Summary:

Land and Resource Management (L&RM) personnel balance complex, competing interests in making decisions that ensure multiple use, preservation, and restoration of public lands. From planning to implementation, the challenges in realizing the benefits of consensus-driven solutions are diverse and ever changing.

This paper describes an approach to assist L&RM organizations in leveraging what they already possess - their data, information and knowledge assets. Most L&RM data assets are highly federated, and decentralized IT infrastructures impede collaboration. The approach presented in this paper enables L&RM organizations to derive greater value from existing data, improve its quality without disrupting its production, and thereby enhance operational or adaptive management efforts.

The approach shifts manager's time away from awkward systems integration, data calls and time consuming data cleansing efforts and over to informed, selective use of organizational Knowledge, Information and Data (KID) by theme, scale, time and location. Predictable and strategic governance reduces uncertainty, redundant or misfit solutions, and miscommunication. As the organization adopts this approach it lessens costs to the work force and systems and provides a platform for efficient and iterative learning, maturation toward higher quality decisions, and improved workforce utilization.

L&RM Challenge:

"The challenge confronting managers is to make 'good' decisions in [a] complex environment, recognizing that the quality of decision making in the face of uncertainty should be judged by the decision making process as well as progress towards desired outcomes"[1].

L&RM organizations such as the BLM, NPS, and USFS have always required high-quality data and information to support smart, defensible program outcomes. L&RM practices are complex and as such are susceptible to scrutiny. The experience of the workforce, information from multiple disciplines and partners, and data from many systems and sources informs the collective knowledge of the organization. However, experience shows that the challenges in collecting quality data or information are surpassed by the even more difficult problem of contextualizing it for analysis. Such "processing" should occur in a timely, sustainable manner in order to support effective operational or adaptive management practices. Specifically, data and information need to be reprocessed for access, cleansed for quality, and/or enriched with spatial and temporal characteristics.

In response, L&RM experts must coordinate across numerous programs to secure and validate the data, then analyze and synthesize the information to create the knowledge to execute land stewardship practices and decisions. How do L&RM organizations, working with the resources they have – very often in the field - create a more agile and reliable ecosystem of Knowledge, information and Data (KID) which - like the dynamism of the natural landscape - invigorates an enriches our land management decisions?

[11] Department of the Interior - DOI Adaptive Management Technical Guide, P.12

Where are we today?

Real moves to enhance information and knowledge take place today when experts collaborate or when there is meaningful application of business intelligence dashboards or big data analytics. Very often, however, single-point solutions or technology-driven pushes occur when organizations are not fully prepared to adapt to them. The challenge of adoption is compounded by the persistent need under conventional approaches for data to be **E**xtracted, **T**ransformed, and **L**oaded (ETL) into additional computing environments. ETL often results in altered data that is disconnected from its source and lacking scale, spatial or temporal context. In other words, in highly federated organizations, much of the organizational intelligence is left in data files and documents.

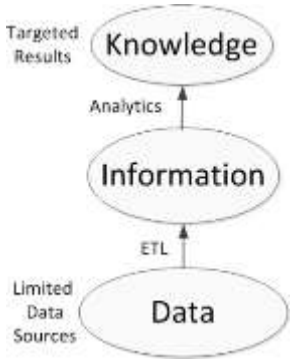


Figure 1 - Information and Knowledge Creation - Technology Based

Todays' IT focus is on transactional systems. However, such systems do not address the broader set of data and information required for the complexities of L&RM tasks, such as land assessment, monitoring or policy evaluation. Very often transactional data is inaccessible; localized analysis datasets are not interoperable; or they are not structured for temporal or visual analysis. Under these conditions, the workforce may not understand the alternatives that may exist for exploration and hypothesis, for a new line of analysis, or for researching the concerns of a stakeholder more deeply. If the data is dirty or of low quality, it is not "fixable" under the current analytical environments; yet the value of data gaps and deficiencies are identifiable and should be resolvable back to the source.

Today's information management environments are not designed to share or publish the data or information for reuse or other KID sharing purposes outside of a narrow user base. For example, Figure 1 describes the basic work flow that exists currently to create knowledge with analytic tools. It is a unidirectional path, and results are typically sub-optimal and often require additional projects and costs to be useful or otherwise fix challenges and problems relating to KID. Nevertheless, higher value information and knowledge have great relevance and are quickly becoming the lifeblood of organizations. L&RM personnel may observe this occurring in other sectors, but they remain particularly if not uniquely challenged by the federation problem and the need to work with natural environments with localized or regional characteristics.

What types of issues and barriers will need to be addressed?

The KID approach challenges some of the fundamentals of how we have thought about or managed knowledge, information and data. Barriers to full appreciation and adoption of a KID perspective are:

- IT investment strategies focus on transactional systems supporting business processes
- Extended (and often successful) analytics or BI work is very often tied to localized systems which are not positioned to support the enterprise level due to stove-piped funding.
- Culture change is a necessary prerequisite to allowing data of varying quality to be put into new environments for new uses outside the source environment.
- The owners of systems and programs that supply data are not motivated or incentivized to share data beyond their boundaries unless doing so provides an immediate benefit

- The time and staff resources needed for successful engagement with management, domain and technical leadership to coordinate across programs and management jurisdiction and to form communities of use and KID governance.

Approach:

What if L&RM organizations were to take a step beyond the traditional approaches, moving past fixed notions of improving data and information use via system integration or deriving knowledge via data warehouse implementations? How can L&RM evolve towards an agile ecosystem where KID flowed and matured seamlessly, reliably and predictably? This type of ecosystem would provide L&RM personnel with the capability to see all of the organizational data, information and knowledge assets holistically and access relevant parts flexibly.

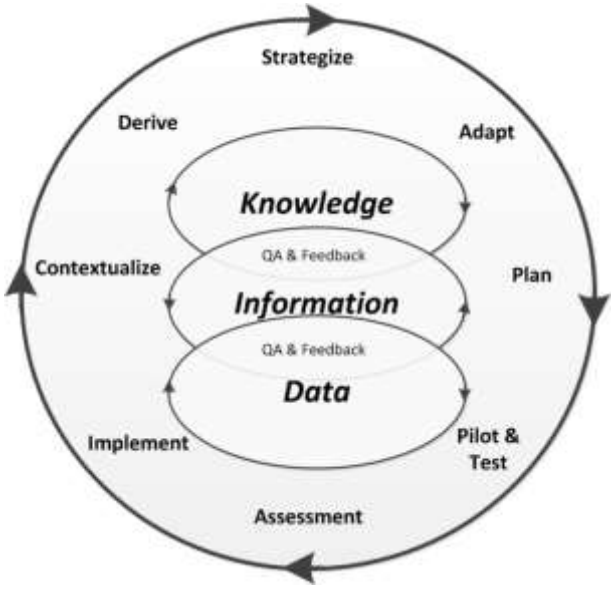


Figure 2 KID Lifecycle

The traditional architectural views of data, systems, technologies and business processes have been limiting data's potential value by inhibiting access to data sources, settling for parochial data management strategies, and perpetuating gaps in ownership and management between data, information and knowledge. KID is designed on a lifecycle-premise naturally supported by all levels of the organization for all relevant sources. This lifecycle model in Figure 2, better positions the organizations to refresh information and knowledge possibilities. KID provides an approach to organize knowledge development efforts, develop management and expert participation and design new tools and architectures. Ultimately, integration found in all facets of the KID operating model drives improvements in public land management practices and improved plans and collaboration.

The KID's operating models for the purposes of this paper are defined as follows:

Knowledge Operating Model: *A strategic business operating model that emphasizes enterprise analytical techniques, processes, management systems and culture to consistently and continuously support adaptive understanding and drive change using derived knowledge that reflects the organization's practices, outputs, information and data assets. The KID supports technical, domain and management experts in identifying the knowledge based solutions to strategic, policy and performance challenges. Knowledge relies on a contextualization platform supplied by the organizations' systems and other sources of data.*

Information Operating Model: *A business operating model that emphasizes enterprise level information and data analysis process and techniques as essential to understanding the breadth and efficiency of its business for adaptive change. The information operating model relies on a secure flexible platform for the creation and enrichment of the "contextual" value of an organization's collective operational data and information assets. It serves to share and exchange data with other systems or external partners or*

systems. It supports the operational management and experts who are responsible for development of operational solutions.

Data Operating Model: *The data operating model is the collection and processing of data used to solve business process and transactional needs. The solutions emphasize process efficiency and compliance with business and regulatory rules or creation of targeted products. There are a range of platforms from desktops to cloud based computing supporting these needs. Data operating model supports the operations staff performing business functions and service delivery*.

The KID operating model fundamentally alters the traditional approach to L&RM architectures by repositioning the data, information and knowledge relationship to be the greatest influence in architectural design and the most impactful for organizational effectiveness. The significance of technologies, processes and systems remain important but become the supporting dimensions of the architecture. The KID not only becomes the dominant architectural view but the organizing principle. Integration that leverages KID will enhance L&RM data quality, increase the potential for contextualized information, and accelerate and sustain the development of organizational knowledge.

What needs need to be done differently?

L&RM managers have had many successes with collaborations in knowledge, information and data sharing in support of a major programmatic issue, but these important exercises are necessarily ad hoc, topic-specific, and term limited. As concluded above, for organizations to improve strategic and operational practices using information and knowledge, it is essential to recognize and holistically design to the data, information, and knowledge environments and their interdependencies.

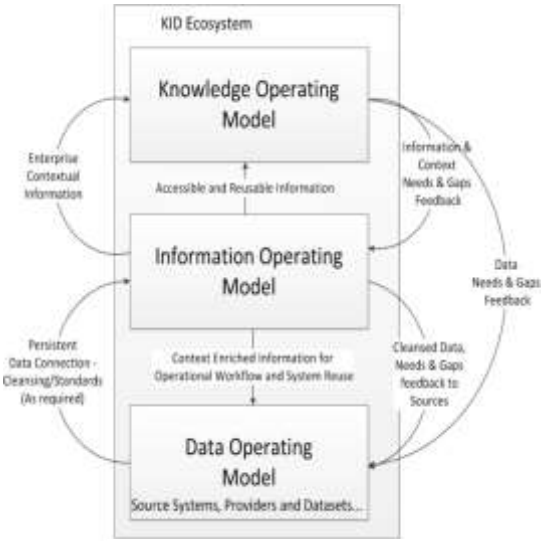


Figure 3 - KID

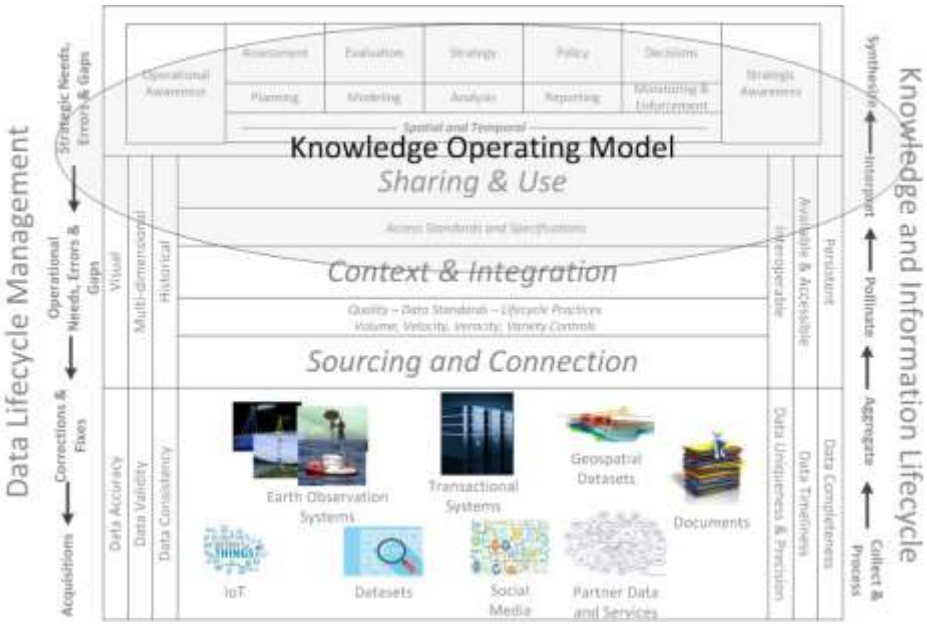
Today's L&RM management concerns derive both from problems unresolved in the past and problems we can now better predict for the future. As L&RM organizations become more informed yet dependent on data, information and knowledge, their architectures and operating models should follow suit!

So, what are we really talking about? KID is an overarching architecture design encompassing a series of complementary and intentionally overlapping operating models supporting strategic and operational awareness use cases. The use cases define the methods where knowledge is created, retained, information shared and contextualized or data sources and quality deficiencies remedied. The KID ecosystem is designed to support agile and iterative tool development, discovery of patterns, experimentation, correction of data quality issues, and identification of gaps in data and information (See Figure 3). Through a governance model with constancy and predictability, it provides persistent data at programmable time intervals and feedback loops to improve data quality and operational

awareness. Combining L&RM scientific and operational data together will produce the management innovation required for staff and organizational learning and feedback. Transactional data will finally have its programmatic complement.

"Learning and feedback. The understanding gained from monitoring and assessment helps in selecting future management actions. The iterative cycle of decision making, monitoring, and assessment, repeated over the course of a project, leads gradually to a better understanding of resource dynamics and an adjusted management strategy based on what is learned."[2]

Functional Description of Operating Models



L&RM Knowledge Operating Model: The strategic business operating model (See Figure 4) emphasizes enterprise analytical techniques, processes, management systems, and a dynamic culture to consistently and continuously support adaptive understanding.

Figure 4 L&RM Knowledge Operating Model

The model sees managers as driving change through derived knowledge that reflects the best in an organization's practices, outputs, information and data assets. This derived knowledge is used as the means to direct changes and improvements. The operating model uses various forms of readily secured and accessible synthesized data and information assets to identify opportunities for improvement. These data and information assets are derived the organization's own recorded and documented data and information assets. These knowledge sources capture the organization's collective operational experiences and stakeholder perspectives.

Where currently the organization may rely on senior staff as a sort of "clearinghouse" for aggregating information and applying the "right" filters for resolving problems, derived knowledge provides the capacity to agilely assess and evaluate cross organizational or domain improvements for L&RM strategic management, planning, monitoring, land evaluations and assessments by providing up to date information, spatially referenced with temporal instances. Knowledge analysis and insights help

[2] DOI Adaptive Management Applications Guide, P. 11

develop adaptive management strategies that will help influence policy, regulations, or address organizational strengths, weakness, opportunities and threats. The adaptive strategies provide a knowledge-based rationale for various forms of organizational change or refocus. The knowledge analysis also yields benefits in improved strategic positioning, communication, collaboration, strategy fulfillment, while improving the functional practices of planning, budget allocation, workforce, portfolio management, R&D and policy and management controls.

L&RM Information Operating Model: The Information Operating Model (See Figure 5) emphasizes enterprise level information and data analysis processes and techniques as activities essential to understanding the breadth of its business. The operating model relies on a secure resilient flexible platform for the creation and enrichment of the "contextual" value of an organization's collective operational data and information assets. Its environment is designed to provide agility for experimentation, and recombination of the organizations structured and unstructured data and information.

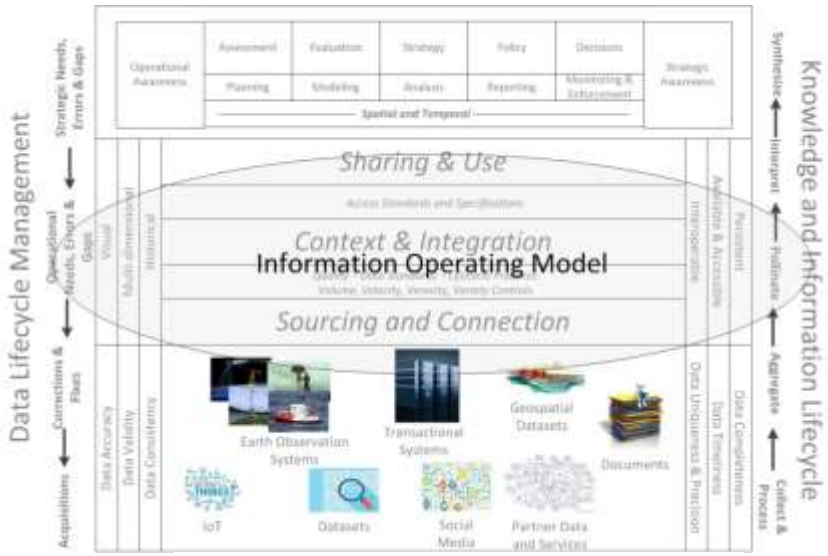


Figure 5 – L&RM Information Operating Model

The information operating model provides, in addition to traditional BI capabilities, the capacity to do multi-dimensional analysis, visualization, cross system reporting, data exchanges, publishing, and enterprise reporting. It distinguishes itself from knowledge by focusing on more operational information and data with the intention of enhancing the efficiency and innovation of operations or effectiveness of products and services.

The Information operating model provides data management services to source, standardize, transform, exchange, connect, manage metadata and publish multi-dimensional (x,y,z,t) data and information for the organization. It provides user tools to exploit data rapidly through standards or open based API designs for data and information access, visualization, time series study, analytics, modeling, exchange and reporting. The architecture model is designed to enable access to untapped information "context" within and between programs and the broader organization. The data sourcing methods provide the capability to flexibly access a wide variety of data structures and formats while controlling for data update frequencies, volume and velocity from all connected stores/sources.

The information operating model provides data quality services for the sourced data that enhances its integration potential and contextual value. The Information operating model is capable of applying

standards to legacy data, an important but often expensive activity and can address differing implementations within multiple sourcing systems. The information operating model supports the need to comply with external exchange and publishing standards and transformation needs independent of changes at the data sourcing level.

The information operating model environment is designed to support simplified data access methods and the rapid prototyping of use cases to demonstrate, test and build for information use, exploitation and understanding of opportunities. It natively supports advanced visualization, spatial, temporal rendering, modeling and linking data to further enrich context. These capabilities are intended to provide timely and accurate operational awareness of the organization's behavior, resources, practices and outputs. This awareness will yield opportunities for adaptive operational collaboration, management, performance, production, productization and process enhancements.

The architecture is built upon the best practices of metadata management, data interoperability, data standards, and information exchange and is extensible to handle all data structures, formats, and schemas of data. The architecture is designed to support the discovery of fundamental gaps, discontinuities, inconsistencies, or incompleteness of the organizations "required" information.

L&RM Data Operating Model:

The data operating model is the collection and processing of data assets produced or acquired by the organization. Much of the data is used to solve business process, analysis and transactional needs. This model accommodates relational databases, object databases, geospatial files, imagery datasets, social media or sensor feeds, documents or standardized data services. The data operating model is where the authoritative sources for information are managed using configuration control and governance practices systems. The data sources are defined and managed using the best practices of Master Data Management. Authoritative data best practices like accuracy, completeness, and precisions and are addressed in the Data operating model. Integrating the data lifecycle management process to synchronize internal and external data collection and acquisition provides the means to drive planning and decision making needs into data sources.

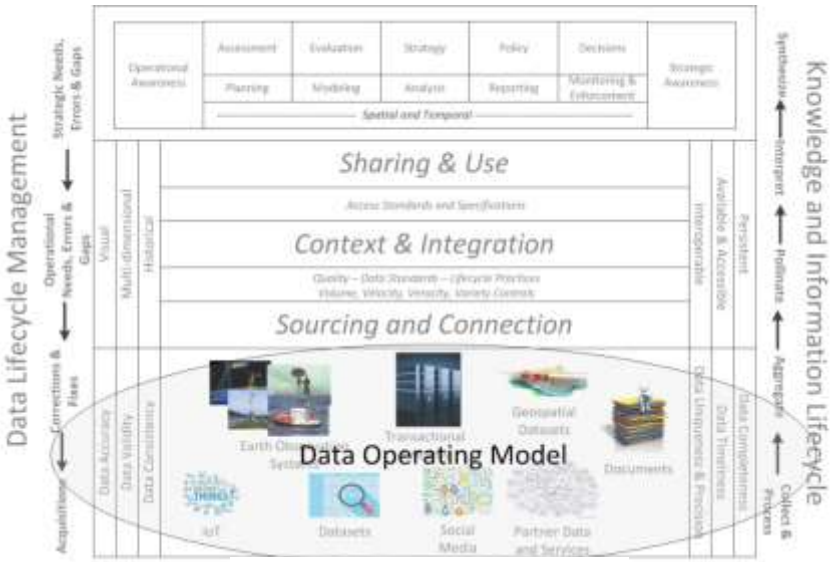


Figure 6 L&RM Data Operating Model

Governance:

KID is governed by senior business managers representing the performance objectives and strategy of the organization. They work closely with operational subject matter experts who provide domain and

technical expertise. The also work with policy teams to ground truth and validate strategic objectives. The governance team coordinates with key external customers and partners to validate and verify the perceptions of its current position and performance. Collectively, the governance body evaluates and assesses how to develop knowledge to move the organization toward new L&RM strategies.

What are the advantages of the new operating models?

Data Quality and Management:

- Know what data and information to fix and why – improved your data quality investment at the right level of the organization in time sensitive fashion.
- Data does not need to be perfect before you can see how it can and should be used for new or innovative purposes
- Reproducible features means a more structured context for using the full range of L&RM data assets, including common forms and those untapped
- Agility to increase information context and usability dynamically
- Reduction in the costs of reporting, data calls, and exchanging information
- Flexibility to support standards less expensively

Data Sharing and Exchange:

- Allow data to be maintained by source systems while still providing data connections for persistent enterprise use
- Build common pool of data and information and allow access to complete organization.
- Publish data in interoperable methods and formats
- Exchange data to partners easily without burdening systems
- Need to support Open Data initiatives
- Leverage licensed data more effectively

Operational Awareness and Information:

- Choose what data and information to access while it is actually being recorded at any level of the organization
- Positions the organization to manage the demand growth in data and information Partner and Supplier relationships.
- Envision your information in multiple dimensions – location (x,y,z) , scale, time
- Access cross discipline data curated data for understanding complexities
- Improve Investments in analytical, warehouses, BI and reporting technologies
- Broaden the number of users taking advantage of the investments in data and information
- Increase the number of reviewers of your data quality and create an environment where data quality can be identified for targeted improvements more quickly and confidently

Strategic Awareness and Knowledge

- Demonstrate L&RM effectiveness improvements and defend your budget in a competitive environment.

- Improve land and resource stewardship policy and practices
- Reduce organizational learning time, training and mitigate loss of workforce knowledge,
- Cross organizational and program boundaries and see the work
- Establish ROI for investment in L&RM
- Know how your strategy is coming together in a more timely fashion.

Conclusion:

The KID operating model is an approach that reorients traditional business and IT strategies towards a richer use of an organization's data, information and knowledge. It provides a framework for L&RM organizations to develop key processes, governance and computing environments to improve the predictability, availability and quality of KID assets. The environment provides services for data quality improvement in source systems, contextualization of data to information, data and information exchange/sharing and the derivation of knowledge. It integrates with powerful tools for geospatial and temporal analysis and visualization that show what is happening on the land from the perspective of multiple programs, systems and data sources. The KID provides a reproducible means for an L&RM organization to coordinate its evolution to a higher order of information and knowledge awareness by empowering management, technical and domain leadership and expertise.