Critical Knowledge Index

Identification and Prioritization of Critical Knowledge

December, 2015
The IKNS Capstone Project

Class of 2015: 55 Students
18 Sponsors

Consulting project to initiate or improve information and knowledge processes, or to expand revenue opportunities from intelligent, knowledge-enabled products.
Goal

Recommend a method for implementing a continuous and formal effort to **Identify**, **Prioritize**, **Capture** and **Transfer** critical knowledge.

- Ensure knowledge, that is at the risk of being lost, is preserved.
- Expand the Agency’s intellectual capital across NASA’s enterprises and generations.
- Support the NASA workforce in successfully carrying out NASA’s missions.
“Critical Knowledge is defined as broadly applicable lessons learned that enable mission success, stimulate critical thinking and help raise questions that need to be addressed at various phases in a project life-cycle.”

Critical Knowledge Gateway Compendium

Two-part classification approach:
1.) A notional simplified project timeline
   - Up-Front
   - Development
   - Operations
   - Close-out
2.) High-level topical themes
   - People
   - Technical
   - Process
Knowledge Referees determine which lessons:

- Possess *broad applicability*
- Involve *Top 5%* of updateable knowledge most important for programmatic & engineering missions to learn
- Involve knowledge that *keeps evolving* towards new applications and missions
- Lends itself to a *formal process* as candidates for formal *incorporation into appropriate policies and technical standards as well as to technical workforce development products and activities to prevent skills dissipating over time*

---

**NASA Knowledge Community**

- Incorporate and integrate dispositions into agency digital tools and across CKOs

---

**Agency CKO and Knowledge Referees**

- Validate priorities
- Coordinate disposition recommendations
- Identify current and new agency activities and resources to address recommended dispositions
Knowledge Referees

People
[OHCM] Office of Human Capital Management

Process
[OSMA] Office of Safety and Mission Assurance

Discipline Technical
[NESC] NASA Engineering & Safety Center

Knowledge Transfer & Digital Technology (Services)
Agency CKO

Disposition Activities

- Training/Development
- Knowledge Service
- HCM
- Policy & Procedure
- Process
- Awareness
- Other

Agency Digital Tools

- Search
- Analytical/Visualization Tools
- Collaboration Platforms
Top 3 priorities identified in each NASA Critical Knowledge Element

**People**
1. Address Toxic Management
2. Improve communications at all organizational levels
3. Improve situated and virtual teamwork

**Process**
1. Improve Risk-Informed decision-making
2. Improve requirements definition process
3. Improve agile versus rigor procedures and hybrids

**Technical Discipline**
1. Improve technical perspective on cost versus requirements trade capability
2. Address decision biases when working technical problems
3. Implement iterative capability to refresh technical knowledge

**Knowledge Transfer & Digital Technology**
1. Identification and integration of Agency sources for improved findability and searchability
2. Formalization of lessons-learned process
3. Increased executive participation
A continuous and formal method for Identifying, Prioritizing, Capturing and Transferring Critical Knowledge is largely a novel concept.
IKNS-NASA Capstone Project: Two Main Dimensions

First (I) Dimension

Define, Identify and Prioritize Critical Knowledge

- Lessons Learned +
- Critical Thinking +
Critical Knowledge Index (CKI) = Critical Knowledge (Top 5%)

Second (II) Dimension

Capture and Transfer Critical Knowledge

- Critical Knowledge + Knowledge Service implementation into policies and formal standards

IKNS Critical Knowledge Framework

Critical Knowledge Index
Steps to Identify and Prioritize Critical Knowledge

1. Knowledge Classification
   Classify knowledge based on 3 categories

2. Critical Knowledge Framework
   Apply 0-5 scoring system to 5 knowledge criteria

3. Critical Knowledge Index (CKI)
   Calculate CKI based on a formula.

4. CKI Ranking & Prioritization
   Top 5% most relevant items to constitute agency wide CK

5. Trends and Decision Making
   CKI dashboard

Lessons Learned Entries from Kennedy Space Center
## Critical Knowledge Classification Categories

<table>
<thead>
<tr>
<th>Category 1</th>
<th>Category 2</th>
<th>Category 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UP-FRONT</strong></td>
<td><strong>OPERATIONS</strong></td>
<td><strong>Knowledge Services Area</strong></td>
</tr>
<tr>
<td>Architecture studies, Forming the project team, defining roles &amp; responsibilities, systems requirements definition, earliest milestones</td>
<td>Ground processing, launch, and on-orbit operations of a space system.</td>
<td><strong>INFORMATION MANAGEMENT</strong></td>
</tr>
<tr>
<td><strong>CLOSE-OUT</strong></td>
<td><strong>PEOPLE</strong></td>
<td><strong>KNOWLEDGE TRANSFER &amp; DIGITAL TECHNOLOGY</strong></td>
</tr>
</tbody>
</table>
| Deorbit, program/project termination, facility closure, human resource management, close out of records, historical recordation, environmental cleanup | Factors Involving:  
  • Communications  
  • Individual Behavior  
  • Team Behavior  
  • Organizational Culture  
  • Expectations | Factors involving moving knowledge across organizational boundaries and digital information and communications tools that enable and accelerate interaction and learning. |
| **DEVELOPMENT** | **PROCESS** | **COLLABORATION / NETWORK** |
| From PDR onward through CDR and into manufacturing phases | Factors addressing specific actions towards defined outcomes in a system perspective. | Social capital, Tacit to Explicit, Working environment, Network dynamics, Network design |

**UP-FRONT**
- Architecture studies, Forming the project team, defining roles & responsibilities, systems requirements definition, earliest milestones

**OPERATIONS**
- Ground processing, launch, and on-or-bit operations of a space system.

**PEOPLE**
- Factors Involving:
  - Communications
  - Individual Behavior
  - Team Behavior
  - Organizational Culture
  - Expectations

**PROCESS**
- Factors addressing specific actions towards defined outcomes in a system perspective.

**PROJECT MANAGEMENT**
- Communicated Vision, Leadership, Common Goals, Acknowledgement, short-term wins

**INFORMATION MANAGEMENT**
- Databases, Codification practices, Findability, Access, Knowledge technologies

**KNOWLEDGE TRANSFER & DIGITAL TECHNOLOGY**
- Factors involving moving knowledge across organizational boundaries and digital information and communications tools that enable and accelerate interaction and learning.

**COLLABORATION / NETWORK**
- Social capital, Tacit to Explicit, Working environment, Network dynamics, Network design
Critical Knowledge: Lessons Learned Scoring System

Scoring System on a scale from 0-5 where:

0 - Not at all
1 - Minimally Relevant / Low
2 - Somewhat Relevant
3 - Average / Middle
4 - Relevant / Applicable
5 - Definitely Relevant / Highly applicable

- Innovation 1/6
- Impact 1/6
- Benefit 1/6
- Broadly Applicable 1/4
- Risk 1/4
The Critical Knowledge Index - CKI

Calculated from the scores in the Critical Knowledge Framework

CK Framework

Variables can have different weights in the formula

Risk (R) = 1/4

Broadly Applicable (BA) = 1/4

Impact (I) = 1/6

Benefit (B) = 1/6

Innovation (In) = 1/6

Formula:

\[
\text{CKI} = \left[\frac{1}{4} \cdot R\right] + \left[\frac{1}{4} \cdot BA\right] + \left[\frac{1}{6} \cdot I\right] + \left[\frac{1}{6} \cdot B\right] + \left[\frac{1}{6} \cdot In\right]
\]
Critical Knowledge Index Variables

Risk (R)
Situation, process or behavior involving some exposure to danger (e.g. High Risk vs. Low Risk)

Impact (I)
Knowledge that has a substantial effect on enhancing project outcomes (e.g. Low Impact vs. High Impact)

Broadly Applicable (BA)
Extent to which knowledge can be deployed in diverse contexts across the agency (e.g. Marginally applicable vs. Broadly applicable)

Benefit (B)
Comparative advantage gained from something (e.g. Marginal Benefit vs. Substantial Benefit)

Innovation (In)
Viewed as the application of better solutions emanating from new knowledge that meet evolving requirements (e.g. Blind Spot vs. New Insight)
<table>
<thead>
<tr>
<th>Knowledge ID</th>
<th>Subject</th>
<th>Knowledge (KSC Lessons Learned)</th>
<th>Project Life Cycle</th>
<th>Project Element</th>
<th>Knowledge Service Area</th>
<th>Risk</th>
<th>Broadly Applicable</th>
<th>Impact</th>
<th>Benefit</th>
<th>Innovation</th>
<th>CKI</th>
</tr>
</thead>
<tbody>
<tr>
<td>12901</td>
<td>Procurement of Nonconforming Titanium Alloys</td>
<td>As counterfeiting of aerospace parts and materials has become increasingly commonplace, flight system and instrument developers must exercise a high level of vigilance and institute screening processes that are sufficiently rigorous to counter the risk.</td>
<td>Operations</td>
<td>Discipline Technical</td>
<td>Project Management</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>4.67</td>
</tr>
<tr>
<td>11501</td>
<td>Mars Science Laboratory Actuator Design Process Escape</td>
<td>Demand a higher standard of proof-of-readiness prior to incorporation of risky new technology. This proof did not exist at the time the MSL project chose to implement titanium gearing (for mass reduction) and dry lubricant gear coating (for cryogenic operation without active heating).</td>
<td>Up-Front</td>
<td>Process</td>
<td>Project Management</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4.58</td>
</tr>
<tr>
<td>12901</td>
<td>Procurement of Nonconforming Titanium Alloys</td>
<td>Assure that a thorough review of all Certification Data Packages accompanying received Ti alloys is performed by trained and experienced Materials &amp; Processes (M&amp;P) engineers, Procurement Quality Assurance (PQA) specialists, or equivalent personnel.</td>
<td>Up-Front</td>
<td>People, Process</td>
<td>Project Management</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>4.42</td>
</tr>
<tr>
<td>12901</td>
<td>Procurement of Nonconforming Titanium Alloys</td>
<td>Material suppliers should be Nadcap (National Aerospace and Defense Contractors Accreditation Program) certified, and they should be audited and approved by PQA and M&amp;P engineers and placed on an Approved Suppliers List (ASL).</td>
<td>Up-Front</td>
<td>Process</td>
<td>Project Management</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>4.42</td>
</tr>
<tr>
<td>12901</td>
<td>Procurement of Nonconforming Titanium Alloys</td>
<td>All procurements should require that the material type and specifications be listed in the contract.</td>
<td>Up-Front</td>
<td>Process</td>
<td>Project Management</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>4.42</td>
</tr>
<tr>
<td>12901</td>
<td>Procurement of Nonconforming Titanium Alloys</td>
<td>Material testing should be performed on a sample basis to validate the supplier’s material test reports.</td>
<td>Development</td>
<td>Process</td>
<td>Change Management</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>4.42</td>
</tr>
<tr>
<td>5006</td>
<td>Evolution and Management of Spacecraft Configuration</td>
<td>The effects of baseline changes on budgets need to be understood before new baselines are accepted.</td>
<td>Development</td>
<td>Process</td>
<td>Project Management</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3.17</td>
</tr>
<tr>
<td>6358</td>
<td>Thermal Environments Data File Format</td>
<td>It is preferable to use a simple, easy to read and understand file format so that it can be reviewed in any text viewer. Also its contents can easily be plotted.</td>
<td>Up Front</td>
<td>Process</td>
<td>Information Management</td>
<td>1.5</td>
<td>2.5</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Operationalization of the CKI as a Decision Making tool

There are two ways in which the CKI could be used:

1. Formulate a threshold value and then classify any lessons learned with a CKI above that value as part of the agency’s CK.

2. Rank lessons learned and choose a certain fraction (5%) with the highest CKI scores to constitute the agency’s CK.

On the basis of the criteria set by NASA, it was decided that the lessons learned with the Top 5% CKI values would conform the agency’s CK.
CKI Visualization Dashboard: Exploring Identified and Prioritized Critical Knowledge

**Apply CK Framework**
Classification Categories

**CKI Ranking:**
List of top 5% lessons learned

**Browse Top 5% Entries**
for each category combination

- **Project Life-Cycle**
- **Project Element**
- **Knowledge Services Area**

- **Up-Front**
- **Operations**
- **Development**
- **Close-Out**

- **People**
- **Knowledge Transfer & Digital Technology**
- **Process**
- **Discipline Technical**

- **Infor. Mgmt.**
- **Project Mgmt.**
- **Collaboration**
- **Governance**
Questions

Should the CKI also take into account the experience and position of the user applying the scores in the CK Framework?

How should the age of the knowledge or date it was recorded influence its effect on the CKI?

What is the natural extension of the CKI to prioritize other knowledge products generated by NASA?
Classification filters allow to focus CK framework implementation.

Methodology can be customized with different variables and weights in CKI formula.

Selection criteria (e.g. currently top 5% CKI) can be tailored to adjust CK flow appropriately to account for limited bandwidth.