lists [11], booking conference rooms [12], and scheduling meetings [13]. In more recent years, commercial applications have been employed at CERN, whenever possible provided they address the requirements of the collaborations, as this has helped to reduce development and maintenance costs. Some recent examples include the Alcatel My Teamwork phone conferencing system [14], Microsoft Sharepoint [15] and the SCALA public display system [16].

#### *3.2. Assessing the Needs*

This multi-pronged effort to address the communication challenges of the LHC has not occurred in a vacuum. Several important efforts have been made to survey the collaborations in order to obtain a clear view of their requirements, to understand the strengths and weaknesses of existing tools and methods, and to research the latest developments offered by the private and public sectors, in terms of both applications and techniques. Collaboration surveys made from within the LHC community have included an extensive study prepared for ATLAS in 2003 [17] and a key video conference survey prepared by the VRVS group in 2004 [18], recently followed up by a general LHC-wide survey [19] performed by CERN IT on behalf of the collaborations.

In an effort to consolidate information and to assess the complete requirements of the LHC for collaborative tools, the LCG (LHC Computing Grid) Project launched an RTAG (Requirements and Technical Assessment Group) in 2004. The group's findings and recommendations were presented in a final report [3], which was endorsed by the spokespersons of the four major LHC experiments. A

summary of this report was presented at numerous international conferences, including CHEP 2006 in Mumbai, India [20].

In brief, the group found that very little existed at CERN, in terms of infrastructure, management, or support systems, for handling the rapidly growing needs of the LHC collaborations. The existing infrastructure was either outdated or in need of repair, there was no central project organization or R&D at CERN, and there was a lack of sufficient oversight from the LHC collaborations. The paper then presented a complete set of recommendations to improve the situation at CERN and for the LHC collaborations, in general. There was broad consensus in the group, which comprised participants from CERN IT, the collaborations, and experts in the field, to pursue fulfilling these recommendations. What remained was identifying resources.

### *3.3. Coordination & Resources*

Before completion of the RTAG, work had already begun at CERN to bring collaborative tool support under a single organizational umbrella at CERN IT, in the UDS group. Some time after publication of the report, a follow-up oversight committee was formed, called the RCTF (Remote Collaboration Task Force) [1]. This group was chaired by the UDS group leader and contained representation from the newly formed development and support teams, as well as from each of the major LHC experiments. The charge of the group was essentially to oversee implementation of the RTAG recommendations by setting priorities for the experiments, identifying resources, and following up on the projects.

The identification of resources was not a trivial matter. While all parties saw clearly the need for improving the situation at CERN and all agreed on the importance of improving communication for the LHC, the field of Collaborative Tools was relatively new and there existed no precedent for the sharing of support. In December, 2006, a workshop called Shaping Collaboration 2006 [21] was held at the CIG in downtown Geneva, featuring participation by world experts in the field of collaborative tools, representatives of the LHC experiments and CERN. A complete report on the workshop was presented at CHEP 2007 in Victoria [22]. Most importantly, follow-up discussions between CERN management, CERN IT, and the LHC experiments resulted in the drafting of agreements providing funding for the equipping of videoconference facilities at CERN and the establishment of a support team at IT dedicated to maintaining and providing service for those facilities.

## **4. Some Progress, Some Plans**

### *4.1. Organization*

Without doubt, the most important outcome of the efforts described above, is the creation of an organizational body at CERN dedicated to the planning, development, and maintenance of collaborative tool facilities and services for the LHC. With CERN-IT/UDS identified as this body and with oversight from the collaborations provided via the RCTF, significant progress was made on a variety of fronts. This has included audio and video conferencing facilities, web casting and archiving systems, integrated environments, and web-based authentication and authorization. That represents progress on pretty much every major recommendation of the RTAG document.

Credit is due to all involved in this follow-up and it serves as an excellent example of strong coordination and cooperation between CERN IT and the experiments. Not only were the facilities installed, but the work was done in a professional manner, taking into consideration such key factors as the lighting and sound characteristics of the rooms, common usage scenarios, documentation, and central maintenance capability.

### *4.2. Video Conferencing Facilities*

The drafting of the video conferencing hardware agreements between CERN and the experiments, although they required much time and effort by all parties to be completed, opened the way for serious progress. By the end of 2008, all meeting rooms and auditoria commonly used by the LHC

experiments were equipped for high-quality audio and video conferencing. A complete list of facilities, their equipment and status, is available via the CERN-IT/UDS web pages [23].



**Figure 1.** ATLAS collaboration members profiting from the recently installed video conferencing facilities at CERN.

The installations take advantage of the latest technology in video conferencing codecs, supporting H.323 and SIP, often with local MCU units to support hardware bridging between numerous clients, such as phone and video connections. High-resolution flat screens are employed for the video conferencing client, with projectors displaying the presentation material in larger format, for local and/or remote viewing. Sound is transmitted via echo-cancelling microphones, typically mounted to tables for best audio quality.

A significant number of tests were performed under a variety of conditions, to assure best-quality audio for both audio and video conferencing. User input was obtained (sometimes through solicitation) and evaluated. The development team put a serious effort on monitoring and reviewing data from meetings held in pilot rooms, before determining the final set configurations employed throughout.

Finally, it should be noted that all facilities are documented, with user guides available on the web and printed in the rooms. A central maintenance system was set up, so that all devices can be operated, updated, and often repaired remotely, speeding up and improving the level of service provided. Online tutorials are available and, although meeting conveners are expected to run the equipment on their own, new users are welcome to request assistance for first meetings, including monitoring and debugging. In short, a professional service has been set up, where only a bare-bones service existed before.

#### 4.3. Video Conferencing System

The issue of selecting and supporting a video conferencing system or systems to be used by all of the LHC collaborations is a bit trickier to solve. The facilities described above were specifically designed, keeping in mind the RTAG recommendations to support both VRVS (now EVO [24]) and H.323 MCU-based systems, such as ECS (ESnet Collaborative Services) [25]. These two systems represented the vast majority of usage by the HEP community. However, both systems have their shortcomings.

The ECS system requires clients to be H.323 compliant. Although this protocol has been adopted by all major vendors for meeting room installations, that is not the case for many of the free clients installed on smaller desktop and laptop computers. There is only one free application, for example, currently available for Mac OS X, an increasingly popular platform in HEP, it is less than perfectly reliable and is not supported by any major vendor or development team. In addition, ECS is supported

entirely by the U.S. DoE (Department of Energy) and is not (yet) intended to support the kind of international usage required by the LHC. In fact, current rules of usage require the clients to be associated with a DoE project.

EVO, on the other hand, was specifically designed to handle the highly heterogeneous environment of its LHC clients. It supports H.323, but also has a variety of codec implementations, allowing it to work on pretty much any common computing platform. Although much of the development work has been supported by the DoE, it has, up until recently, been provided free of charge to the entire worldwide HEP community, regardless of nationality or experiment.

And therein lies the problem. As EVO entered production mode, a few years ago, the DoE withdrew its annual grant and requested that a new user-based funding model be set up. Such a model would require that all clients benefitting from usage of the system, including those outside of the U.S., contribute in one form or another to its development and maintenance. The two largest user communities (CMS and ATLAS) agreed, in principle, to the concept, provided collaboration and market surveys support EVO as the application of choice, and provided a fair and reasonable cost sharing plan could be drawn up. Similar to the agreements drafted to equip the conferencing rooms with hardware, the experiments would prefer to have the videoconference service managed and financed through CERN-IT.

To address this issue, the RCTF was expanded to include representation from a variety of other physics labs and to include video conferencing expertise. The new body, called the LCEB (LHC Collaborative Environments Board) was given the additional charge of following up the surveys and drafting a solution that satisfies all parties. Unfortunately, the process of finding a solution has been slow, with EVO living in a state of funding limbo for more than a year, now. Although the experiments have provided some level of “emergency funding,” the situation is not healthy for a variety of reasons. There is a risk that key developers of the EVO team will leave, seeking more stable positions, long-term project planning is on hold, and meeting conveners are hesitant to make a large effort learning how to use the tool or convincing their groups to convert from phone-based meetings.

The issues under discussion are fairly clear. In exchange for funding, the experiments would like the service handled through CERN-IT and would like some degree of control over the development priorities, thus assuring that LHC issues receive adequate attention and support. In addition, they want the sharing of costs to reflect the measured usage of the experiments. This can be calculated relatively accurately from the EVO meeting database, however there are still some concerns on how to pay for the usage of the smaller LHC or non-LHC experiments, the usage of which can be variable and /or difficult to accurately monitor. Whatever system is chosen (EVO or an alternative identified by the study group), it is imperative that a solution be found soon.

#### *4.4. Audio Conferencing Facilities*

Concerning meeting rooms and auditoria, the needs for audio (phone) conferencing at CERN are well covered by the systems that have been installed for video conferencing. In fact, for many of the facilities, one can easily bridge between systems, allowing a variety of connection possibilities. It is interesting to note that audio problems are typically reported more often for audio than for videoconferences for the same installations. This is most likely due to the fact that visual signals play an important role in human communication and that, without them, audio shortcomings (level, noise, echo, etc.) are more perceptible [27]. Regardless, an important effort has been made to tune the equipment, based on user feedback and audio measurements.

Inside offices, typical equipment includes the old reliable telephone and VOIP services, such as Skype [28]. This hardware works reliably and effectively, provided the participant uses a headset or echo-cancelling microphone. One notable shortcoming in the CERN phone system is that fact that DTMF (Dual-Tone Multifrequency) tones required by some phone systems for entering data (“please enter your meeting code”) are not generated automatically, requiring one to first enter the sequence “98.” Such a banal problem is the cause of many disrupted meetings, but has yet to be addressed.

#### 4.5. Audio Conferencing Systems

One of the more important recommendations of RTAG 12 was the replacement of CERN's operator-based phone conferencing system with an automated 24/7 system. The web-based Alcatel My Teamwork system [14] was set up even before completion of the group's final report, as there was consensus to its urgency. Following an initial breaking-in period, the system has reached stability and has overcome the old system in popularity.

The system supports a potentially useful feature, called callback, whereby a participant enters a meeting via the web interface, using authorization, and requests for the system to call a given number. The advantage is that it provides security and takes advantage of the inexpensive international rates that have been negotiated by CERN. In addition, the caller is identified, so that a convener can monitor attendance of the meeting. Unfortunately, only one single budget code can be entered for the entire meeting and many conveners do not wish to pay for other participants to join periodic meetings. That is, it does not fit a typical collaborative funding scheme. Potential solutions would be to either alter the software to allow participants to enter budget codes when requesting call back or for experiments to provide budget codes to cover communication costs. The former solution has been deemed technically impossible, at the moment, and the experiments have not adopted the latter solution due to the difficulty in cost estimation and the possibility of abuse.

Other audio conferencing systems currently in use by the LHC include the phone bridges connected to ECS and EVO. The ECS bridge has the same usage limitations described in the video conferencing section above and also requires one to call a U.S. phone number. EVO supports a number of bridges, around the world, with local phone numbers at CERN, Germany, The Netherlands, Italy, UK, Slovakia, Australia, and the USA. Any meeting booked on EVO can be attended via the standard interface or by calling one of the phone bridges. It should be noted that the EVO phone system has lacked somewhat in reliability at CERN, due to insufficient hardware resources and an unexpectedly quick ramp-up in usage. New hardware installations and decreased usage, as participants move to using the video conferencing interface, are expected to improve that situation.

#### 4.6. Meeting Management & Tool Integration

The Indico Meeting Management system [29] was first implemented at CERN in 2005 as a replacement for the CDS Agenda System. Since then it has been improved and expanded to serve as a point of integration for meeting management and collaborative tools. Indico's web-based interface allows users to create agenda for meetings, conferences, and other events, within a hierarchical directory structure. Authentication is required to determine the viewing and editing privileges of users, and meeting conveners can define authorization schemes.

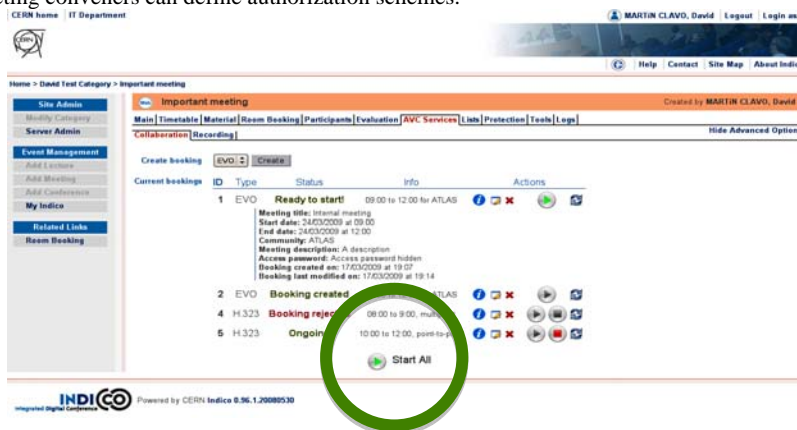


Figure 2. Collaborative Tool Integration in Indico (The Green Button).

Currently, Indico allows users to create agenda, to attach documents necessary for meetings, and to write and store minutes. Indico requires the entry of meeting metadata, such as meeting date, time, location, similar to what is requested when reserving a room or a video conferencing service, such as EVO. It would thus seem possible to simplify the preparation of a meeting and to reduce the workload of a meeting convener, by integrating these reservation systems. While this is already completed for room reservations, integration with EVO and Alcatel My Teamwork is still in the works.

One could take the concept a step further and also automate the running of video conferencing equipment in the CERN facility. This was pointed out by the author in his presentation at CHEP 2007 [2], in Victoria, in which he proposed the “green button” interface on Indico. The idea would be that a meeting convener only need click on a button on the Indico agenda web page to turn on the equipment and start the meeting. CERN IT-UDS-AVC has recently implemented this concept in Indico (Figure 2), and has promised to make this and other developments available during the summer of 2009.

Other improvements with Indico have taken place over the past few years, based on feedback from the user community, which has adopted the tool with enthusiasm. Among these are improved handling of conferences, simplification to the scheduling mechanism, minute compilation, more exportation possibilities, usage of SSO authentication, and more. A significantly simplified interface is also reportedly in the works. The development can be tracked via the Indico Latest News site [30].

#### 4.7. Web Casting & Archiving

Over the past several years, webcasting facilities have been installed at CERN at key locations, such as the Main Auditorium and the Council Chamber. These systems are used to broadcast live events, such as collaboration plenary sessions or CERN colloquia, and several dedicated “channels” can be viewed on the webcast site [31]. For special events, such as the LHC First Beam Event, mobile systems have been set up, and worked very well, broadcasting to millions of viewers around the globe.



Figure 3. Michigan Lecture Archive of an ATLAS plenary session.

Web Lecture Archiving involves the recording of a speaker giving a presentation, typically during meetings, conferences or tutorials, and the subsequent re-creation of the talk in a digital form for viewing with web browsers or personal electronic devices. The University of Michigan has developed

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a somewhat automated system used to create lectures that synchronize high-resolution images of the presentation material (slides, screen captures, and/or blackboard writing) to the audio and video of the speaker. By introducing the intermediate step of creating a “lecture object” comprising standard data formats (mp4, jpeg) with metadata expressed in a well-defined XML format, stored in a database, they hope to create an archive that can outlive the typical lifetime of changing media standards, a more-or-less permanent record of the event. A complete description of this system and its usage for recording and archiving CERN, LHC, ATLAS, and other events, can be found in the CHEP 2009 presentation of Jeremy Herr [32]. The presentation also describes hardware advancements, such as a robotic speaker-tracking device, and the special requirements of large-scale recording.

CERN-IT UDS is currently evaluating a variety of recording and archiving systems, with the goal of setting up a service at CERN to support the LHC and other communities. The idea is to record workshops, conferences, seminars, and tutorials at CERN, as part of a standard service. Recording could also be made available for experiment-specific events, upon request, most likely for a fee. A request option is already being integrated to Indico, in a similar manner as for video conferencing.

#### *4.8. Data and Detector Monitoring*

One of the more interesting topics of CHEP 2009 was the recent emergence of new data and detector monitoring tools for both CMS and ATLAS. The CMS effort was presented by Lucas Taylor, as part of a more general report on CMS Centres [33]. These Centres act as remote monitoring stations, featuring many of the same displays as those available in the central control room, and connected via permanent video link to each other and the control room.

While remote control of the detector is not currently enabled, the CMS Centres are of similar size and layout to the control room, allowing the collaboration to effectively monitor all aspects of the experiment in a similar manner to being on shift. Although the large Centres are primarily located at large participating institutes or laboratories, smaller affordable Centres are currently being installed at CMS institutes of all sizes, around the globe.

In the author’s opinion, these Centres are an excellent example of collaborative tool usage, in that the permanent video links keep the collaboration in close communication and the display screens make it possible for nearly everyone in the collaboration to participate actively in the monitoring of the detector and data. This ability will be essential when first collisions start producing data at the end of this year, as the race will probably focus more on the speed with which we understand our detectors, rather than on the accumulation of statistics.

ATLAS is pursuing a similar program of data and detector monitoring, but with an emphasis on providing display screens for all institutes, as well as the public. The construction of large remote operation centers is not foreseen. The ATLAS initiative is less mature than the CMS project and is currently only in its planning stages. Pilot projects at CERN and the University of Michigan, based on commercial signage software called SCALA [16], have shown promise. This system is currently in growing usage at CERN (public screens can be seen next to the Main Auditorium, at IT, and in the ATLAS Control Room), so the initiative could ramp fairly quickly, if desired.

### **5. Summary and Recommendations**

Remarkable progress has been made over the past several years in the planning, development, and deployment of collaborative tools supporting the LHC. Comparing the state of things now to the way things were 3-4 years ago at CERN gives one cause to celebrate some important success. Every major recommendation of the LCG RTAG on Collaborative Tools has either been addressed or is currently being followed up: All commonly used meeting rooms at CERN are equipped professionally for audio and video conference; nearly all meetings held by the experiments are broadcast in one form or another, allowing participation by all members of the collaborations; important presentations and tutorials can be broadcast and/or recorded and a standard service is being put in place to handle requests; an integrated meeting environment is developing, in the form of a common interface that supports authentication; a professional service has been set up to handle requests and to intervene



quickly for problem resolution; and, most importantly, central coordination under CERN IT has provided project management and accountability, and a path for the experiments to define viable financial agreements for the services they require.

This progress has not spontaneously arrived from the vacuum. Rather, it reflects the hard work of many individuals, who have actively pressed for change even from the very early days of the LHC. These include the software system developers, who led the research and development effort, the experts who surveyed the needs of the collaborations, as well as the tools on the market, the technicians who installed and tested the facilities, the collaboration and laboratory management, who agreed to provide funding, and the collaboration members, who insisted on the importance of the development and who often served as testers and/or developers of the systems.

All is not done, however, and it is very important that we focus our attention to the work that remains. The issue of selecting and identifying resources to support a video conferencing system has become urgent. It is imperative that the LCEB move quickly to identify the candidate or candidates and to suggest a fair and reasonable funding scenario that all experiments can agree to. If this issue waits too long, we risk to lose key developers or not to have time to install equipment and train our collaborations in time for LHC collisions. I would suggest that even a partial solution at this time would be better than none at all.

Concerning other issues, such as Indico integration, development of a lecture archival system at CERN, and the development of data and detector monitoring systems, it is the author's belief that progress is moving the right direction, albeit slowly, in some cases.

Of primary importance for all LHC (and HEP) experiments is that they adopt mandates to ensure the possibility of the active participation of all members of their collaborations, regardless of location. To enforce these mandates, policies must promote the usage of collaborative tools, whenever possible. Clear internal communication schemes must be defined, backed by project coordination and sufficient budget allocations for the development and maintenance of those tools. Building a 10-story office building is admirable, but building a 9-story office building that includes chairs, desks and telephones, is arguably more effective.

### **Acknowledgements**

The author would like to acknowledge and thank the University of Michigan and the U.S. Department of Energy for supporting his physics research and allowing him to occasionally get sidetracked into analyzing our requirements for Collaborative Tools. He believes the investment to be a wise one. In addition, the author would especially like to thank Prof. Homer A. Neal for introducing him to this remarkable field and for motivating his work. Finally, the author acknowledges and thanks Joao Fernandes of CERN-IT UDS for co-authoring the corresponding slide presentation and, along with his group, for providing CERN with the kick-in-the-pants it needed to get in shape for the LHC.

### **References:**

- [1] [RCTF: Remote Collaboration Task Force](#) was a body chaired by CERN-IT UDS, with representation from that group and the LHC collaborations, charged with the development and installation of collaborative tools at CERN in support of the experiments.
- [2] [Collaborative Tools and the LHC: An Update](#), S. Goldfarb, Proceedings of the International Conference on Computing in High Energy and Nuclear Physics, Victoria 2007, Journal of Physics: Conference Series 119 (2008) 082002.
- [3] [Report of the LHC Computing Grid Project RTAG 12: Collaborative Tools](#), S. Goldfarb, et al., CERN-LCG-PEB-2005-07 (2005).
- [4] **Virtual Room Videoconferencing System**. Developed by the California Institute of Technology (Caltech). Replaced by [EVO](#) in 2008.
- [5] [Web Lecture Archive Project](#). Developed in 1999 as a collaboration between the University of Michigan, ATLAS, and CERN Technical Training.
- [6] [ATLAS Collaboratory Project](#). A University of Michigan project supporting research and

- development for large-scale collaborative research experiments.
- [7] [CMS Centres Worldwide: a New Collaborative Infrastructure](#), L. Taylor, Oral Presentation, Collaborative Tools Session, CHEP 2009.
  - [8] [ATLAS TV – Project Proposal](#), S. Goldfarb, ATL-COM-GEN-2008-004 (2008). This will be replaced by a proposal called “ATLAS Live”, to be published as an ATLAS Note in 2009.
  - [9] [CERN IT Switchboard Audio Conference System](#), (77000 system). Still in existence, but in decreasing usage compared to automated [Acaltel MyTeamWork](#) (76000 system).
  - [10] [CERN Document Server](#). Heavily used by LHC for archival of papers, notes, communications, talks, multimedia, etc.
  - [11] [CERN Listbox Service](#). Currently being replaced by Sharepoint-based mailing list service.
  - [12] [CERN Conference Room Booking System](#). Replaced by [Indico](#) room booking system.
  - [13] [CERN CDS Agenda](#). Replaced by [Indico](#) Event Management System.
  - [14] [Alcatel My Teamwork](#) audio conferencing system.
  - [15] [Microsoft Sharepoint](#) content management software.
  - [16] [SCALA](#) digital signage system.
  - [17] [Opportunities for Use and Development of Collaborative Tools in ATLAS](#), S. Goldfarb, et al., ATL-GEN-2003-002 (2003).
  - [18] [VRVS User Community Survey Results](#), March 2004.
  - [19] [CERN Remote Collaboration Tools Survey](#), Fall 2008.
  - [20] [LCG RTAG 12: Collaborative Tools for the LHC](#), S. Goldfarb, Proceedings to International Conference on Computing in High Energy and Nuclear Physics, Mumbai 2006, McMillian India, Ltd., Vol I:421-425 (2006).
  - [21] [Shaping Collaboration 2006](#), a joint workshop held Dec. 11-13, 2006, with participation by the Workshop for Advanced Collaborative Environments and LHC Users.
  - [22] [Shaping Collaboration 2006: Action Items for the LHC](#), S. Goldfarb, J. Herr, H.A. Neal, Proceedings of the International Conference on Computing in High Energy and Nuclear Physics, Victoria 2007, Journal of Physics: Conference Series 119 (2008) 082003.
  - [23] [CERN Videoconference Rooms](#), web site of Audiovisual and Collaborative Services.
  - [24] [EVO: Enabling Virtual Organizations](#) is video conferencing system designed for HEP, capable of connecting a variety of clients, including H.323. It succeeds [VRVS](#).
  - [25] [ECS: ESnet Collaboration Services](#) is an MCU-based H.323 video conferencing system supported by the U.S. Department of Energy.
  - [26] [LCEB: LHC Collaborative Environments Board](#) is a body chaired by CERN/IT UDS and containing representation from that group, the LHC experiments, other physics laboratories, and expertise in video conferencing.
  - [27] [Successful Video Communication](#), CISCO White Paper, Jan 2009.
  - [28] [Skype](#) is a popular VOIP (Voice Over IP) peer-to-peer audio and video conference system.
  - [29] [Indico](#) is an Event Management System used to manage meetings and conferences (such as CHEP). It is used for scheduling, room reservation, attaching documents, minutes, etc.
  - [30] [Indico Latest News](#) reports development and plans for Indico.
  - [31] [The CERN Webcast Site](#) hosts several dedicated channels, broadcasting CERN events live, around the globe.
  - [32] [Lecture Archiving on a Larger Scale at the University of Michigan and CERN](#), J. Herr, Collaborative Tools Session, International Conference on Computing in High Energy and Nuclear Physics, Prague, 2009.
  - [33] [CMS Centres Worldwide: a New Collaborative Infrastructure](#), L. Taylor, Collaborative Tools Session, International Conference on Computing in High Energy and Nuclear Physics, Prague, 2009.