Creating An Architecture to Deploy Knowledge Management at Your Organization

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Agenda

• Identify critical success factors for successful KM implementation
• Learn how to develop a knowledge architecture comprising processes, services, and systems
• Share lessons from the front lines in KM implementations
  – U.S. Federal Knowledge Management Group
    • http://km.gov
  – IAA Working Group on Knowledge Management
Drafting the Architecture

- Scoping the job
  - What are the drivers for KM in the Government?
- Creating the blueprints
  - What constitutes a knowledge architecture?
- Finding the builders
  - How do you start the community?
- Laying the foundation
  - How do you begin the initiatives?
- Moving in
  - How do you sustain the environment?
What is Driving KM?

- KM can been shown to
  - Improve efficiency
    - Speed up core processes and information retrieval
    - Free up workers’ time for content production
  - Avoid knowledge loss
    - Compensate for dilution or loss of experts
    - Avoid costs and consequences of relearning lessons
  - Stimulate knowledge growth and creation
    - Improve collaborative environments to promote research and cross-discipline sharing
    - Recognize and reward knowledge reuse

- Current drivers include
  - Increasing percentage of workforce is eligible for retirement
  - People spend ~30% of their time looking for information
  - Of the Fortune 500, 2/3 have KM initiatives
  - In the U.S., *The President’s Management Agenda*: “KM systems are just one part of an effective strategy that will help generate, capture, and disseminate knowledge and information relevant to the organization’s mission.”
Differentiating “Information”

- Lessons learned
- Interconnections between objects and people
- Documents
- Drawings
- Raw data
- Test results

Added value and human analysis required
Types of Knowledge

There are two types of knowledge discussed in the literature and that need to be addressed:

- **Tacit**: That which is embedded in the minds of people and is difficult to or has not been written down or communicated.
- **Explicit**: That which has been written down or captured in some persistent way (video, web, documents).

<table>
<thead>
<tr>
<th>Tacit</th>
<th>Explicit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not teachable</td>
<td>Teachable</td>
</tr>
<tr>
<td>Not articulated</td>
<td>Able to be expressed</td>
</tr>
<tr>
<td>Not observable in use</td>
<td>Observable in use</td>
</tr>
<tr>
<td>Rich</td>
<td>Schematic</td>
</tr>
<tr>
<td>Complex</td>
<td>Simple</td>
</tr>
<tr>
<td>Undocumented</td>
<td>Documented</td>
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Types of Tacit Knowledge

- Exists in individuals and groups, and is created through repeated experiences (or routines) and experiments (content + context)
- Tacit knowledge, internalized by a user, is almost impossible to put into a document or a database—we cannot codify it
  - Incorporates accrued, embedded learning
  - May not be separable from individual’s actions
    - A musician’s style
    - Steps a researcher follows to decide what to study
- Has been historically eased by turning it into explicit knowledge through language, printing, and collective understanding
Polanyi’s Theories of Knowledge

- Polanyi (1948) started the philosophical discussion of personal knowledge
- Polanyi’s three theses
  - True discovery cannot be accounted for by rules or algorithms
  - Knowledge is both public and to a great extent personal (and contains emotions)
  - Knowledge that underlies explicit knowledge is either tacit or rooted in tacit knowledge
Polanyi’s Hierarchy of Knowing

- **Skill**
  - The ability to act according to rules (typing)

- **Know How**
  - *Skill* + ability to act in social contexts (problem solving)

- **Expertise**
  - *Know How* + ability to influence the rules of the domain of knowledge (innovative solutions and new creations--doing what you *must*)
Other Theorists on Knowledge

- **Sveiby** looked at the implications and Polanyi and noted that knowledge is an *activity* that would be better described as a process of knowing (to know *is* to do)
  - Acquiring knowledge is *action*-oriented
  - A medical diagnostician’s skill is as much an art of doing as of knowing

- **Barnard** notes knowledge is skills + mental processes and attempts to combine logical (explicit) and non-logical (tacit)

- **Simon** develops “information processing theory”, stresses keeping information within company and dismisses tacit knowledge

- **Weick’s** “sensemaking” theory emphasizes that knowledge is created by individuals sharing and debating ideas and experiences
Benchmarking

- In 1998, we reviewed 43 published case studies and visited 6 organizations to understand what others were doing in KM
  - Standard set of questions, which generally devolved into long conversations
  - Analyzed for critical success factors or reasons why implementations failed or stumbled
  - Has held up over the test of time
- These organizations succeeded at KM when they were
  - Recognizing and rewarding people for sharing knowledge
  - Encouraging and supporting communities of practice
  - Balancing their long-term corporate needs (capturing knowledge) with short-term local needs (completing a task quickly)
- **Culture** was the most important factor: recognize, reward, and acknowledge the importance of knowledge sharing throughout the organization
KM Critical Success Factors

- Training, Services, Strategic Tools
- Ownership, Sharing and Reuse, Incentives and Rewards
- Access Methods, Building Blocks, Standards, Service Bases
- Knowledge Resources, Repositories, Content, Context, Directories, Interoperability
Recognizing the Importance of Culture

- The most critical factor in the success of a KM implementation is cultural acceptance
  - Recognizing issues of data ownership
    - Individual vs. organization
    - Individual vs. team
  - Acknowledging the appropriateness and acceptance of knowledge sharing and reuse
    - Knowledge reuse is not always perceived by the individual to be “good” (innovation or creation is “better”)
  - Rewarding individuals and teams for promoting KM when they
    - Capture team discussions and decisions
    - Create a supportive environment for mentoring
    - Document and share lessons learned
    - Make tacit knowledge explicit
Cultural Differences in Sharing

- Nonaka and Takeuchi (1995) studied knowledge-creating companies

<table>
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<th>Japanese</th>
<th>American</th>
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<tr>
<td>- Information is a resource that can be bought both internally or externally</td>
<td>- Information is to be guarded and legally protected</td>
</tr>
<tr>
<td>- Value tacit knowledge</td>
<td>- Ignore outside sources of knowledge</td>
</tr>
<tr>
<td></td>
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Importance of Mentoring

- Benefits to the protégé
  - A stimulating environment to develop intellectual (Haensly & Parsons, 1993) and creative skills (Buhler, 1996; Edlind & Haensly, 1985)
  - Advancement of career (Turban & Dougherty, 1994)
  - Development of a personal ethic (Edlind & Haensly, 1985)
  - Increase in confidence (Newby & Heide, 1992)
  - Protégés hold a greater influence on their organizations and also are more apt to control organizational resources than workers who do not have the benefit of a mentor (Fagenson, 1988)
Importance of Mentoring (continued)

- Benefits to the mentor
  - Assistance in completion of work
  - Work and personal stimulation
  - Personal satisfaction (Edlind & Haensly, 1985)
  - Continued life of their ideas (Buhler, 1996)

- Benefits to the organization
  - Mentoring leads both parties to greater levels of job satisfaction (Corzine, Buntzman, & Busch, 1994)
  - Increase in organizational loyalty (Buhler, 1996)
Mentoring Study at JPL

- **Research Questions**
  - Can shared interests be transmitted between mentor and protégé?
  - What characteristics of the mentor or the mentor’s method of transmission affect the protégé’s perspective of the mentoring relationship?
  - What promotes a protégé to exhibit the positive experiential state of flow?

- **Online survey instrument**
  - $N = 147$
  - Those who report having a mentor, $n = 95$
  - Those who report having a protégé, $n = 88$
  - Those who report having both a mentor and a protégé, $n = 42$
  - $\sim 55\%$ from administrative and management, $45\%$ from technical areas
Significant Findings on Mentoring

- Mentor’s primary method of conveying message is oral and/or written communication vs. modeling
  - Protégées reported that when their mentor used modeling, as opposed to oral/written communication, they were more apt to attribute their interests to them

- Protégées are most likely to attribute their interests to the influence of their mentor when
  - Protégées feel they share their work-related interests or are working on specific projects with their mentor
  - When protégés felt that the mentor supported their personal growth

- Protégés report that one of the most important things their mentor did for them was related to socialization within JPL
The Essence of Transferring Knowledge

- There are two types of knowledge we deal with in an organization
  - **Tacit**: Embedded in the minds of people and difficult to write down or communicate (a musician’s style, the steps a researcher follows to decide what to study)
  - **Explicit**: Captured in a persistent way (video, documents)

- Knowledge transfer occurs in one of two modes, through
  - Making tacit knowledge explicit to another person synchronously
    - Imitation (apprenticeship, mentoring)
    - Identification (familiarity)
    - Learning by doing (experience)
  - Making tacit knowledge explicit to another person asynchronously
    - Capture tacit knowledge explicitly (books, programs, or procedures)
    - Share that explicit knowledge through discussions or tools
    - Sustain access to that knowledge across generations and projects
Creating Architectural Approaches to Knowledge Management
Creating a Knowledge Architecture

- There are three ways to look at architecting a KM program
  - **Process**: Oriented on the way in which people do their day-to-day work in the organization (the *how* and *why*)
  - **Services**: Focused on who will help people share their knowledge and who will maintain tools and processes (the *who*)
  - **Systems**: Are the IT infrastructure and tools necessary to deliver the processes and services efficiently and effectively to the end users (the *what* and *where*)
Step 1. Creating KM Processes

Adapted From Ernst and Young
Capture Knowledge

- Helping people articulate knowledge that can be easily shared and reused
- Supporting people in moving tacit knowledge to explicit knowledge
Organize Knowledge

- Organize information so that people can easily share it, find it, and use it once it’s found
- Structure information in standardized ways for use by others
Develop Knowledge

- Refining knowledge so that it can be easily reused by others (such as others on your team, future teams, or in your discipline)
- Selecting which knowledge will be most useful based on the question asked or the need defined
Distribute Knowledge

- Helping people get access to knowledge
- Encouraging people to use and reuse knowledge
- Training people in how to use the knowledge management tools
Step 2. Establishing KM Services

- The way in which people in an organization interact with knowledge management activities is through a service.
- Services integrate processes, people, and systems into a cohesive support structure for how people actually do their work.
- The “build it and they will come” mentality doesn’t work in the deployment of content-rich, enterprise-wide systems.
  - Users need to be an active part in order to keep content refreshed, accurate, and relevant.
Writing a Document Today...

- What's in this document?
- Talk to coworkers
- E-mail
- Search for similar documents
- Invent your own format
- Solicit ideas

Receive comments

Distribute to reviewers

Create draft

Does it comply with the regulations?

Not approved for external release

Forgot to address x, y and z

Rewrite

What's the latest version?

√ Release document

Distribute

Time for a change

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KM @ NASA
Writing a Document in a KM-Enabled World...

What’s in this document?

Review and release

Template with all required areas

Subject matter experts

Good examples

Collaboration tools

Regulatory compliance

Rules and regulations

Routing and distribution

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KM @ NASA
A Sample Service: Document Management

- Document management is about much more than a shared, accessible repository enabled by workflow:
  - Authoring environment (templates that include content guidelines and samples of good material)
  - Information lifecycle (how do objects move from stage to stage and how are they reused?)
  - Service base (where and who do you go to for support today, tomorrow, and in two years?)
  - A one-stop shop for all information publishing needs
Step 3. Develop a System Architecture

- A layered approach, building upon already existing infrastructure and services, KM provides
  - User interface
    - Enterprise portal or web sites with data channels for roles, interests, and disciplines
  - KM functions
    - Virtual team environments (sharing and collaborating)
    - Taxonomies for browsing
    - Robust search capability
  - Application infrastructure services
    - Document management
    - Content management
    - Standards for documentation
    - Metadata management
Step 3. System Architecture (continued)

- Knowledge resources
  - Existing resources
  - Experts profiles
  - Q&A databases

- Infrastructure services
  - Network
  - Messaging
  - File
  - Desktop support
  - Data access
  - Security
INFORMATION SYSTEM ARCHITECTURE

"What do you want to do?"  
"Who are you?"  
"How do you want it?"

KNOWLEDGE MANAGEMENT FUNCTIONS
Search, Browse, Retrieve, Create, Add Value (metadata), Update, Archive, Index, Filter, Catalog, Analyze, Validate, Associate

APPLICATION INFRASTRUCTURE SERVICES

KNOWLEDGE RESOURCES

INFRASTRUCTURE SERVICES
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Checklist for Successful KM Systems

- In looking at best practices in technology implementation, KM choices should judge success by ensuring
  - High accessibility, searchability, and ease of use
  - Potential to save a large amount of work
  - Potential to help avoid expensive problems
  - Richness of the data repository
  - Features such as online help, help desk, and frequently asked questions
  - Openness to unsolicited submissions of information
  - Information that is maintained and accurate
Implementing a Knowledge Architecture at NASA
What is Knowledge Management?

- Knowledge management (KM) is getting the right information to the right people at the right time, and helping people create knowledge and share and act upon information in ways that will measurably improve the performance of NASA and its partners.

- Driving forces at NASA
  - Less experienced project teams need to see key information quickly
  - Highly specialized and compartmentalized knowledge
  - Management drivers
    - Better Mechanisms Needs for Sharing Lessons Learned (GAO) recommends linkage between KM and lessons learning at NASA
    - Administrator O'Keefe: Make NASA a leader in e-Government
    - NASA Integration Action Team: Promote the continuous capture, dissemination and utilization of knowledge
Creating a KM Community at NASA

- NASA's KM Team is chartered by the Chief Information Officer (Lee Holcomb)
  - Representatives from across the Agency, system architects to authors to anthropologists
- We find good solutions, fill the gaps, and build a federation of resources to support our missions and research communities
  - KM supports and enables other processes and initiatives by advocating best practices, promoting good solutions, and building infrastructure and applications to bridge distributed systems
  - KM’s goal is to help infuse new ideas or needed technology and to leave or turn over operations to the appropriate content area
- Actively share and benchmark with other Agencies, the National laboratory community, and academia
Key Areas for NASA’s KM Strategy

- To sustain NASA’s knowledge across missions and generations
  - KM will identify and capture the information that exists across the Agency

- To help people find, organize, and share the knowledge we already have
  - KM will efficiently manage NASA’s knowledge resources

- To increase collaboration and to facilitate knowledge creation and sharing
  - KM will develop techniques and tools to enable teams and communities to collaborate across the barriers of time and space
Framework for KM at NASA

Sharing and Using Knowledge

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<thead>
<tr>
<th>People</th>
<th>Process</th>
<th>Technology</th>
</tr>
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<tbody>
<tr>
<td>Enable virtual collaboration</td>
<td>Enhance knowledge capture</td>
<td>Enhance knowledge integration and data mining</td>
</tr>
<tr>
<td>Support communities of practice</td>
<td>Manage information</td>
<td>• Utilize intelligent agents</td>
</tr>
<tr>
<td>Reward and recognize knowledge sharing</td>
<td></td>
<td>• Exploit expert systems</td>
</tr>
<tr>
<td>Encourage storytelling</td>
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Supporting Activities

<table>
<thead>
<tr>
<th>Education and Training</th>
<th>IT Infrastructure</th>
<th>Human Resources</th>
<th>Security</th>
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</table>
Creating a Process Architecture in 2001

- The NASA KM Team first focused on three pilot activities to prove the viability of KM at NASA:
  - **Knowledge Navigation**: enabling access to information
  - **Lessons Learned Information System**: improving the capture of key knowledge and infusion into engineering processes for better decision making
  - **Experts Directory Service**: helping to find scientists and engineers to facilitate collaboration across boundaries
Deploying Systems and Services in 2002

- Information portals
  - For the public, scientists, and employees to streamline access to NASA’s 4,000,000 web pages
  - Identifying content and publishing processes
  - Building framework and technology for distributed use
  - Creating taxonomies and metadata standards for ease of interoperability

- Collaborative environments for missions
  - Creating access to tools, training, and venues for managing virtual teams
  - Quick start environment for proposals and tasks

- Capture design knowledge
  - Creating a service and tools to capture in-process design decisions for use on current and future missions
Portal in Development

NASA Mockup:
http://km.jpl.nasa.gov/portal/insidenasa

JPL Prototype:
http://insidejpl.jpl.nasa.gov
Expert Connections

- Finding people to get answers or work on a project, includes profiles of 1100 technical experts
- Linked to other systems
  - Publications database
  - Caltech experts
- Search or browse
Technical Questions Database

- Best questions asked at technical reviews
- Helps to create a virtual presence when key people cannot be there
- Over 700 questions
- 42 subject areas
KM Embeds Methods and Technology Into The Way People Work

KM Project

Individuals
- Finding information
  Taxonomies and portals
- Finding people
  Know Who
- Capturing information
  Technical Questions and design decisions
- Sharing information
  Portals

Teams
- Sharing information
  Project Libraries online
- Collaborating
  Collaborative tools and rooms and portals

Projects
- Preparing for reviews
  Technical Questions
- Making design decisions
  Knowledge capture
- Ensuring easy collaboration
  Standards for engineering

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KM @ NASA
Sharing Knowledge
- Adaptive knowledge infrastructure is in place
- Knowledge resources identified and shared appropriately
- Timely knowledge gets to the right person to make decisions
- Intelligent tools for authoring through archiving
- Cohesive knowledge development between JPL, its partners, and customers

Enables sharing of essential knowledge to complete Agency tasks
- MarsNet
- Europa Orbiter
- SIM

Integrating Distributed Knowledge
- Instrument design is semi-automatic based on knowledge repositories
- Mission software auto-instantiates based on unique mission parameters
- KM principals are part of Lab culture and supported by layered COTS products
- Remote data management allows spacecraft to self-command

Enables seamless integration of systems throughout the world and with robotic spacecraft

Capturing Knowledge
- Knowledge gathered anywhere from hand-held devices using standard formats on interplanetary Internet
- Expert systems on spacecraft analyze and upload data
- Autonomous agents operate across existing sensor and telemetry products
- Industry and academia supply spacecraft parts based on collaborative designs derived from JPL's knowledge system

Enables real-time capture of tacit knowledge from experts on Earth and in permanent outposts
- MarsNet
- Europa Lander/Submersible
- Titan Organics; Lander/Aerobot
- Neptune Orbiter/Triton Observer
- Mars robotic outposts
- Comet Nucleus Sample Return
- Saturn Ring Observer
- TPF

Modeling Expert Knowledge
- Systems model experts' patterns and behaviors to gather knowledge implicitly
- Seamless knowledge exchange with robotic explorers
- Planetary explorers contribute to their successor's design from experience and synthesis
- Knowledge systems collaborate with experts for new research

Enables capture of knowledge at the point of origin, human or robotic, without invasive technology
- Interstellar missions
- Permanent colonies
Sharing Knowledge (2003)

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Integrating Distributed Knowledge
- Instrument, design is semi-automatic based on knowledge repositories
- Knowledge is integrated into custom products based on unique mission parameters
- KN principals are part off of culture, framework, and products
- Results of KN deployment allows spacecraft to self-configure

Enables sharing of essential knowledge to complete Agency tasks
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Europa Orbiter
Space Interferometry

2003 2007 2010 2025
- Comet Nucleus Sample Return
- Europa Land/Submersible
- Neptune Orb/Triton Observer
- Lander/Aerobot
Lessons Learned

- Enlist, encourage, empower (baptize the evangelists)
- Develop solutions, services, and rewards
  - Deliver specific solutions to specific customers
  - Build KM into the way people already do their jobs
  - Understand that cultural acceptance is key
  - Make services operational (including funding and metrics)
  - Reward knowledge sharers through promotions, recognition, and time to learn and share
  - Recognize and celebrate contributions of the KM team and others
- Keep the alliances strong
- Balance long-term desires (capturing knowledge) with local requirements (specific solutions to a problem)
- Don’t try to solve the whole problem—just start somewhere and solve part of the problem
Thanks!

- Many thanks to my JPL and NASA colleagues and our academic partners who contributed to these ideas and to the excellent work they are doing in implementing knowledge management solutions at JPL and NASA.

- If you have any additional questions, please contact me:
  
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- More information can be found at
  - NASA’s KM program: http://km.nasa.gov
  - JPL’s KM program: http://km.jpl.nasa.gov