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Bridging the Communication Gap at NASA – A Case Study in Communities of Practice

Daria Topousis, Keri Murphy, and Jeanne Holm

***Abstract*—**Following the loss of NASA's Space Shuttle Columbia in 2003, it was determined that problems in the agency's organization created an environment that led to the accident. One component of the proposed solution resulted in the formation of the NASA Engineering Network (NEN), a suite of information retrieval and knowledge-sharing tools. This paper describes the implementation of communities of practice, which are formed along engineering disciplines. Communities of practice enable engineers to leverage their knowledge and best practices to collaborate and take information learning back to their jobs and embed it into the procedures of the agency. This case study offers insight into using traditional engineering disciplines for virtual collaboration, including lessons learned during the creation and establishment of NASA's communities.

***Keywords*—**Collaboration, communities of practice, knowledge management, virtual teams.

I. Introduction

FOLLOWING the loss of NASA's Space Shuttle Columbia and crew in 2003, the Columbia Accident Investigation Board was convened to identify underlying causes of the accident. After extensive review, the Board determined that "NASA's organizational culture and structure had as much to do with this accident as the External Tank foam" [3]. This uncovered an endemic problem across the Agency: that the full body of NASA's existing knowledge and resources are not sufficiently accessible or utilized to solve engineering problems [6]. The Columbia Accident Investigation Board also discovered that while most NASA Centers capture lessons learned, they tend to keep knowledge of problems contained within their Center [3]. In the end, the Board determined that "NASA has not demonstrated the characteristics of a learning organization"[3].

In order to bring this information sharing and learning to the agency, the NASA Engineering Network (NEN) was established. It provided a suite of information retrieval and knowledge-sharing tools specifically aimed at facilitating communication among engineers at all of the NASA centers and affiliated contractors. NEN includes a metasearch capability, the Lessons Learned Information System, communities of practice formed along engineering disciplines, and a portal to integrate these components. Fig. 1 illustrates NEN.

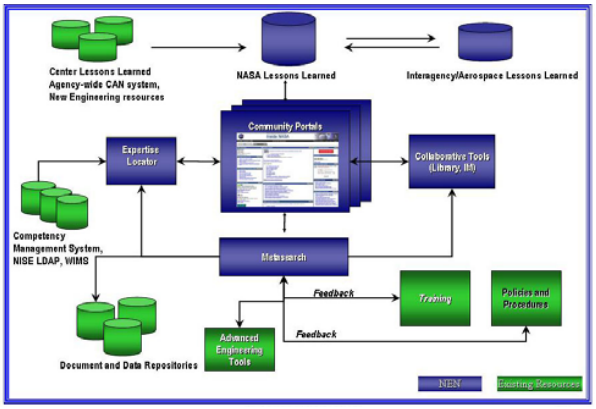

Fig. 1 NASA Engineering Network

Within NEN, communities of practice are defined as "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" [13]. Communities of practice connect individuals with expert peers and promote collaboration, information exchange, and the sharing of best practices across boundaries of time, distance, and organizational silos. NEN rolls out its communities with the goal expressed by Hoadley and Kilner that purposeful conversation might occur around content in context [5].

The community of practice concept grew out of early work in the idea of innovation at NASA and research from Kuhn's work that innovation occurs at the "edges" of communities—for example, when thermal engineers and mechanical engineers are brought together to work a complex problem [7]. This idea that innovation and knowledge-sharing could be driven from communities of practice enhanced the early technical architectures of the NEN.

Following extensive benchmarking with organizations such as the U.S. Navy, U.S. Army Company Command, the U.S.

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D. Topousis is a business analyst with the Jet Propulsion Laboratory, Pasadena, CA 91109 USA (phone: 818-314-8794; e-mail: daria.topousis@ jpl.nasa.gov).

K. Murphy is deputy project manager of the NASA Engineering Network at the Jet Propulsion Laboratory, Pasadena, CA 91109 USA (phone: 818-393-1674; e-mail: keri.murphy@ jpl.nasa.gov).

J. Holm is Chief Knowledge Architect at the Jet Propulsion Laboratory, Pasadena, CA 91109 USA (phone: 818-354-8282; e-mail: jeanne.holm@ jpl.nasa.gov).

Department of Commerce, and Boeing, it became clear that effective engineering communities of practice are aligned with the Office of the Chief Engineer. In addition, because the NASA Office of the Chief Engineer was responsible for resolving issues that arose in the Columbia Accident Investigation Report, this office was most interested in implementing communities of practice.

II. Implementation

A. Identification of Communities

NASA underwent a series of core competency exercises from the late 1990s through the present, looking at the areas of expertise that would be needed to operate existing NASA projects and build a new human capability to the moon and Mars. These competencies were initially instantiated into NASA's Competency Management System (an online system that maps individuals to their competencies). The Office of the Chief Engineer and NASA Engineering Safety Center (NESC) later identified a smaller list of 25 key engineering disciplines that are at the heart of NASA's work. This list comprises the communities in the NEN. At the core of the NESC is an established knowledge base of technical specialists pulled from the ten NASA Centers and from a group of partner organizations external to the Agency. This ready group of engineering experts is organized into 25 disciplines areas. Similar to Orr's study of photocopier repair technicians, where the "construction of their identity…occurs both in doing the work and in their stories" [10], engineers at NASA are accustomed to identifying themselves by their discipline. Engineering disciplines include: structures, systems engineering, environmental test, materials and processes, software engineering, and nondestructive evaluation.

In addition to the engineering disciplines, other key communities were identified as potentially successful for communities of practice. These communities included program/project management and the NASA Engineering Management Board.

These communities build upon existing virtual, programmatic, or traditional groups to the maximum extent possible to enhance already existing social networks and build others where necessary. Such online communities have as underpinnings innovative search capabilities to provide access to key information, discussion areas, and collaborative tools to allow engineers from all of NASA's partners and Centers to seamlessly share ideas and work together. This follows the notion that Bresnen et al lay out, that "to appropriate knowledge from someone else means having a shared mental model or system of meaning that enables the other to understand and accept that knowledge." [1]

The NASA Engineering Network facilitates communities of practice through an online portal that contains contact lists, discussion boards, announcement portlets and blog and wiki capabilities. NEN uses Vignette software.

B. Community Leader Selection and Role

Any sort of complex community requires a leader who will align interests and perspective and guide conversation [2]. An engineer's trust in the appointed leader is key to the success of the communities; as Nahapiet and Ghoshal wrote, "where relationships are high in trust, people are more willing to engage in…cooperative interaction" [8]. The leader's role is to align the community with strategic and operational goals, energize the community, and organize meetings and events [4]. The leader makes final decisions about how to communicate about the community as well as how individual portlets will be used. For example, some community leaders ban anonymous posting to discussion boards.

Because Technical Fellows had been identified to recognize technical excellence and provide agency-wide leadership of their discipline, those fellows would also be invited to lead their respective community of practice. Where the Technical Fellow was not available, an alternate was identified.

C. Community Facilitator

Once a community has been identified, the NEN Project Manager assigns a facilitator to it. This person is a member of the NEN team who has technical proficiency to provide expertise on layout and communication approaches. He or she also conducts behind-the-scenes maintenance on Vignette and any associated electronic libraries, wikis, or blogs. The facilitator works with the leader to integrate standards and key lessons learned within each community. The facilitator also trains new community members as needed.

Because the facilitator is a member of NEN, lessons learned from other facilitators are easily shared and new technology developed for one community can easily be implemented for another. This also creates consistency across the communities, so that users who are members of more than one community of practice will have a frame of reference when moving from one community to another.

D. Establishing a New Community

Following the identification of discipline, leader, and facilitator, the initial stage in establishing a community includes identification and collection of key information for each community. The facilitator, working with the leader and a librarian or content lead, mines NASA's numerous online resources to identify content specific to the engineering discipline.

Each community leader is presented with a set composition and layout of portlets, which he or she may then modify based on his or her discipline's needs. Once the community is designed according to the leader's approval, a core group of community members are identified to review of the site. As community interest widens and builds, the leader determines when the community should be made live. All communities are by default available to anyone with access to NASA's intranet. This includes NASA personnel and badged contractors.

All communities are implemented using Vignette Portal

software, version 7.2. This tool was selected because it adhered to IT security policies within NASA and provided a range of tools useful to engineers, including discussion boards, calendars, resources links, and web connectors into electronic library collections.

To enable seamless transition from any given community to NASA resources that require authentication, the NEN team added the ability to pass the encrypted username and password from NEN to applications such as DocuShare, one of the electronic libraries used at NASA. This allows a user to transition with one click from a NEN community into an associated library or other resource.

E. Milestones

The following are key milestones in formulation: 1) Initial meeting with leader to determine preliminary content such as calendar, discussion board and associated topics, announcements, key documents, basic links. 2) Development of a welcome portlet that includes a picture of the leader and a brief description of the community's purpose and scope. This generally appears in the upper right-hand corner of a community's page. 3) Creation of a charter to define the community's scope and relevant topics, logistical and role information such as establishment of regular meetings and ways for new members to get involved, and detailed information about how information and issues will be shared and discussed (e.g., through working groups).

While some criteria would be unique to each community, there are four that will be universal to the NASA engineering communities: 1) membership – after defining the scope of membership of each community, attract a large percentage of that target community as well as attract a large percentage of the key experts in that community. Also, to what extent are new hires or new practitioners are reached and become members; 2) engagement, acceptance and support – of the members we have attracted, to what extent do they participate in the knowledge sharing and to what extent do they accept the value of a particular community; 3) retention – of the members we have attracted, to what extent do they remain participatory members after 6 months; and 4) mechanics – of the key activities in the communities, how smoothly do the tools, processes and infrastructure work in supporting the community?

F. Success Criteria

Table I shows the success criteria at varying stages of community development.

TABLE I
SUCCESS CRITERIA

Timeframe	**Goal**	**Success Criteria**
0-6 months	Gather information about community and successfully market to them and help them with their work. At the end of this phase conduct survey, analysis, and course correction	Reach all members of community as defined by identified leader *¼ of respondents to survey indicate it helps people with their daily work*
6 months–1 year	Apply course correction to community, identify additional practitioners of community and successfully market to them, establish core knowledge set (Standards, NPRs, templates, Lessons Learned, and welcome FAQs) for community. Begin monthly telecons.	½ of respondents to survey indicate it helps them with their daily work *Establish individual community success criteria developed with communities leaders*
2+ years	Establish community traditions (annual face-to-face, quarterly events, and "member of the month" recognitions), assure that all members (existing and new) are conversant on core knowledge set, mechanisms for outreach to new discipline engineers, establish community best practices and archives of best community discussions, and community health survey	At least 75% of respondents to survey indicate it helps them with their daily work Measure and report on individual community success criteria

III. DISCUSSION

Not all communities have been implemented, but of those that have, several lessons have been learned that are changing how NEN develops its communities. One major lesson was that while the Technical Fellows were respected in their field, this also meant that they were in high demand. As such, they did not have adequate time to focus on establishing a community. Having a backup leader proved to be critical for some communities to have a successful rollout.

Once a community had been identified and a leader established, the first step that helped guide the following stages of development was to create a clear charter that defined the purpose and scope of the community. This charter could then be used in the communication strategy used to help grow the community. Leaders and facilitators alike sought to develop communities that would enhance an engineer's ability to do his or her job, and to avoid providing content for the sake of providing content.

The initial community design phase between leader and

facilitator enabled them to build trusting relationships that aided in later developmental stages.

Several technical lessons were learned as well. Users did not embrace discussion boards as much as anticipated, but were keen to integrate wikis and blogs into their communities. In addition, seeking and giving advice were successful means of gaining initial community member involvement.

As Wierba et al state, collaborative tools must merit their development [14]. The Systems Engineering community, after several months of development and growth, began working with the NEN team to advise on technological advances in the collaborative capabilities.

One major benefit of integrating the communities of practice in one system, i.e., the NASA Engineering Network, was the ability to integrate content from other components. For example; saved discipline-specific queries from the formal NASA Lessons Learned Information System which is housed in NEN, could be made available from the community page. Likewise, content developed in a community could be pushed out to other users through the search tool. The team implemented a link to communities in the search tool, so if a user is conducting a general search on environmental test, for example, in addition to the list of resources they will see a link to the Environmental Test Community of Practice.

The NEN team also realized that users cannot learn in an insular fashion. Engineers expressed the need to communicate with other institutions, whether they were aerospace corporations or universities. To meet this need, the NEN team developed an extranet capability so that identified users who did not have access to resources behind the NASA firewall could participate in communities of practice.

Finally, it was clear that those communities that thrived were ones that complemented their online collaboration with face to face or telephone meetings. Therefore, telephone or face to face meetings were added to the success criteria.

IV. Next Steps

In Fiscal Year 2008 and 2009, the NEN team will focus on rolling out the remaining engineering communities of practice until all 25 have been established and launched. In addition, other communities that have formed organically have requested a presence within NEN. These and any other new communities are pending review and approval by the Office of the Chief Engineer.

References

[1] Bresnen, Mike, Linda Edelman, Sue Newell, Harry Scarbrough, and Jacky Swan. Social Practices and the Management of Knowledge in Project Environments. International Journal of Project Management 21 (2003), 157-166.

[2] Garrety, Karin, Paul L. Robertson, and Richard Badham. Integrating Communities of Practice in Technology Development Projects, International Journal of Project Management 22 (2004), 351-358.

[3] Gehman, Harold W. (Chairman). Columbia Accident Investigation Board Report, Volume 1. NASA and GAO, August 2003.

[4] Greenes, Kent. Communities of Practice Facilitation. Presentation to the NASA Engineering Team, 2006.

[5] Hoadley, Christopher M., and Kilner, Peter G. Using Technology to Transform Communities of Practice into Knowledge-Building Communities. SIGGROUP Bulletin, 25(1), 31-40.

[6] Kuhn, Thomas. 1962. The Structure of Scientific Revolution. University of Chicago Press.

[7] Nahapiet, J and Ghoshal, S, 'Social Capital, Intellectual Capital and the Organizational Advantage', Academy of Management Review, 23(2), (1998).

[8] Nielsen, Jakob, and Molich, R. (1990).Heuristic evaluation of user interfaces, Proc. ACM CHI'90 Conf. (Seattle, WA, 1-5 April), 249-256.

[9] Nielsen, Jakob. (1994). Heuristic evaluation. In Nielsen, J., and Mack, R.L. (Eds.), Usability Inspection Methods. John Wiley & Sons, New York, NY

[10] Orr, Julian E. Sharing Knowledge, Celebrating Identity: Community memory in a service culture. in Middleton, D. and Edwards, D. eds. Collective remembering, Sage Publications, Newbury Park, CA, 1990, 169-189.

[11] Shenhar, Aaron J. Strategic Project Management: The New Framework. Proceedings of PICMET, Portland International Conference on the Management of Engineering and Technology, 1999.

[12] Wenger, E., and W. Snyder. 2000. “Communities of Practice: The Organizational Frontier.” Harvard Business Review. 78(1): 139–145.

[13] Wenger, Etienne, Richard McDermott and William M. Snyder. Cultivating Communities of Practice. Harvard Business School Press, 2002.

[14] Wierba, Elizabeth E., Thomas A. Finholt, and Michelle P. Steves. Challenges to Collaborative Tool Adoption in a Manufacturing Engineering Setting: A Case Study, Proceedings of the 35th Hawaii International Conference on System Sciences (HICSS-35’02).