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Overcoming the Social and Technical Challenges to Virtual Scientific Collaboration

The Birth of the NASA Astrobiology Institute as a Community of Practice

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Abstract - This paper summarizes a three-year project to create a community of practice [1] among 500+ scientists affiliated with the NASA Astrobiology Institute (NAI). Recognizing the needs to collaborate and still control travel costs, NAI engaged FutureU in 2000 to help facilitate the process of community development across distance. Although the process involved many technical and cultural challenges, by applying large-group intervention principles, especially that of involving the whole system, and by carefully introducing multiple collaboration support technologies, the authors were able to advance the development of a "virtual institute" that functions independently of time and distance as it collectively addresses the big questions about the origin of life (astrobiology).

Keywords: community of practice, virtual collaboration, large-group intervention, e-learning, whole-system intervention, improved user adoption.

I. BACKGROUND

When tantalizing clues to the origin of life and the possibility of extra-terrestrial life started making news in the mid-1990s, the excitement coincided with a trend throughout science toward cross-disciplinary collaboration. Although the rise of the Internet no doubt eased the way, the trend is nonetheless remarkable, given the competition for research dollars, the differences in vocabulary and practice from one discipline to another, the thousands of miles separating major laboratories, the incompatibility among computer systems, and the solitary inclinations of many scientists. The advantages of sharing information and ideas were indisputable, however, and, in 1998, the United States National Aeronautical and Space Administration (NASA) created the NASA Astrobiology Institute (NAI) to encourage a cross-fertilization of ideas and the development of new perspectives about life in the universe [2]

The hope was that by working together, biologists, geologists, astronomers, chemists, paleontologists, physicists and others would have a better chance of answering humanity's most basic questions: How did life begin and evolve? Does it exist on other worlds and, if so, how and where did it form? How have the Earth and its biosphere influenced each other over time? Can human life survive and thrive beyond Earth? And, what will it take to build a human presence "out there," specifically, on Mars?

More than 400 scientists were invited to join NAI right away and by 2004 membership had doubled. The institute today represents 136 disciplines and sub-disciplines. A concentration of activity at the federally operated Ames Research Center in Mountain View, California, made this the logical choice for lead facility and administrative headquarters (NAI Central). Other NAI members are widely dispersed, currently at more than 100 universities, U.S. government facilities, private research institutions and international research centers in Europe and Australia. The group as a whole represents many of the world's leading experts in astrobiology.

In principle, there was immediate and widespread support for NAI. However, early attempts at collaboration fell short, especially when it came to the use of information technology for interaction and information sharing across distance.

Part of NAI's charter is to provide such technology to its members. Tools were introduced initially by administrative decision; that is, NAI Central selected the hardware and software and distributed it to the 15 lead teams. Unfortunately, members failed to embrace what they were given. Operating systems proved incompatible. The document management program never gained a solid user base. Scientists found the room-based video conferencing system inconvenient and frustrating. The smart-boards seldom got used. In short, the scientists gave up. What collaboration did take place was primarily face to face or by telephone or email—useful but limited in potential.

A reassessment by NAI Central in 2000 led to the hiring of a social scientist, anthropologist Lisa Faithorn, Ph.D., as NAI Collaborative Research Manager. Dr. Faithorn's role would be to serve as liaison between the IT staff and the membership and to improve interaction throughout NAI. To assist her with both the technical and cultural aspects of this process, Dr. Faithorn engaged FutureU (http://www.futureu.com), a consultancy experienced in the

development of virtual communities for learning and collaboration.

FutureU recommends a methodical approach to the introduction of any new technology to a fledgling community of practice. This approach begins with an ethnographic study of the group (typically, key stakeholder interviews and a community-wide needs assessment), followed by industry research that draws on the study findings to match the identified needs to the most appropriate tool set for the group. This is followed by product demonstrations, with group members encouraged to provide input. A pilot program of the most promising products minimizes purchasing errors and maximizes user support. Finally, a phased roll-out introduces the chosen products to the entire population, with an evaluation of the delivery process to follow. Overall, this approach enhances adoption of the new technology and advances the process of community building.

II. ENGAGEMENT AND ANALYSIS.

Dr. Faithorn and the FutureU team tested the assumption that members of any group will more readily identify with the whole and participate more enthusiastically in its intended activities (in this case, collaboration across distance) when they have the opportunity to voice opinions, contribute to decision making, remain fully informed about choices that affect them, and receive both basic and "best-practice" instruction in the processes they are expected to embrace. In other words, for collaboration and collaborative learning to take hold, they must be modeled from the very beginning. For NAI, this meant that all major decisions about new technology and interactive processes would henceforth involve at least all principal investigators (PIs) and often the entire population.

The project began with an analysis of the existing situation. Three qualitative research tools were used: 1) on-site observations, 2) face-to-face ethnographic interviews with all 15 PIs and other key participants, and 3) an automated survey instrument distributed to the entire population.

The goals for the analysis were to identify members' needs, obstacles, and impressions; actively demonstrate respect for their viewpoints; provide an outlet for their possible frustrations; and foster a sense of inclusion and awareness. Ultimately, the qualitative research was intended not merely to study NAI members and their activities but actually to *influence* their behavior with regard to collaboration tools and virtual community.

In the interviews, investigators were asked how they *wanted* to interact and what occurred when they attempted to use the available technology. Many reported frustration, but also an earnest desire to keep trying. The interviews also revealed how little was actually known about the members, their commonalities, differences, needs, preferences, concerns and hopes for NAI.

TABLE 1. Number reporting by role.

Role	Number Reporting
Principal Investigator (Lead Team)	15
Principal Investigator (Project within a lead Team)	29
Co-Investigator	40
Postdoctoral Fellow	22
Graduate Student	27
Undergraduate Student	0
Administrative Support	7
Information Technology Support	7
Education and Public Outreach Support	11
Collaborator	20
Other	9
Total	187*
* Total greater than sample size because some individuals reported filling more than one role.	

Regarding technology, the interviews prompted Dr. Faithorn to recommend several technical changes to the video-conferencing installations that easily eliminated most of the obstacles to that system's use. She also recommended abandoning the original document management program before its reputation eroded confidence in NAI (The subsequent institute-wide survey confirmed that the document management program originally provided was unpopular with the scientists; instead, access to NAI email lists and Science Organizer, a knowledge management/document-sharing tool, were added to the NAI website. The timeliness of these technical changes reportedly encouraged members to believe that their input made a difference.

Twenty-six survey questions emerged from the leadership interviews, including two open-ended questions intended to elicit qualitative impressions of NAI. Before the survey was distributed, PIs and selected NAI administrators were invited to comment on the content of the questions; thus, key leaders were involved from the very beginning in problem definition and research design.

The survey was distributed by email to 572 individuals—everyone associated with NAI, including university students working for NAI researchers. Lead investigators were actively encouraged to respond and to prompt their team members to take part as well.

In total, 164 out of 572 individuals submitted surveys, including all PIs and Co-PIs. Every team and every role (see Table 1) was represented, and representation was proportional to team size (Larger teams were not proportionally more represented than smaller teams.). No undergraduate student chose to submit a response (Perhaps

they thought the survey had come to them as information only.) When this group is *included* in the results, the response rate was 29%. If undergraduates are *excluded*, the response rate was closer to one-third.

Whether students are included or not in the tally, with a sample size this large, the likelihood is that even though the participants were not a statistically random sample, they *probably* represent the population fully enough to generalize to the whole about the patterns uncovered.

It is worth noting that most respondents gave their names on the survey, providing NAI Central with valuable information for project planning and addressing individual needs.

Dr. Faithorn and the FutureU team analyzed and summarized the results, first in oral presentation to NAI Central and, later, to the entire membership, on the Web[3], as part of NAI's comprehensive written annual report, and at the 2003 annual meeting of all members [4]. The Web-based version employed PageSeeder, a collaborative document annotation tool that allowed readers to write comments throughout the document.

The interview and survey process gave everyone a chance to play a role in the future of virtual communications at NAI. Even those who chose not to participate had at least been asked. The overall membership was operating the way any community operates, with some members stepping forward and others sitting back.

III. FINDINGS.

What emerged from the survey and interviews was a detailed picture of NAI; its composition, culture, successes, and possible areas for improvement. Of immediate interest was the portrait painted of the members—their diversity of discipline, team size, geographic distribution, and research interests; the lack of professional IT support available locally to fully 25 percent of them; and the unevenness of their skill level with information technology. (Despite the scientific and intellectual sophistication of the population, fully 25 percent said they were "beginners" when it came to IT.)

Respondents also provided information about their computer systems, Internet connections, and what tools they were currently using, if any, to share data. They indicated what other tools they might appreciate in the future. They ranked the available NAI resources for their usefulness to them. And, they indicated whether they would be willing to help pilot new collaborative technologies.

The survey went on to identify the collaborative tools and processes of greatest interest to the respondents. Features reported as being of greatest interest were: Cross-Platform Compatibility as the most desirable feature, followed, in descending order of desirability, by Desktop Availability, Web-based Access, Ease of Use, High-Speed Access, Reliability, Security, Privacy, and Reasonable Cost.

TABLE2. Top 10 most requested collaboration tools by number reporting.

Tools	Number Reporting
Video desktop computer tools	60
Web-based NAI emailing lists	60
Web-based photo directory	55
Web-based information repository (knowledge management system)	54
Scientific visualization/ imaging capabilities	54
Room with videoconferencing screen and camera	51
Wireless data sharing to/from remote field sites	50
Web-based document sharing capability	48
Data sharing desktop computer tools (e.g., NetMeeting)	47
Live chats (secure on-line spaces for real time discussion)	44

As for collaboration tools, the respondents provided a "top-ten" list, starting with Desktop Video as the most desired (See Table 2).

In descending order, the other priorities were Web-based NAI mailing lists, a Web-based photo directory, Web-based information repository (knowledge management system), scientific visualization and imaging capabilities, a room-based video-conferencing system (such as Polycom), wireless data-sharing tools with two-way access from field locations, Web-based document sharing, desktop data sharing, and real-time online meetings with live chats.

Perhaps most noteworthy of all the findings regarding technology (See Fig. 1) was the discovery that 11 percent (37) of the NAI members sampled were using the Linux or Unix operating systems and, of the remaining 89 percent, nearly half used Macintosh computers (128 Mac, 158 Windows). This discovery—that more that 58% (165) of all

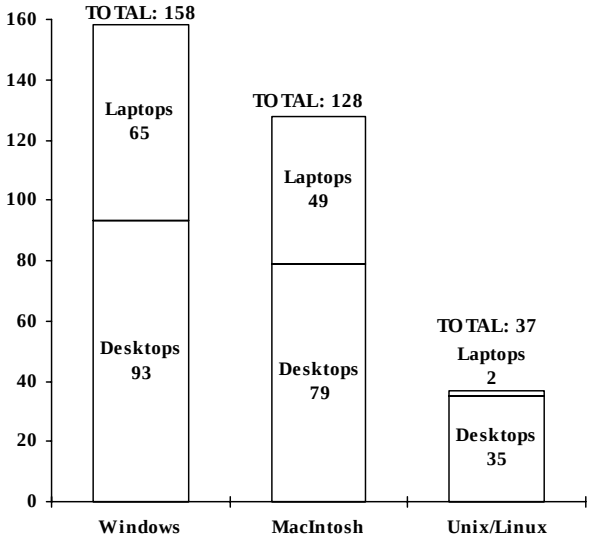

Fig. 1. Hardware Platform (Personal Computers)

NAI members were not using the Windows operating system—would influence all subsequent IT purchasing decisions.

To provide equal access to collaborative opportunities, every effort must be made to avoid system incompatibilities that might exclude some members. The survey made it clear:

No tool that failed to accommodate Linux, Unix or Mac users could be considered, even though the majority of commercial vendors support only Windows.

IV. INDUSTRY RESEARCH

The FutureU team then matched the identified needs with those tools in the marketplace most likely to contribute to NAI's development as a community of practice. The Internet, industry publications, and interviews with vendor representatives helped identify nearly 100 software features that might prove desirable. These features fell roughly into the following ten categories: Communication, Document Collaboration, Work Organization, User Personalization, Distance Learning, Delivery/User Interface, Management and Administration, Licensing Model, Training and Support, and Cost Factors.

Further research revealed that the marketplace offered categories of software that each contained some but not all of the features. From this view, the products fell roughly into the following categories: Desktop Video Conferencing; Web-based, Real-time Meetings; Document or Data Sharing; Knowledge Management; and full-featured Collaboration Portals. More than 200 vendors made the initial list, but a check for cross-platform compatibility quickly eliminated more than half, leaving 90 packages for further review.

Three basic criteria—Linux/Unix/Macintosh compatibility, server license availability (several vendors offered only an application service provider or ASP model) and greatest number of key features—reduced the list of 90 down to the 20 most promising packages, including six document/data-sharing tools, four knowledge management tools, six collaboration portals, and four web-based, real-time meeting packages, all of which included desktop video conferencing as a feature. In addition to the desktop video conferencing offered by the four web-based meeting software solutions, Polycom's desktop hardware solution, ViaVideo, was also considered.

V. PRODUCT DEMONSTRATIONS

For almost all products that showed promise, FutureU was able to arrange for a demonstration to take place within the context of actual NAI work, thus making the experiences far more meaningful than most vendor sales presentations. Prior to each demonstration, an invitation to attend went out by email to every NAI member. Later, those who attended received a follow-up survey and request for feedback. Although participation was limited primarily to executives, scientists, and others working at NAI's Ames offices, the inclusive approach reinforced NAI's message of collaboration and produced a number of insightful contributions to the decision-making process.

Given constraints of time and budget, it was fortunate that the same packages which made it into the finalist list for knowledge management tools were also those on the collaboration portal list, and the document/data-sharing list. This meant that only six demonstrations were necessary to evaluate the finalists in all three of these categories.

As for Web-based meetings, although several of the above-mentioned collaboration portal candidates offered their own built-in capabilities, none could adequately support Macintosh. Therefore, three stand-alone packages were considered instead: HorizonLive, WebEx and Virtual Design Net.

Although Polycom's ViaVideo was available only for Windows machines, it had the important advantage of allowing individual researchers located away from the existing room-based Polycom systems to join video conferences, and therefore it was immediately adopted as a solution for that special application, with the understanding that Windows machine could be purchased relatively inexpensively for individuals now using a different platform. Polycom thus would become an affordable option integrating desktop video conferencing with room-based video conferencing.

VI. PRODUCT PILOTS

Of the three Web-based conferencing packages, only WebEx did not offer a server license. However, because of its stronger cross-platform support at the time for the Linux, Unix, and Macintosh operating systems, WebEx was chosen for a six-month pilot that ran from November 2002 through April 2003. This process, which provided NAI members with considerable opportunity for input, led to the adoption of WebEx as the NAI standard, and, as of this writing, it is in steady use. Experience revealed that any video conference using the room-based or desktop Polycom solutions could be integrated into WebEx's video window and that WebEx could be projected onto the SmartBoards in the 15 video conference rooms, thus further merging desktop and room-based conferencing.

Again using the three criteria of cross-platform compatibility, server license availability and greatest number of key features, NAI Central considered piloting two solutions that offered combined document sharing, knowledge management, and collaboration tools (Intraspect and LiveLink). However, budgetary constraints reduced the

pilots to one, and a six-month pilot of LiveLink began in September 2003 and concluded in March 2004.
Cost factors and user-interface issues ultimately eliminated LiveLink from consideration. It was replaced as a candidate by a newly developed package, NX, which is based on the Xerox Docushare product. A product co-developed by NASA (the "N" in NX) and the Xerox Corporation (the "X"), NX was being piloted with high hopes by NAI as this article went to press. NX delivers the full set of desired features (document sharing, knowledge management, collaboration) that had been identified earlier, and NAI was able to obtain a 300-seat NX license at no charge, in exchange for serving as a beta-test site for the specific tailoring of Docushare that will result in the final NX product.

VII. TRAINING AND FOLLOW-UP REMINDERS

During all pilots, FutureU provided each team's IT professionals and other interested NAI personnel with group training and individual coaching. After an initial few weeks of training and coaching, weekly reminders were distributed by email. Each bulletin contained a practice tip, the answer to a frequently-asked question, and a mini-tutorial on an advanced feature that had not been covered in the initial training and coaching. Best practices for virtual collaboration were also introduced throughout the training and follow-up. These post-implementation reinforcers helped keep interest and engagement high and ultimately led to broader adoption.

VIII. CONCLUSION

Today, NAI researchers at all major sites can simply walk into a Polycom-equipped room, turn on the machine and hold a video conference while using WebEx to share files from their computer desktop with other meeting participants, and they do so regularly. Researchers located away from the major sites can still join in those meetings or collaborate with other scientists using WebEx with a PC Cam or the desktop ViaVideo camera. More than 470 WebEx meetings have taken place among NAI members since the pilot began. More than half of these meetings were specifically held to conduct everyday team business among collaborating scientists. Another 10 percent of the WebEx meetings involved seminars with participants from multiple sites. The rest of the meetings were held to test equipment and software and to conduct training and demonstrations.

The teams participating in the NX pilot have made it their first order of business to store files on the system for easy access by all team members irrespective of their locations. Their next priority will be to use the discussion feature of either NX or PageSeeder or both to collaborate on the editing or creation of documents. To address the uneven availability of IT support (as identified in the survey), NAI has funded additional staff for NAI team sites.

The process of developing NAI as a community of practice is ongoing. Meanwhile, NAI members continue to report, as they did in the interviews and survey for this project, that, although cross-disciplinary virtual collaboration is hard work, successfully bridging the technical and cultural barriers can lead to creative breakthroughs, an expanded knowledge base, and new ideas that are well worth the effort.

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