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Implementation of External Changes

Highlights

Map-Matrix of Engineering Courses

Minimization of the Chi-Square Test

Discovering Thoughts, Inventing Future

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Change in Organizations: Best Practices in the Implementation of External Changes Imposed on Government Agencies

By Elie Geisler & Giuseppe Turchetti
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Introduction- The healthcare delivery sector in the United States is the largest in the world. It consumes over 1/6 of the Gross Domestic Product of the nation—the largest such slice of an economy among all developed countries. The federal and state governments account for about half of the national expenditures in this sector.

The complexity and the magnitude of the healthcare sector impose considerable challenges on the federal government, particularly with regard to the role played by knowledge management systems (KMS) necessary for the effective discharge of the federal healthcare functions. The federal involvement in the sector ranges from a vast regulatory apparatus to the massive funding of care through Medicare and Medicaid, the research, monitoring, and prevention of diseases, and the provision of care through military departments and the Department of Veterans Affairs.

Keywords: 1. knowledge management systems; 2. federal health agencies; 3. organizational change and transformation; 4. restructuring.

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Change in Organizations: Best Practices in the Implementation of External Changes Imposed on Government Agencies

Elie Geisler [α] & Giuseppe Turchetti [σ]

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I. Introduction

The healthcare delivery sector in the United States is the largest in the world. It consumes over 1/6 of the Gross Domestic Product of the nation—the largest such slice of an economy among all developed countries. The federal and state governments account for about half of the national expenditures in this sector.

The complexity and the magnitude of the healthcare sector impose considerable challenges on the federal government, particularly with regard to the role played by knowledge management systems (KMS) necessary for the effective discharge of the federal healthcare functions. The federal involvement in the sector ranges from a vast regulatory apparatus to the massive funding of care through Medicare and Medicaid, the research, monitoring, and prevention of diseases, and the provision of care through military departments and the Department of Veterans Affairs.

This paper addresses the issues related to the adoption, implementation, and utilization of knowledge management systems (KMS) in the federal government health agencies. The emphasis of this paper is on the metrics of KMS, as they are applicable to the evaluation of KMS—all within the management of the federal healthcare system.

To this end, this paper starts with the discussion of what KMS are, how they are adopted and implemented, and why they succeed or fail. Next, the book describes the critical success factors (CSFs) and the metrics used in the evaluation of KMS. Part Three focuses on the transformation of the federal healthcare agencies, in view of the new healthcare legislation and its legal challenges. The emphasis in this chapter is on how KMS helps these agencies to discharge their obligations.

Part Four describes a study of KMS in the federal health agencies. Eight cases are described, and a comparative analysis of the cases is provided. The focus of the chapter is to explore common factors that may explain how KMS is used and evaluated by the various government healthcare agencies.

Part Five focuses on the best practices in the use of KMS, which are extracted from the eight cases. The chapter lists and discusses what works, what doesn't work, and why.

Part Six describes the challenges faced by federal health agencies and lessons they can learn from this paper. These lessons are also applicable to other government agencies, including state health agencies and even county and municipal healthcare delivery organizations,

In these times of fluid events that unfold with the continuing transformation of the nation's systems of healthcare delivery, it is essential to understand how KMS contributes to the effective management of healthcare organizations. This paper focuses on government agencies, yet the findings and the lessons may also be applicable to the private sector.

This paper integrates knowledge management and the management of healthcare delivery: two topics that are very current and relevant to the nation's welfare and its economic stability and growth. As such, this paper will appeal not only to academics and to managers of healthcare organizations, but also to the everyday reader—who looks at the headlines and wonders: where is all this going?

The United States spends over $2 trillion or one sixth of its gross domestic product (GDP) on the provision of health care to its citizenry. This sector of the economy has been growing steadily in the past two decades at a pace considered by many to be unsustainable (Geisler, 2001; Mango and Riefberg, 2008). The complexity of the healthcare sector and its immense impact upon the economy, all employers, and all Americans make any changes envisioned for this sector a very difficult endeavor (Hill, 2006).

The federal administration has undertaken the task of reforming healthcare in America. Both Congress and the President have invested considerable effort in drafting legislation and enacting plans for radical changes in the healthcare system. Whatever form the final product will ultimately take, the process of transforming health care will be lengthy and will

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undoubtedly result in a dramatically different system from the one we have today (Lincoln, 2009).

The changes that are planned in the reform of the healthcare system will entail different dimensions of funding the system, regulating providers and payers (such as the health insurance industry) and restructuring of the balance of interactions among the many constituents in the healthcare delivery segment of the economy. Thus, a major participant in this effort of reform will be the role of federal health agencies. Their task will involve lending support to the change process and restructuring themselves to successfully deploy the new processes, procedures, and objectives of the changed healthcare system (Fredrick, 2009).

In the current reform environment, federal health agencies face a very difficult task of navigating a national system of many divergent constituents, values, expectations, and perceptions of success and failure (Currie and Finnegan, 2009). Examples of these agencies include: The Centers for Medicare & Medicaid Services (CMS) within the Federal Department of Health and Human Services (HHS), The National Institutes of Health (NIH), Food and Drug Administration (FDA), and The Centers for Disease Control and Prevention. Besides HHS, there are other federal agencies engaged in the health arena, such as the National Institute of Occupational Safety and Health (NIOSH), the Veterans' Administration (VA), and the Military Health System (MHS) whose mission is the provision of healthcare services to the nation's armed forces.

In their effort to carry out their mission, the federal health agencies are confronted with the need to maintain an adequate stock of knowledge. This is a challenging demand in the "normal" course of events, but it becomes even more exacting in times of change. The combination of the complexity of the federal healthcare system, rapid technological advances, and the forthcoming pressure of healthcare reform contributes to the formidable challenge of managing knowledge (Chan et al., 2005).

The difficult task of navigating the federal healthcare system through these changes also requires effective management. How do we provide federal managers with lessons and recommendations for action? What do these managers need to know? and What is the role that KMS plays in their effort to ensure the successful transition of their agencies from the current healthcare environment to the new system, with its unique challenges and opportunities?

This paper is an attempt to answer some of these questions. The author and his colleagues have been studying KMS in healthcare organizations for over two decades (Geisler, 1999; Geisler, 2009). The complexity of the healthcare sector is a strong deterrent to a comprehensive report or study with most or all of the answers. This paper contains a set of individual cases of federal agencies and offers lessons we can learn from the perceptions and opinions of their managers.

This is a *descriptive* rather than a normative approach. The managers who are in the front lines of the challenging transformational environment are those who explain and define the issues. Parts Four and Five offer an empirical insight into how federal health agencies are coping with the reforms in the nation's healthcare delivery system.

II. Part One What Are Knowledge Management Systems (KMS)?

Knowledge Management Systems (KMS) are generally defined as the integrated set of artifacts, processes, and mechanisms that organizations create to make the flow of work more efficient so as to contribute to their success and survival (Geisler, 2007; Nicolini et al., 2008; Rubenstein and Geisler, 2003). Other definitions abound. Some consider KM as a discipline that promotes an integrated approach to the management of the information processes of the organization. Consulting companies define KM as a discipline that enables the processing of knowledge to accomplish business objectives, or as a formal process providing solutions to getting knowledge to the right members of the company when they truly need such knowledge.

There are currently several acceptable definitions of knowledge management (KM). They are summarized below:

- KM is a discipline that promotes an integrated approach to identifying, managing, and sharing all of the enterprise's information needs (Gartner Group).
- KM is an intelligent process by which raw data is gathered and transformed into information elements. These are assembled and organized into a contextual relevant structure that represents knowledge.
- KM is a formal process that engages an organization's people, processes, and technology in a solution that captures knowledge and delivers it to the right people at the right time.
- KM is the discipline of enabling individuals in an organization to collectively acquire, share, and leverage knowledge to achieve business objectives (Arthur Andersen/Accenture).
- KM is the management of intellectual capital in the interests of the enterprise.
- KM is the concept under which information is turned into actionable knowledge and made available effortlessly in a usable form to people who can apply it.

In this paper, KM is defined in terms of an amalgam of the definitions in the list above. KM is the

formal organization, the processes and the standards and the procedures by which government organizations collect, store, manage, share, and analyze actionable information that enables these organizations to perform their functions and to achieve their objectives. This means that KM in this paper is considered an active component of the organization's discharge of its responsibilities and functions. in these organizations, KM contributes to the processes of decision making, structure and design, evaluation and monitoring, and to the processes of change and transformation that affect all managers and employees.

There are still some unresolved issues with the differences between knowledge management and the management of information in the organization (Geisler, 2006). How distinctly unique are KMS compared with management information systems (MIS)? And to what extent has the conceptual and empirical separation of KMS from MIS indeed crystallized? (Geisler, 2007).

Because knowledge in organizations is still being defined and measured with some specificity, the "rift" between KMS and MIS is a work in progress. KMS continues to be equated by many experts with MIS. Knowledge is still described in many instances as a more advanced or *actionable* form of information—not as an independent notion and mechanism (Geisler, 2006a).

This also means that a key difference between information and knowledge is the use of knowledge in the actions of the organization and its managers. When information is integrated into such actions as decision-making, this information is now called *knowledge*. In this vein, the experiences of the organization in actionable information (or *knowledge*) are collected in a repository of the Knowledge Management System (KMS). Therefore, knowledge exists as a part of the organization's actions and activities, hence also a part of its functions and structure.

All federal agencies and their various divisions, departments, and sections continually collect information. When such information is used in the function, purpose, and actions of the agency, we now have a knowledge system. For example, within the federal department of the Veterans' Administration (VA), the Office of Information and Technology collects information and develops information and knowledge tools. Within the same agency, the hospitals and clinics of the VA utilize knowledge to make clinical and administrative decisions in the pursuit of their function to provide care to veterans and their families.

However, KM systems have evolved in the past decade to the point of being considered—in most organizations—as a system possessing its own distinctive characteristics. Among these are: (1) cognitive aspects of "tacit" knowledge; (2) links to decision-making; and (3) applications throughout the organization. So, although inadequately defined, in practice, KM in the private and public sectors can be treated as a stand-alone, organization-wide system (Geisler, 2009).

a) A Typology of KMS

Geisler (2006a) proposed a typology of KMS, based on three criteria: (1) *structure* (how knowledge is designed and what it contains); (2) *purpose* (why organizations collect knowledge—for what purpose); and (3) *function* (what organizations do with the knowledge they collect, store, and manipulate). This classification scheme allows the analyst to evaluate the KMS of an organization such as a federal agency and to make reasoned statements about why and how these agencies utilize a specific form of KMS.

According to their different functions and structures, organizations will create and utilize a KMS best suited to their needs. For example, a federal department may be mainly responsible for collecting information and assembling knowledge, whereas a different department utilizes information and knowledge as a tool in the discharge of its responsibilities.

Geisler's classification scheme by structure, purpose, and function is a powerful analytical instrument. A KMS can now be assessed according to its design: what it contains; why it was created; and what outputs, impacts, and benefits it provides to the organization and its stakeholders. Moreover, comparison can now be made among KMS by using these three variables (structure, purpose, and function), common to all KMS.

A government department may be different from a midsize company when we compare their KMS by: (1) how the system is structured; (2) for what purpose it was established; and (3) what function it performs. Such an assessment result should provide empirical support to the argument that KMS should *not* be designed and implemented on the basis of "one size fits all," but should rather be tailored to the specific needs and unique characteristics of an organization (Rubenstein and Geisler, 2003).

Other typologies also focused on outputs of KMS. Popov and Vlasov (2011) classified organizations by the impacts of new knowledge they generate on their technological processes. This model suggests that *qualitative* knowledge will have weak impacts on technological processes, whereas *structural* knowledge will have moderate impacts and *functional* knowledge will have strong impacts.

Similarly, Geisler (2006b) focused on the actors who transact in knowledge. They are classified as: generators, transformers, and users. *Generators* procure, collect, acquire, assemble, prepare, and store knowledge, thus creating the KMS and its content. *Transformers* are people and organizations who transfer, share, transmit and exchange knowledge. They put the KMS to use by transforming the content of the KMS into

a usable commodity for others to use. They are similar to the "marketing" function of the organization, whereas the generators are the research, development, and new product functions. *Users* are people and organizations who utilize, adapt, absorb, and exploit the outputs and benefits from the KMS.

In this classification scheme, each type of transactor in knowledge has different motivators for establishing and using the KMS. The structure, purpose, and functions of a KMS depend on the type of transactor. Thus, there are three distinct perspectives in the classification and later evaluation of a KMS. The more influential type of transactor will bias the KMS to better fit its needs and motivation.

b) Adoption and Implementation of KMS

The adoption of KMS in an organization is a complex process with multiple stages and an elaborate set of actors and activities. There are powerful pressures or facilitators to adopt the KM system but also strong barriers. Figure 1 lists these variables that affect adoption.

Figure 1

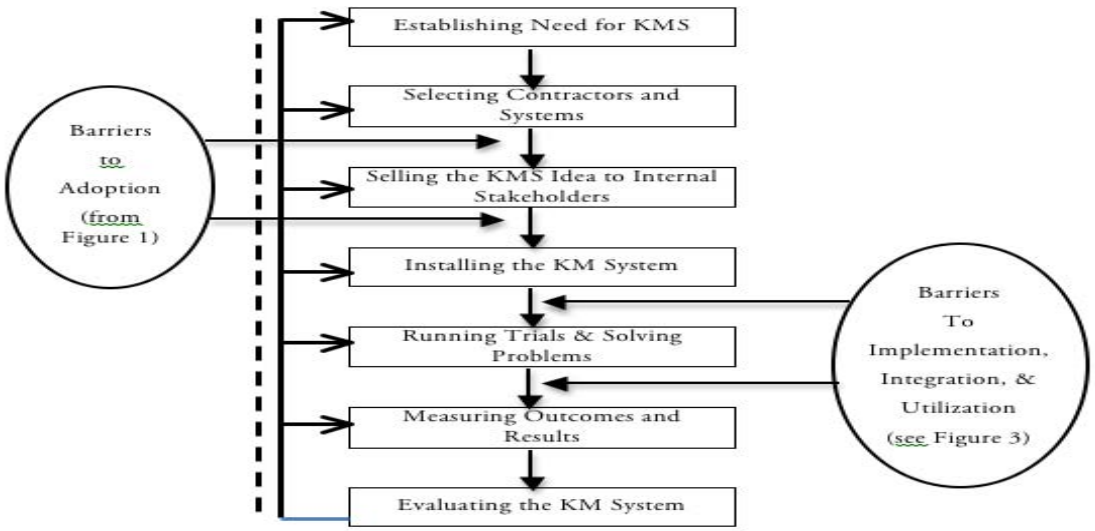
Illustrative Pressures and Barriers to the Adoption of KM Systems

Pressures to Adopt	Barriers to Adoption
• Government paperwork elimination legislation • Government performance and results legislation • Developments & innovations in e-government • Some initial successes with KM initiatives • Perceived need to manage mass of information • Perceived need to share and disseminate knowledge • Changes in federal workforce: retirements, telecommuting, aging workforce • Competition and demands from the private sector and the knowledge economy • Growing roles of government involvement in the economy and society	➢ Lack of standards ➢ Lack of connectivity and shared platforms ➢ Lack of executive support ➢ Unwillingness to invest adequate resources ➢ Few cases of successful adoption experience ➢ Issues of ownership: who owns the KMS and where should it be housed? ➢ Lack of clarity in the distinction between KMS and information systems ➢ Issues of cost and economics: What is the total cost and who will pay?

A simplified model of the adoption of KMS is shown in Fig. 2. This model contains the stages in which KMS is marketed to stakeholders and installed in the organization. In both cases there are several factors that act as barriers to the successful implementation and adoption.

Figure 2

A Simplified Model of the Adoption of the KM System



In most organizations in the private sector this process of adoption is yet to produce an enduring and successful KM system. There are too many factors impinging upon the implementation of KMS and their integration with other processes and activities. Some units implement *local* KM systems with some measure of success, but the real challenge remains the adoption of the KMS throughout the entire organization, with links also to external stakeholders (Rubenstein and Geisler, 2003). A similar scenario is also found in public organizations.

Figure 3

Why KMS Fail: Key Barriers to Implementation, Adoption, and Utilization

I.	**Organizational Factors**
	▪ Ownership issues
	▪ Clarity of adoption process
	▪ Economics of establishing the system
	▪ Lack of top management support
II.	**Human Factors**
	▪ Users' disregard, fear, and lack of trust
	▪ Reluctance to deposit or use knowledge
	▪ Perception of KMS as intrusive change
	▪ Reluctance to share knowledge
III.	**Systemic Factors**
	▪ Insufficiently interactive
	▪ Extracts are irrelevant or difficult to use
	▪ Too broad for specific unit uses
	▪ "Identity issues" for KMS as separate from MIS
IV.	**Implementation/Strategic Factors**
	▪ Installing without goals: "shooting blind"
	▪ Using concept of "one size fits all"
	▪ "Notify once and forget it"
	▪ Weak marketing KMS to stakeholders
	▪ Focus on functional and localized system

Source: Rubenstein and Geisler (2003), review of the literature, and studies by the author and his colleagues.

c) Why KM Systems Fail

The barriers to adoption listed in Figure 1 impact the initial stages of the importing and implementing a KM system in the organization. Once installed, KMS may still fail due to a set of factors that act as barriers to the adaptation, integration, and utilization of the system. These barriers are listed in Figure 3.

The four categories of barriers encompass the key factors that may impinge upon the success or failure of KMS. The fourth category of "Implementation/ Strategic Factors" is an especially powerful inhibitor of KMS performance (Hochstadt and Kent, 2009; Tirpak, 2005; Zamont, 2010). The lack of preparatory work for KMS implementation is often coupled with weak internal marketing of the system, and the neglect of follow-up and evaluation of the KMS (Fahey and Burbridge, 2008).

There are few systematic studies of the rate of failure of KMS in the private or public sectors. There is, however, the prevailing belief in both sectors that knowledge management has not had a stellar record of successful adoption and utilization. This belief is due, in part, to the very few reported cases of successful application of organization-wide KMS and, conversely, the very few reported cases of failure of KMS adoption by contractors and users. What remains is a universal wisdom of popular genesis that KM systems—in general—don't succeed or don't work (Rubenstein and Geisler, 2003).

d) Factors Affecting the Adoption of KMS in the Federal Government

The revolution in the exchange of information that e-commerce has generated has also manifested itself in the growth of knowledge management (KM) in federal agencies (Boyle, 2009). There is a host of companies selling software, hardware, and solutions targeted to the needs of federal agencies to better achieve their mission (Barquin, 2008). Among the key components of the various initiatives to develop useful knowledge management systems for these agencies are: (1) management of the exploding volumes of government information and the extraction of relevant

knowledge from this massive volume; (2) management and sharing of such knowledge; and (3) application of this knowledge for better decision making, improved services, and higher efficiency (Barth, 2009; General Accounting Office, 2005).

There are some differences among agencies in the rate and breadth of KM adoption. The U.S. Army, for example, developed in 2008 a list of twelve KM principles, the first being the training and education of KM leaders. In addition, the principles include the manipulation, sharing, and dissemination of knowledge (Tirpak, 2005). The Department of Homeland Security is concerned about the balancing act between sharing its knowledge and matters of trust and security threats (Barth, 2009).

The differences in rates of adoption and implementation of KMS by federal agencies are mainly explained by the elements of the typology of KMS. Agencies and their units are more likely to adopt a knowledge system when they believe that their function or purpose requires such a system for the discharge of their responsibilities. The structure of these units is another determinant of the rate of adoption. Multiple units of similar functions within the agency (such as the network of VA hospitals or research centers at NASA) will drive the need for sharing and the interchange of knowledge—hence leading to a higher rate of adoption of KMS.

There is also a constant tension between the needs of federal agencies to institute KM systems in their information management processes and the barriers to the implementation and use of such systems. The pressures on the agencies to advance the pace of KM adoption are considerable, from within and from external constituencies such as Congress, the Administration, and the evolving state of information and knowledge technologies (Kho, 2009; National Research Council, 2010). But the barriers to adoption and utilization (shown in Figure 1 above) are also formidable deterrents to KMS adoption.

A cumulative trend of installment of KM systems throughout the federal government, combined with the set of constraining barriers, have led to a situation of—at best—mixed results. Some agencies, such as NASA, the Department of Defense, and the Department of Homeland Security have publicized their effort to establish KM systems with cases of relative success (Clancy, Anderson, and White, 2009). Yet, the "push-pull" scenario of KM adoption by federal agencies is similar to that found in the private sector (Heier, Borgman, and Manuth, 2005).

However, the special case of the federal agencies is also characterized by unique pressures from the public sector (Congress and the Administration). Unlike private companies, federal agencies are more exposed to such public stakeholders who fund and control them. In addition, these agencies also face internal competition with other public entities for budget and resources, bounded by the political priorities of the current administration and its policies.

III. Part Two: Critical Success Factors and Metrics of KMS

a) *Organizational Objectives of KMS*

The objectives of adopting a KMS depend on the actors within the organization's set of stakeholders. *Generators* of knowledge (individuals, groups, organizations, and external stakeholders) have objectives such as personal growth and increased productivity. Figure 4 shows what *generators* of knowledge desire from a KMS.

Figure 4

KMS Objectives of Generators of Knowledge

Who are Generators	Objectives of KMS
• Individuals • Groups • Units/Departments • Organizations • External stakeholders	• To obtain personal growth • To achieve personal benefits • To be competitive • To increase productivity, efficiency, and effectiveness • Improved market position • Improved quality of life

The objectives of KMS adoption for *transformers* of knowledge are shown in Figure 5.

Figure 5

KMS Objectives of Transformers of Knowledge

Who are Transformers	Objectives of KMS
• Individuals • Groups • Units/Departments • Organizations	• Economic and social benefits • Better standards • Improved communication • Improved operations • Improved interoperability • System benefits & improvements

Users have a similar set of objectives, as shown in Figure 6.

Figure 6

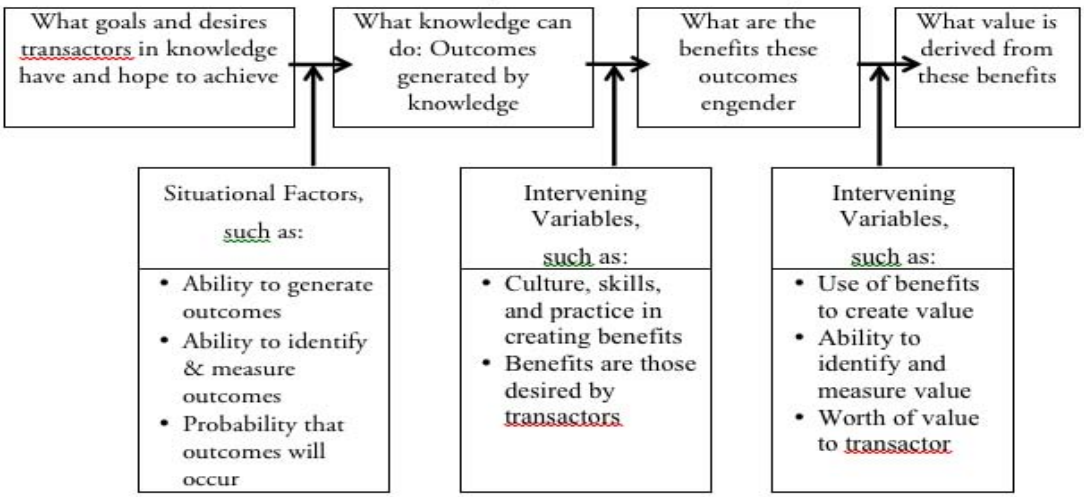
KMS Objectives of Users

Who are Users	Objectives of KMS
• Individuals • Groups • Units/Departments • Organizations • Society at Large	• Economic gains • Technical skills • Competitiveness • Commercial success • Improved capacity to discharge tasks • Dissemination of knowledge • Better life

Such objectives include short- and long-term goals. They are the desire for immediate benefits and even ultimate goals such as "improved quality of life." Overall, transactors want to gain value from their investment in the adoption and use of KMS. Figure 7 shows the process of value creation by KMS.

Figure 7

Objectives that Transactors in Knowledge Want and the Value They Derive from Knowledge



As shown in Figure 7, there are limits to the benefits accrued from KMS and to the value these systems can generate. Successful adoption and use of KMS would depend on the congruence of some—perhaps not all—of the objectives of transactors-in-knowledge with the benefits and value generated by the KMS.

b) Measuring Critical Success Factors (CSFs)

Knowledge management systems are complex organizational frameworks. They impinge upon a variety of organizational stakeholders and divisions/departments. Rubenstein and Geisler (2003) proposed a classification of critical success factors (CSFs) by: (1) factors related to the individual using the KMS; (2) factors related to the mode or method of using the KMS; and (3) factors related to the system itself. Figure 8 lists these factors.

Figure 8

Classification of Critical Success Factors (CSFs) of KMS

Factors related to the Individual	Factors related to the Mode of Use	Factors related to the System
• Fear of technology	• Ease of automation	• Availability
• Familiarity with technology	• Practice	• User-friendliness
• Ego	• Complexity	• Simplicity of operation
• Age	• Uniqueness of knowledge	• Features
• Training	• Regulatory climate	• Cost
• Education	• Proximity to user	• Reliability
• Previous experience	• Specialization	• Need for technical help
		• Ease of maintenance & updating

Another set of CSFs was shown in Figure 7. Successful adoption of KMS will also depend on meeting the objectives set by individuals and the organization upon the establishment and roll out of the KMS (Carlucci et al., 2004; Geisler, 2010).

The success of KMS is measured by: (1) how well the KMS works; (2) how well the KMS meets the objectives; and (3) how well the KMS has performed—from the viewpoint of individual users and other stakeholders of the organization (Bose, 2004).

c) Measuring the Value of KMS

The successful adoption and implementation of a KMS does not guarantee the creation of value to be derived from the KMS. At each stage of adoption and for each actor in this process there is some value being gained from the benefits generated by the KMS (Boyle, 2009; Davenport and Jarvenpaa, 2008).

However, the generation of value from KMS depends on the interplay between the barriers and the facilitators that act as factors in gaining value from the system. Figure 9 lists examples of these factors.

Figure 9

Barriers and Facilitators to the Generation of Value from Knowledge Management Systems

Factors Acting as Barriers	Factors Acting as Facilitators
• Lack of willingness to share what one knows • Sharing in untimely manner • Sharing and diffusing knowledge in a mode that is difficult to absorb by others • Previous negative experience • Sharing and diffusing marginal or irrelevant knowledge • Lack of willingness of others to receive or absorb knowledge • Benefits and ultimate value not recognized or perceived by knower • Cultural, organizational, and economic factors hindering sharing and transformation of knowledge	• Perceived or recognized benefits • Competitive pressures • Perceived or recognized ultimate value • Past positive experience with benefits and value • Strong need for accomplishing goals (e.g., need for skills or improvements • Cultural, social, economic, and organizational factors supporting sharing of knowledge and its transformations

The nature of the value derived from KMS is subjective, largely depending on the perception of the actors whether the KMS has produced outputs and benefits that they consider of value. When the KMS critical success factors are satisfactorily identified and measured, there is high probability that the various actors will also identify some value in these CSFs (Yu-Min and Yi-Shun, 2009).

d) Issues in the use of Metrics

Figure 10 lists three categories of metrics of KMS that measure: (1) utilization; (2) outputs from KMS; and (3) contributions to CSFs.

Figure 10

Metrics of KMS

I. Metrics of Utilization	II. Metrics of Outputs from KMS
• # Of nuggets put into system • # Of queries received • # Of queries answered • Retrieval time • Perceived accuracy of answers • Perceived quality of answers to queries • Perceived usefulness of answers	• Savings in time and effort • Mistakes avoided • New ideas engendered as result of use • Added organizational credibility • Improved decision-making by managers • Contributions to project/program success
III. Metrics of Contributions to Success Factors • New sales • Cost reductions or cost savings • Increased profits • Increased growth and market share • Increased regulatory compliance • Accomplishing the mission (public sector) • Improved effectiveness of operations	

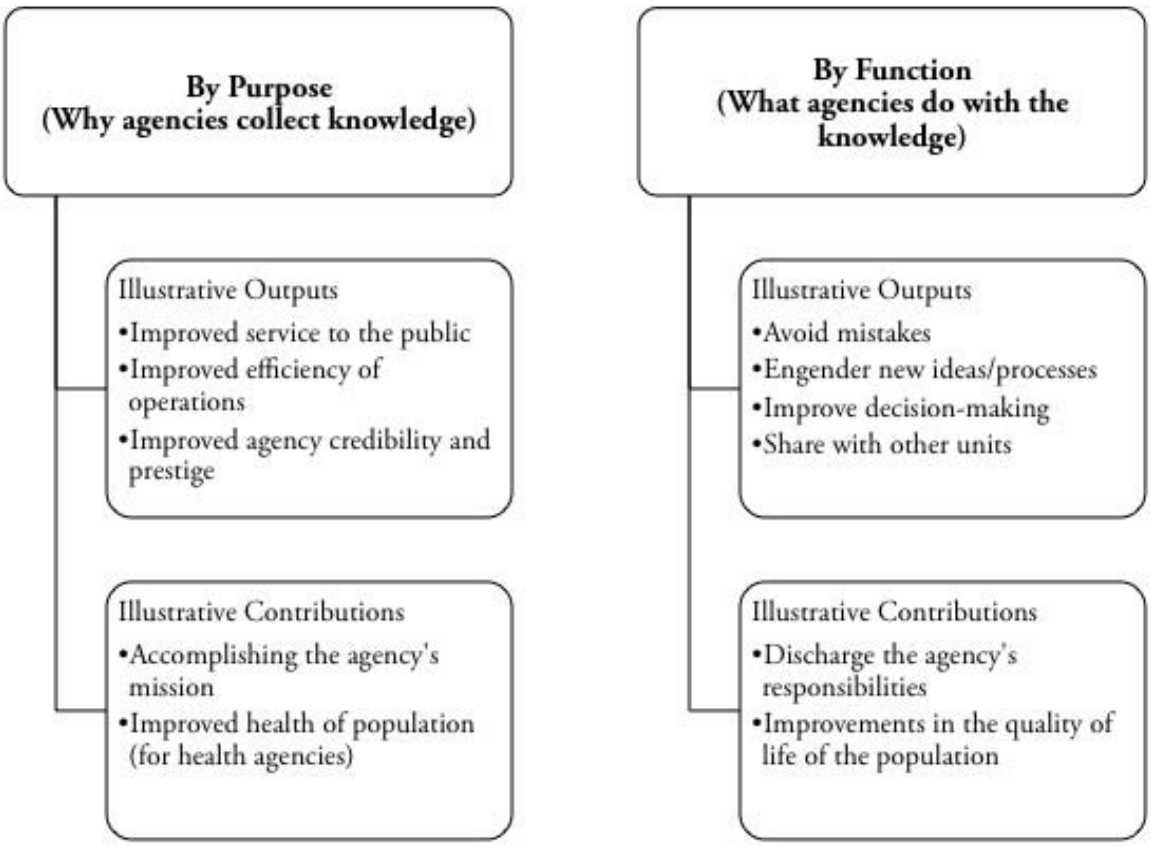
Although there are metrics for the various stages of KMS adoption, most organizations do not make ample use of this powerful assessment methodology. The key reasons include: (1) lack of standardized evaluation framework; (2) lack of acceptable definition of what we measure (this is related to the tenuous definition of what constitutes knowledge management separately from information systems.); and (3) lack of agreement on the strategic role of KMS (why we measure, who are the stakeholders, and how we can causally link the outputs from the KMS to the organization's critical success factors (Yu-Min and Yi-Shun, 2009).

The metrics of utilization, outputs, and contributions of KMS to the organization are of particular interest to the analysis and evaluation of KMS in government agencies. There are differences in the metrics to be used for different agencies, depending on their structure, purpose, and function. The metrics of utilization are generally applicable to all types of organizations. However, outputs and contributions from KMS differ among public agencies, and between private and public organizations.

Figure 11 shows the typology of metrics of outputs and contributions within the typology of KMS, by purpose and by function. The metrics measure how well the KMS contributes to the agency's mission and activities, and how the use of KMS ultimately may contribute to the social and economic welfare of the American public.

Figure 11

Typology of Metrics of KMS in Federal Agencies



In the effort to measure the success of KMS and the value derived from such systems, several frameworks have been suggested and some of these are described in the previous pages. None of these systems of metrics is a conclusive and comprehensive mode of measurement. There are many issues with KMS metrics that impinge upon the effectiveness of a given system of metrics. These issues are summarized in Figure 12.

Figure 12

Major Issues in Metrics

- "Disruptive technologies" can have major impacts on KMS.
- What do beneficiaries and stakeholders want, need, expect, demand from KMS and what are they willing to pay?
- How do we recognize and measure "public good?"
- What are the roles of flow models and criterion trees for progress/results of metrics?
- Is there life after Demos?
- Pros and Cons of outsourcing.
- "Whole Life Cycle" and "Rolling Modified Delphi" (RMD) to metrics.
- Metrics: A tool for communicating with stakeholders of KMS.
- Progress metrics can signal need for changing direction.
- Weighting of "technical" versus "economic" metrics.
- Value of KMS contributions to stakeholders.

The need for better metrics is reflected in the following reasons:

a) Usual process and behavioral measures do not impress managers; thus, they are not likely to use them (Ilebrand et al., 2010).
b) Managers in the private sector are mostly interested in how KMS contribute to their "bottom line." Similarly, managers in government organizations are interested in how KMS help them to accomplish their mission.
c) Managers in both sectors have the need to relate immediate outputs and impacts of KMS to the Critical Success Factors—without going through intermediate stages.

IV. Part Three: Knowledge Management in Government Health Agencies

a) The Case of Healthcare Delivery Organizations

Knowledge management systems are still in their infancy. Although there is a history of over two decades of adoption and implementation of these systems in both the private and public sectors, the experience with these systems is largely ambivalent. There are cases of successful local applications of KMS in some companies and within government agencies such as NASA and the Department of Defense. In both sectors, widespread adoption and successful inter-organizational exchanges are yet to be documented.

Public agencies have been initially slower to adopt these systems than private companies. Some possible reasons are the lack of the powerful market pressures of competitors that drove private industry to early adoption. Once introduced into the public sector, KMS did not fare much better than in private companies (Gates and Urquart, 2007; Hess and O'Neal, 2010).

There is, however, a trend of development and inertia of vendors and users who continue to adopt KM systems and to experiment with the nuances of innovations in the hardware, software, and communication technologies. This trend has spilled over to public agencies and they have increased their investments in KM and their peripheral infrastructure. This trend may be accelerating as the demand for knowledge in specific areas—such as health care—may dramatically increase in the near future.

The American healthcare system is the most expensive in the world. It absorbs over 16 percent of the nation's Gross Domestic Product (GDP). In 2008 the national expenditures for health care amounted to $2.3 trillion, or $7,681 per person, and 16.2 percent of the GDP (CMS, 2010). This share of GDP had increased in 2008 from 15.9 percent in 2007. Governments at all levels contributed 42 percent to these expenditures. In 2008, Medicare and Medicaid accounted for $813 billion (35% of total expenditures).

By comparison, other countries spend much less per capita. In 2008, Switzerland and Canada, for example, spent about $4,000 per person, whereas the United Kingdom spent about $3,000 per person. These countries finance their healthcare sector primarily through public funds. There have been studies comparing various countries, how they finance their healthcare system, and measures of health indicators of

the populations (Lisac, Blum, and Schlette, 2008). As in the United States, countries in the European Union are also concerned with the growth in healthcare costs, considered to be unsustainable even in countries where the expenditures per capita are half those in the United States.

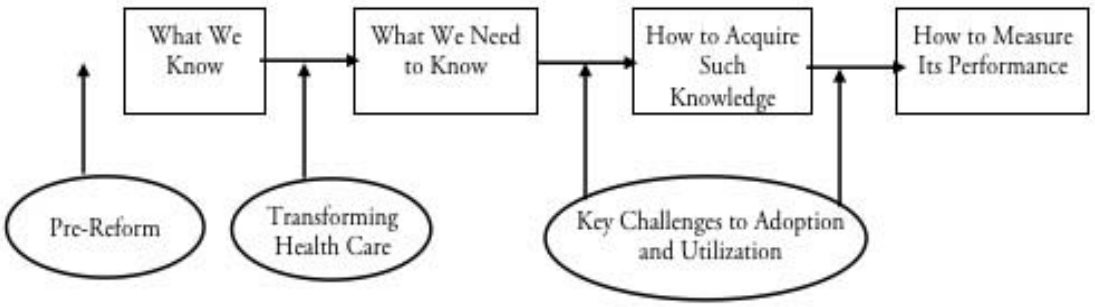
Within this national and global scenario of the rising burden of health care on the economy, the role of federal health agencies is a crucial component in the provision of care to the American public. The federal sector of the economy contributes roughly half of the cost of health care, hence there is a constant need for federal health agencies to improve their services and to efficiently accomplish their mission to support the health of the public.

The challenges are not limited to the unsustainability of the continuing rise in the cost of healthcare delivery. There are also issues of the administration of this immense segment of the economy, combined with the need for improved quality of care and maintaining an adequate level of access to healthcare delivery to all Americans of all social and economic strata. This challenges the ability of federal health agencies to improve performance, to share knowledge, and to sustain the level of effort expended by the federal government for national health services.

To better understand the needs for knowledge and how to measure its performance in the healthcare environment, the model in Figure 13 includes the main stages preceding the reform, and those that are likely to follow the planned changes.

Figure 13

Knowledge Needed by Federal Health Agencies in the Reformed National Health Care System



Based on the model of knowledge needed, an exploratory study was conducted with 23 managers in federal health agencies. The study questionnaire contained three main categories: (1) what knowledge is needed; (2) what are the barriers and facilitators to this knowledge; and (3) what are the best practices known or available at the agency. The study contained eight cases and these are described in the next chapter.

b) What Type of Knowledge is Needed?

There is a consensus among managers of federal health agencies that any *new* knowledge they would need is but an extension of the knowledge they already possess and are currently managing. The differences between the two stages of the model in Figure 13 (what we know versus what we need to know) are few and relatively attainable. There may be several explanations to this. First, the criteria for success of existing knowledge are similar to those of new knowledge. Managers in health agencies believe that their current stock of knowledge is sufficiently adequate to meet the challenges of the reform initiative.

Second, there is little trust that the existing KMS will be able to handle the new knowledge. The current KMS is perceived to be at best a step above the existing information system. Third, there is a lack of consensus on what constitutes *new* knowledge, except for the need for "more of the same" categories of existing knowledge.

Although the underlying hypothesis guiding the exploratory study was that national healthcare reform would generate a need for new knowledge, managers in federal health agencies believe this will not be the case once reform is instituted.

Even when specific programs and systems are named (such as electronic medical records) and their accelerated adoption and use are forthcoming, there is not a sense of urgency in updating current KMS or preparing for the onslaught of new knowledge. A similar sentiment exists regarding the addition of millions of Americans to the roster of the insured, via private or public insurance.

The knowledge needed by federal agencies differs by agency. The knowledge the agency needs to know—as well as what the agency currently possesses—will be knowledge useful to the purpose and functions of the agency. Therefore, whenever the mission (purpose) and functions of the agency change, so will the type of knowledge it needs and should

procure and adopt. These changes occur, for example, when the agency is required to undertake different or additional responsibilities, or when the Congress or the Administration institutes a major reorganization or reform (California Healthcare Foundation, 2009).

The expected reform in the national healthcare system will lead to added administrative burdens on federal health agencies. However, such a burden may be qualified by expanding the *quantitative* aspects of knowledge needed to manage the change—not the variety or qualitative aspects of knowledge. The existing KM systems and their categories of knowledge may prove to be sufficiently robust to absorb and to manage projected additional, yet same, volumes of what the agencies need to know (Nicolini et al., 2008).

An example of this scenario is the upcoming development in electronic medical records (EMR). The planned acceleration of nationwide implementation of EMR is a central component of the national healthcare reform. Over $700 million were budgeted in 2010 and 2011 for incentives to providers to adopt and use EMR systems. When this electronic revolution crystallizes and the rate of adoption increases from the current 10 percent to over 50 percent of providers, a powerful national health information highway could be established (Clancy et al., 2009).

Increased use of EMR would also suggest that federal health agencies would be encumbered with knowledge requirements in four areas. First, there would be new regulations on privacy issues and variants of the current Health Insurance Portability and Accountability Act (HIPAA). Second, compliance monitoring would engender legal cases and the need for intra and inter agency networking and knowledge exchange. Thirdly, a host of new administrative procedures and standards would be established. Finally, EMR usage would lead to intensive effort by government agencies to network and to integrate these medical records with other information and knowledge systems in the private and public sectors (Hess and O'Neal, 2010).

Surprisingly, most government managers do not consider such added knowledge a burden on their current obligations. There is a consensus among them that their agencies are already mired in an overload of knowledge and that their KM systems are inadequate to handle the existing load. Additional knowledge is not the problem. It is merely "more of the same." The problem seems to be the KM system itself and its ability to process knowledge necessary for the discharge of the agency's responsibilities.

There is a belief in both the private and public sectors that the barriers to new knowledge are an extension of the barriers to the utilization of KM systems. The factors identified as barriers to adoption of KMS in the previous chapter are not a concern to the federal agencies. Most of them already have installed a KM system and have adopted some form of knowledge gathering, management, and sharing.

The key barriers of concern to the managers in these agencies are mainly the systemic and implementation or strategic factors. Interestingly, the organizational and human factors that are prevalent in the private sector are not perceived as barriers in the government agencies. Issues such as ownership, economics, and human reluctance to share knowledge have been somewhat resolved in public organizations.

The factors acting as facilitators to the implementation and utilization of KMS in government health agencies can be grouped into a category of "organizational loyalty." Federal employees generally believe that working with a KM system—established by their agency—is a way to explain their contributions to the mission and objectives of the agency.

c) Issues in Managing KMS in Government Healthcare Agencies

In the specific case of the healthcare sector, there are two distinct types of knowledge: (1) clinical knowledge and (2) administrative knowledge. The first includes all those clinicians need to know to practice medicine. The second type of administrative knowledge is composed of all that is needed to know in order to manage, organize, and fund the delivery of healthcare.

Clinicians are generally reluctant to share knowledge with non-human systems such as KMS (Geisler 2009). Hence the failure of medical expert systems such as Mycin. Clinicians also by and large fail to appreciate the benefits from KMS; thus, they tend to perceive them as an intrusion and a detriment to their professional capabilities (Nicolini et al., 2008).

In the government sector, the main barriers to the successful adoption and utilization of KMS in healthcare delivery are the administrative responsibilities embedded in the complexities of public bureaucracies. American government healthcare agencies provide care (e.g., the Veterans Administration and the various armed forces), regulate the provision of care and the health of the public (e.g., the FDA and the Centers for Disease Control & Prevention), and insure and fund the delivery of care (e.g., Centers for Medicare and Medicaid Services). This multi-purpose entity contains a plethora of objectives, needs, and inter-agency cooperation, as well as rivalry and competition (General Accounting Office, 2005).

All efforts to adopt, implement, and use KMS by these various government agencies is often perceived by clinicians and administrators in these agencies as an intrusion by management or the federal department, and as another layer of bureaucratic hurdles. Since KMS are very often designed and structured without much attention to the specific needs of the agency, its potential adopters and users fail to see its usefulness to *their* unique needs.

Federal healthcare agencies are also subordinated to the notion that their mission entails the attainment of some "public goods." These are objectives of government agencies aimed at the general welfare of the nation. Examples include quality of life, environmental protection, the health and safety of the public, and the economic growth of the nation. Therefore, any knowledge needed by government agencies must also include items that will allow these agencies to strive to achieve such overall "public goods" (Nicolini et al., 2008).

V. Part Four: A Study of KMS in Government Health Agencies

The typology of KMS and the convergence of this typology with the barriers to adoption and the process of acquiring new knowledge by federal health agencies were studied in an exploratory investigation. This study was based on responses from 23 respondents in eight different federal health organizations. This study produced eight cases. For each case, the analysis explores *why* (for what purpose) the organization collects knowledge and *how* the knowledge is being used by the organization. The underlying assumption of the study is that government health organizations differ in their need for knowledge and in their use of knowledge from the private sector.

a) Description of the Study and Methodology

The sample of eight health organizations in the federal health system was selected to represent different types of agencies with different missions, functions with the government, and different structures. These cases deal with the administrative, clinical, and technical needs for knowledge of the health agencies to which they belong.

The study was aimed at eliciting data on how managers in the federal health agencies perceive their need for knowledge; what barriers and facilitators do they encounter in the adoption processes; and what are the best practices currently available to them. The analysis integrates the KMS typology described above and is focused on the differences among agencies as well as the similarities that would encourage the sharing of knowledge.

The exploratory study was conducted in four stages. The first was the selection of the eight cases based on the criteria of differentiation listed above. Next, a study questionnaire was created with 14 questions. This research questionnaire was sent to selected managers in the organizations.

The third stage was the collection of data from returned and completed questionnaires. Of the 25 managers originally contacted for the study, 23 returned a completed questionnaire. Finally, the fourth stage was the analysis of the data and the generation of lessons and recommendations.

b) The Cases

Case I: Department of Health and Human Services; National Institutes of Health (NIH); Office of Human Resources

This office is an administrative entity of the agency of the National Institutes of Health. It is responsible for the management of human resources of the agency, which comprises 27 institutes and centers. The office collects knowledge about the personnel (administrative and clinical) of the agency. This knowledge base is comprehensive and complex. It includes not only personnel files of employees but also the legal and economic aspects of employment. This organizational unit of NIH is similar in its purpose and functions to equivalent human resources units in the private sector.

The office has strong links with other institutes and offices within NIH in an advisory and guidance capacity, periodically advising them on aspects of their human resources: who is hired, who is about to retire, changes in laws and regulations governing personnel, and providing answers to specific inquiries.

The knowledge collected and shared by this office is centrally maintained for the agency. Sharing such knowledge is limited by challenges of privacy and confidentiality. The office balances the functional need it has to share this knowledge throughout NIH while striving to ensure the confidentiality of the knowledge base. Managers in this office are faced with the tension between the need to collect and share a broad spectrum of knowledge and the restrictions on how much and what types of knowledge they can collect and disseminate. In the case of human resources, this balancing act goes beyond the *internal* need versus *external* requests for knowledge. The office does not require this knowledge about personnel for its own functioning and performance. It plays a role of a *service organization* that provides assistance to other units within the agency. Some manipulation (such as analyses) is required for the knowledge collected to be in a form suitable for sharing, but not to the extent that such knowledge is intended for the routine functioning of the office.

As such, the metrics of performance and success of the KMS in this office are *functional* outputs. Key metrics are (1) sharing with other units and (2) contributing to better decision making in other units of the NIH.

The lessons derived from the case are threefold. First, KMS practices in this organization are a direct reflection of the purpose and functions of the organization. Second, this office's KMS is evaluated according to how well it collects, analyzes, and shares the knowledge base it has under its control. Third, this type of KMS is for internal agency usage and benefit, so that any attempts to conceptually or empirically link it to

the agency's metrics of performance (such as service to the public or improved national health) should not be undertaken.

Case II: Department of Health and Human Services; National Institutes of Health; National Library of Medicine (NLM); Office of Health Information Program Development

Unlike the previous case in which the Office of Human Resources collected and shared knowledge as a service to other units within the NIH agency, the Office of Health Information Program Development collects knowledge about the availability and utilization of health information, and the evolution of databases, knowledge systems, and other aspects of health information. This office resembles a research unit in the private sector, in which there is an effort to keep abreast of new developments in the field and to generate new ideas and innovative practices.

The office keeps track of progress in the areas of information systems and technology and, in particular, the growing field of health informatics. This is an important, perhaps even crucial, task for the agency and for the Institute (the NLM). One unique attribute of the knowledge collected by this office is the enormity of the task. Health informatics has grown exponentially over the past decade. The knowledge in this area is generated in a variety of organizations, industries, and countries. Keeping track of these developments is therefore a major task.

The office also needs to analyze the vast amount of knowledge it collects, in order to obtain trends and directions in the field of health informatics. This analysis is then shared with the NLM with the purpose of improving the efficiency of the institute. *Purpose* and *function* are the metrics with which the office would be assessed. The knowledge collected and analyzed by the office contributes to the institute's mission and to its efficiency of operations.

There are two key lessons learned from this Case. The first is that the office serves as the "eyes and ears" of the institute and also contributes to its operations. Hence, the combined function of the office requires not only excellence in the collection of knowledge for its KMS, but also, and just as importantly, excellence in state-of-the-art analyses of the knowledge in the system. In this Case, the office depends heavily on both its *external* contacts as well as the *internal* exchange within the institute. In cases where there is a composite function and purpose, there is also a more demanding need for KMS practices in the collection and dissemination of knowledge to the institute and the parent agency.

Secondly, changes in the health environment of the nation or the federal government will be less of a challenge for this office than for other government units because this office routinely deals with technological and clinical aspects of health care and is designed to deal with the challenges of change, new developments, and progress in the rapidly-evolving field of health informatics.

Case III: U.S. Army Medical Corps; Armed Forces Medical Library

This is a Case of a highly specialized library serving the Army's medical needs. With its unique medical corps, the U.S. Army is in need of a library and a knowledge center able to supply Army medical personnel with the information and knowledge they require. There are at least two distinctive characteristics of this library that differentiate it from other medical libraries. The first is the Army's need for an organization that is totally dedicated to its needs, hence able to serve only the Army's Medical Corps. In times of crises and war, the Army's Medical Corps cannot afford to share its needs with other government agencies.

Secondly, the U.S. Army is operating on a global basis. Its medical corps deals with tropical diseases as well as the clinical effects of harsh wintery climates. The U.S. Army's Medical Corps also confronts the possibilities of chemical, biological, and nuclear conflicts. In all of these areas, the medical corps must rely on a dedicated library on a global scale that will supply it with current knowledge.

This means that the library must be a *service* organization, able to collect, classify, and share a vast amount of clinical and scientific knowledge. It must also be able to format this knowledge for specific requests and needs of the U.S. Army—in all theaters of war and wherever the U.S. Army is present.

As in the case of the NLM, the performance of this library is evaluated by metrics of a service provider: contributions to the medical corps in its operations and the accomplishment of its mission to provide care to Army personnel.

The library is faced with several challenges. It must balance the need to internally serve the Army Medical Corps while maintaining constant links and interfaces with similar organizations in the government (such as NLM, The Centers for Disease Control & Prevention (CDC&P) and other libraries of the Medical Corps of the U.S. Navy and Air Force). In addition, it needs to maintain extensive links with the national and international medical communities and with the healthcare industry (e.g., pharmaceutical and instruments companies). The rapid development of medical technologies and the fast-growing medical research literature requires the library to keep track of new knowledge, clinical practices, risk assessments, medical perils, and opportunities on a global scale.

Case IV: Department of the Navy; U.S. Navy Medical Corps; Naval Medical Research Center

The Naval Medical Research Center is an organization within the Naval Medical Corps much

different than other units of the Corps. The center collects and utilizes knowledge specific to naval needs and challenges, but this knowledge is used internally for research and analysis. The center can be loosely described as a combination of the CDC&P and a university medical research laboratory.

The U.S. Navy is spread throughout the globe in missions and naval bases, including navy personnel aboard navy ships in the seas and oceans of the world. This center collects and researches knowledge about clinical issues of diseases, epidemics, modes and practices of clinical treatments, availability and effectiveness of medical facilities around the world, and the state of the art of modern medicine—all in the service of the Navy Medical Corps.

The challenges of this center are of two types. The first is the need to keep the Navy and its medical corps current on what medical emergencies exist or may erupt and the clinical resources available to the corps. This need for current knowledge feeds into the center's need to conduct specialized research into issues that are unique to the Navy's medical corps—its clinicians and its medical necessities. The second type of challenges is the need for the center to act as a laboratory and to respond in a very timely manner to any request from the medical corps for advice, analysis, evaluation, and recommendations in both routine and emergency situations.

The center also maintains links with medical research centers in universities, hospitals, and government research entities in the United States and around the world. This exchange of knowledge is crucial for keeping the center current and to enhance the skills and abilities of its own research personnel.

As a unique service organization, the center's performance can be evaluated by its contributions to the medical corps. These contributions are measured by how the center helped the corps in its mission, its effectiveness and efficiency of operations, and its contributions to the quality and availability of medical care the Corps provides the U.S. Navy.

Case V: U.S. Department of Defense; Armed Forces Health Surveillance Center (AFHSC)

This Center serves the entire complex of the U.S. Armed Forces and is a center of the Department of Defense (DoD). The center provides timely data and analysis for today's military health decision makers. The purpose of this Center is to process and share knowledge on the health conditions and the fitness and medical readiness of U.S. military personnel. The Center is a centralized organization that monitors military personnel from *all* the services. Since 2008, the Global Infections Surveillance and Response System were merged into the AFHSC and became a division of the Center. This organizational change has made the Center the key epidemiological resource of the armed forces and the DoD.

The Center collects, analyzes, evaluates, and disseminates to the DoD knowledge about diseases or other health issues that may create obstacles to military readiness. In effect, this Center is the "health-knowledge-base for DoD." It produces studies, surveys, and analyses for military and defense decision and policy makers—routinely and upon request. The Center generates trends, benchmarks, and, when necessary, alerts the DoD and military commanders of health threats. The Center has the divisions of data and analysis, communications, standards and training, and the GEIS operations.

This Center is a web of data and knowledge bases received from such organizations as the CDC&P, state health agencies, the various service departments of DoD, the HHS, and universities and medical associations. For example, the Center publishes a Medical Surveillance Monthly Report (MSMR) containing reports of studies and surveys. In June 2010 the report included surveys of cancer and cancer-related deaths of U.S. Armed Forces personnel and instances of acute respiratory disease found in trainees at training centers of the U.S. Army.

The Center faces several challenges because of the magnitude of its mission and the complexity of its functions. As the main knowledge-base of health information for the entire military forces, the Center must interact with practically every health organization that can produce relevant knowledge on causes of diseases, trends of propagation, and means to combat and attenuate these threats. The Center is a combination of a CDC&P and a healthcare consulting organization—dedicated exclusively to the needs and special circumstances of the U.S. Armed Forces and the DoD.

Evaluating the performance of this Center is a difficult task. The metrics are by purpose and by function. One set of metrics measures the effectiveness of the Center in collecting and analyzing relevant knowledge. Another set of metrics measures the contributions of the outputs of the Center (reports, studies, and standards) to decision makers in the DoD and the armed services, as well as measuring the effectiveness of their actions in helping to maintain and improve the medical readiness and condition of the armed forces. Clearly, such decisions entail more inputs than those provided by the center, but the decision-makers at DoD and the armed services depend on the knowledge given to them by the Center to be current, accurate, relevant, and useful—among other attributes.

Another key measure of success for the Center is its ability to interact with the large number of organizations supplying it with knowledge as well as those requesting health knowledge. The Center is a "super-library" with the added functions of conducting studies and generating reports. These complex

responsibilities create a demand for knowledge combined with the processing of knowledge and its dissemination. The Center is effectively a knowledge management system dedicated to the Armed Forces.

Case VI: U.S. Department of Veterans Affairs (VA); Office of Policy and Planning

This case is of a unit of the VA responsible for developing initiatives, conducting analyses, and formulating possible courses of action for the senior administrators of the department. The office has four major areas of activities: (1) strategic planning; (2) analytics, evaluations, and surveys; (3) advisory committees; and (4) management systems improvements.

The office is a crucial component of the flow of information and knowledge for the Secretary and the senior VA leadership. In addition to the task of developing the department's strategic plan, the office is also engaged in a variety of studies, data collection and analysis, and the generation of ideas, innovations, and processes to improve the management of the department. This task is similar to the organizations in private companies responsible for industrial engineering, quality control, and managerial improvements.

This office has the double function of generating knowledge and using knowledge to meet its obligations of planning and evaluation. In organizational terms the office is a *staff* support unit whose contributions to the department encompass a long-term outlook and the monitoring of future events. The office formulates strategic options, directions, and scenarios. Once adopted by the Secretary, the knowledge embedded in these plans has a marked influence on the future of the VA and the services it provides the veterans of the nation's armed forces.

The Office of Policy and Planning faces several challenges in the collection, analysis, use, and dissemination of knowledge. First, it balances the need to acquire as much knowledge as possible not only of current operations and services of the VA but also the future needs, resources, and changes that the department and the Armed Forces will face in the coming years. Second, the office must sort through such streams of knowledge and process them with the ever-present limitations of the uncertainties of the nature and outcomes of wars, changing demographics, and the availability and nature of the national healthcare delivery system. Third, the office, as a staff unit, has little control over the use and effectiveness of its outcomes in the form of reports, plans, and recommendations.

The metrics for the evaluation of the office are in terms of its contributions to better decisions made by VA senior leadership. This outcome will depend on the quality of the knowledge collected and processed by the office. Measures of quality include: relevancy, reliability, currency, and accuracy of the knowledge utilized by the office.

Case VII: U.S. Department of Veterans Affairs (VA); Veterans Health Administration; VISN 11: Veterans in Partnership; VA Hospital in Region 11

This Case is of the KMS in a VA hospital in region 11 that comprises the states of Michigan, Illinois, and Indiana. The VA has 23 such Veterans in Partnership regions in all 50 states and the territories. This case explored the needs and challenges of knowledge in one hospital.

Like any other hospital that is part of a large network of healthcare providers, the VA hospital is faced with the need to acquire clinical and administrative knowledge that will allow it to deliver care to its patients. The VA hospital has a unique target population of veterans and their dependents. It also has a single payor in the federal government and, in this instance, it is similar to hospitals fully funded and managed by states, counties, and municipalities. Unlike private hospitals, the VA hospital need not be concerned with competition for patients, malpractice, or payment for services. It does, however, compete for medical talent and needs knowledge about clinical innovations, new procedures, and advances in medicine.

The purpose of the hospital is to provide the best available care to its patient population. To do so, the hospital must have a knowledge base of clinical and administrative procedures and maintain a current state of quality and availability of care. This hospital, therefore, is evaluated by the same metrics used for non-governmental hospitals: how well is care provided to patients? The clinical staff of this hospital and its facilities must be equal in their levels of skills and services to the private sector and to university hospitals.

But, as a member of the network of hospitals under the Department of Veteran Affairs, the hospital competes for resources with other hospitals in the network and in its region. The hospital needs to acquire and process knowledge about the federal system, any changing policies and evaluation criteria, and any present and forecasted changes in its target population of patients.

Case VIII: U.S. Department of Health and Human Services (HHS); Centers for Disease Control and Prevention (CDC&P); Office of Non-Communicable Diseases, Injury, and Environmental Health; National Center for Chronic Diseases, Prevention, and Health Promotion (NCCDPHP)

The CDC&P is the nation's premier organization in charge of protecting the health of the American public. Its mission is multifaceted: to monitor, detect, and investigate health problems; to conduct research and to train health professionals; to foster prevention of health problems and diseases; and to educate the

public on issues of healthy behavior (such as the recent emphasis on obesity and chronic diseases).

Within these complex and critical objectives of the CDC&P, the National Center for Chronic Diseases Prevention and Health Promotion (NCCDPHP) is focused on prevention and control of chronic diseases such as diabetes, cardio-vascular disease, asthma, cancer, and neurological decay. In the national scene, healthcare expenses for chronic diseases take a disproportionate chunk of the nation's investment in healthcare delivery. Seven major chronic diseases account for about 80% of hospital admissions, almost 90% of prescriptions filled, and over 70% of the total expenditures for healthcare delivery in America.

These statistics clearly position this CDC&P Center for chronic disease prevention as a critical component of the nation's first-line defense instrument to help prevent and control chronic diseases. To accomplish these goals, the Center needs to acquire, process, and share various knowledge bases on the clinical aspects of chronic diseases, the epidemiological attributes of these diseases, modes of prevention and treatments, and the means by which the public can be made aware of the magnitude of threats from these diseases and how to prevent and combat them.

The Center faces the challenges of the need to balance the internal use of knowledge on these diseases and the external dissemination to the public and to other health organizations of the knowledge the Center has attained, processed, and analyzed. The Center's performance is measured by two sets of metrics: internal and external. The challenge is with the external measures. The Center can promote, advocate, and foster healthy behaviors, safety, and healthy environments. But it is up to the American public to heed the advice of this government organization. Therefore, improvements in the prevention of chronic diseases depend not only on the work of this Center but especially on the will of the American public to live a healthier life.

A Knowledge Management System (KMS) to be designed for this Center will have to account for the dual functions of clinical knowledge processing and diffusion, and the public-relations aspects of the Center's mission and objectives. These are two distinct types of KMS that need to closely collaborate and not only interface with each other but effectively merge to produce a single—albeit complex—and workable system.

c) Comparative Analysis of the Cases

Managers in the eight federal health organizations described above considered the strengths and challenges of their KMS. There is an agreement among these mangers that any new tasks and new knowledge imposed by the federal government on their knowledge system can be met with their existing KMS. There are some concerns expressed by these managers. Their current systems are not designed to meet the specific needs of their organizations. In most cases the systems are standard instruments installed by contractors without much regard for the unique attribute of the agency, the center, or the federal department or office. Another example is the challenge of implementation and evaluation of the KMS. As illustrated in several of the cases, there is a continuous tension between internal and external aspects of the acquisition, processing, utilization, and sharing of knowledge by the individual organization. Existing KMS are not designed to effectively address these concerns. The following section elaborates these concerns.

VI. Part Five: Best Practices

This part discusses the best practices of knowledge management in the private and public sectors of the economy. Although respondents in federal health agencies are distrustful of the experience of other organizations, there is, however, a pool of practices that can be a valuable source for lessons to be drawn by these agencies. The practices outlined in this section are derived from the literature and from the experience of the author and his colleagues in their research and consulting on knowledge management.

a) *Categories of "Best Practices"*

Best practices of knowledge management are classified into three categories: (1) implementation; (2) utilization; and (3) evaluation. These categories cover the process of adoption of KM.

i. *How to Best Adopt and Implement KMS*

The literature and our experience in research and consulting have yielded several principles on how to best adopt and implement KM systems. These principles are useful not only for newly adopted systems, but also for any restructuring or reconfiguring of existing KM systems (Gates and Urquart, 2007). Figure 14 shows this category of best practices as a list of what to do (what successfully works) and what not to do (what would very possibly lead to failure).

Figure 14

Best Practices for Adoption and Implementation of KMS

What To Do: Practices That Work	What Not To Do: Practices that Fail
• Plan the adoption process in detail. • Select an implementation mode or framework that covers the *entire* adoption process. • Select vendors who will support your system throughout the implementation process. • Select a KMS that is up to the needs you have and *will have* in the near future. • Market the system and gain support from *all* levels of the organization for adoption. • Select a KMS that allows you to network within the agency and outside. • Consider restructuring KMS as a *new* system.	➢ Don't assume that venders have all the answers. ➢ Do not relegate the implementation process to vendors. You are in charge—vendors support you. ➢ Do not assume that making some changes in your KMS to accommodate new needs for knowledge will be sufficient. ➢ Do not confuse your agency's information systems: KMS is a different animal. ➢ Do not stop at the implementation of KMS. To have the system in place is only the beginning.

The best practices in this figure can be summarized in terms of careful planning and taking into consideration the special attributes of a KMS. For example, the California Healthcare Foundation (2009) offered some lessons learned from successful adoption of electronic health records. There are "best practices" that include: (1) "garner organizational buy-in"; (2) "engage in a comprehensive and multifaceted planning process that includes strategic, technological, business, and financial considerations," and (3) "practice change management techniques."

There is a similar set of best practices in the adoption and implementation of technological systems such as KMS. These practices are anchored in good planning and insightful organizational and behavioral tactics that allow for a smooth introduction of such systems into the organization (Ilebrand, Mesoy, and Viemmix, 2010).

ii. *What Works, What Doesn't, and Why*

Once the KMS has been selected and installed, there arises the need to make it work. This means that members of the government organization need to utilize the system by depositing knowledge into it, by sharing its contents with others inside and outside the organization, and by employing the system's content as elements in the discharge of their jobs. The mere existence of the KMS is the first step in a long process of adoption of the system. So, when the demand for knowledge and the diversity of types of knowledge increase over time, there will also be an added set of challenges to utilize the agency's KMS with more efficiency and to make the system work harder and smarter (Hess and O'Neil, 2010).

Figure 14 offered examples of best practices for the management and utilization of KMS. These practices cover the parts of the adoption process of KMS from its initial installation to its routine utilization by members of the organization.

The practices that work for making the KMS useful to organizational members can be summarized in two key notions. The first is to continue incessantly to sell the system throughout the organization. Work with all levels to overcome resistance to change and establish a culture that supports the creation and exchange of knowledge. It's not enough simply to adopt a KM system. Even when the agency lets the contractor install a "turnkey" operation, once the system is in place, the agency must be tireless in making the system acceptable, workable, and useful.

The second notion is to break the organizational barriers that hinder the use of KM systems. Key barriers are the existence of "silos" of knowledge and the reluctance of organizational members to exchange knowledge with those outside the agency. Silos are created and maintained due to differences in technical abilities, organizational divisions and functions (e.g., scientists versus administrators), different professions, and departmental cultures. These silos are also present in the networking of agency personnel with other people and entities in the healthcare sector. For example, clinicians in government health agencies are more likely to exchange knowledge with other clinicians in the private sector and other government agencies, but are less likely to exchange knowledge with non-clinicians in their own agency (Geisler, 1999).

As the need arises to overhaul existing KMS because of their challenges, the best practices are to avidly manage the KMS to make it useful. This is done by overcoming the barriers to utilization—such as silo mentality, adverse culture, and resistance to change.

iii. *How To Best Evaluate KMS*

The third category of best practices is the evaluation and assessment of KMS. This practice is not limited to monitoring the success of the KMS. By its nature, evaluation is the means by which the organization can affect changes in its strategy and institute course redirection. Figure 15 shows the best practices for evaluating KMS.

Figure 15

Best Practices for the Evaluation of KMS

What To Do: Practices That Work	What Not To Do: Practices That Fail
• Link KMS outcomes and benefits to the mission, strategic objectives, and to the performance of the agency. • Bring to bear examples and anecdotes of KMS that worked. • Use metrics of positive outcomes and benefits, rather than solely relying on metrics of use. • Conduct your agency's own evaluation program. • Allow for a period of time for KMS adjustment and for users to get accustomed to the system. • Select metrics that assess exchange, cooperation, and intra- and inter-agency networking. • Evaluate the effort to sell the system and to overcome resistance to change.	• Don't get bugged down with metrics of utilization. • Don't outsource the evaluation of your KMS to vendors. • Don't conduct the evaluation of KMS to manage the basket of incentives. • Don't mix the evaluation of KMS with that of your agency's MIS • Don't assume that all or many of your metrics are going to be positive: success of KMS is a relative concept. • Don't utilize one category of metrics to make the evaluation of the system: e.g., evaluating only on economics.

To make the evaluation of KMS a useful tool for federal health agencies, there are two key principles that emerge from Figure 15. The first is the choice of evaluation metrics. A common practice in evaluation programs is to focus on the accounting, financial, and audit aspects of an agency-wide system such as the KMS. This is poor practice that generates misleading findings. Cost accounting and financial oversight are important management tools but they are the least desired metrics to evaluate the effectiveness of KMS.

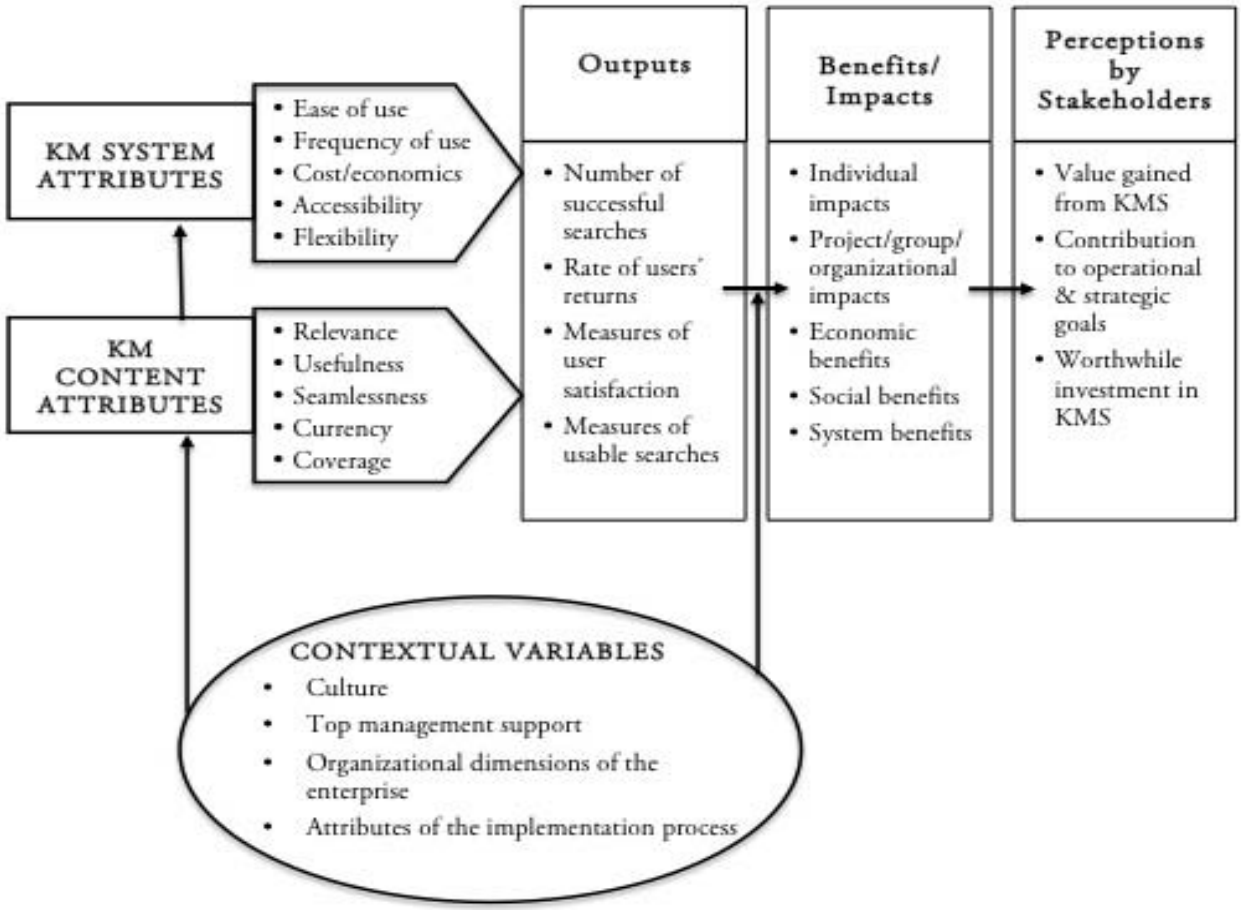
The emphasis in the choice of metrics should be on metrics of benefits and contributions of KMS to the agency, to its mission, and to the performance of its units, departments, and people. The question asked in the evaluation should not be: "How much does the KMS cost and how much use has the KMS had?" or "What is the ratio of these two measures?" This means that calculating the "cost per use" of the system is a meaningless metric of what the KMS has done for the agency.

iv. *Key Metrics of Utilization, Performance, and Benefits*

The choice of metrics for the evaluation of KM systems in government health organizations is a crucial component of best practices of KM. Wrong, weak, or inadequate metrics may lead to poor decisions on the adoption and assessment of KM systems. Figure 16 shows a model of KMS evaluation and some illustrative metrics.

Figure 16

A Model and "Best Metrics" of KM Evaluation



The model lists two sets of metrics. The first includes metrics of the *utilization* of the KM system. These metrics are employed to measure (1) the system attributes or (2) the content attributes of the KMS. *System* attributes are the measures of the frequency of use, ease of use, cost of use, accessibility, and the flexibility of the system. Similarly, *content* attributes are measures of how useful, relevant, current, and seamless the KMS happens to be—as perceived by its users.

These metrics of utilization can be quantified by measures of actual use (e.g., number of successful searches or cost per search) and measures of perceived satisfaction of users with the system. But, as emphasized above, these metrics provide some data on use of the KMS, but are not sufficient to measure the impacts, benefits, and value of the KMS to the organization.

Successful implementation of KMS (such as the case of Siemens' "Sharenet": Heier et al., 2005) is measured by a combination of metrics of utilization and a second set of metrics of *value* of the KMS. This second set of metrics includes measures of perceived and actual contributions of the KMS. In the case of federal health organizations, the contributions are a mix of clinical and administrative measures, applied to the *internal* and *external* impacts of KMS. Best metrics are those which combine measures of the intra-agency exchange and management of knowledge—with the networking and the interlocking of inter-agency systems to form a cohesive and integrative multi-agency knowledge exchange in the relevant aspects of the national health landscape.

An example of this network would be the seamless flow of knowledge among KM systems of such agencies of the HHS (Health and Human Services) department of the federal government, as the Centers for Disease Control and Prevention (CDC&P), the Food and Drug Administration (FDA), the National Institutes of Health (NIH), the Centers for Medicare and Medicaid Services (CMS), and the Agency for Healthcare Research and Quality (AHRQ). In addition, knowledge about health could flow between the KMS of these organizations and other offices, agencies, and departments in the federal and state governments.

Examples are the need for knowledge exchange in matters of health between agencies of HHS and the Federal Department of Homeland Security, state departments of public health, and the healthcare organizations of the armed services. Although some interface exists today, there is a long way to go before we achieve seamless flow.

The metrics selected to evaluate KM systems in the federal health organizations should capture the value of these systems throughout the federal government. A focus on the internal working aspects of a KMS and its economics would miss the more crucial aspects of knowledge management of the national healthcare landscape.

Best practices in the selection and use of evaluation metrics for KM systems are the inclusion of both sets of the utilization and the impacts/contributions of these health KMS. The application of these metrics within a framework of decision-making will depend on the culture of the agency and on the preferences of policy makers in the agency. Senior managers who are more concerned with the efficiency and performance of the KMS will emphasize the importance of metrics of utilization. However, senior managers in federal health agencies should give added consideration to the metrics that assess the impacts, contributions, and value of the KMS to the agency and to other organs of the government.

VII. Part Six: Challenges and Lessons Learned

The findings from the study of managers in federal health agencies and the literature suggest three key challenges to knowledge management. These challenges harbor potential solutions for these agencies.

a) The Challenge of KMS Implementation and Evaluation

Managers in federal health organizations consider the implementation and evaluation of KMS a challenge to their ability to best utilize the knowledge that they acquire and process. The existing KM systems are usually standardized versions of systems sold in the private sector. These systems are often implemented "as is" with insufficient amount of adaptation to the unique attributes of the federal organization. In addition, the KM systems implemented in these organizations are inadequately equipped with an evaluation framework that provides metrics sufficiently distinctive to measure the contributions of the KMS by the purpose, function, and structure of the individual government organization.

b) The Challenge of Making Current KM More Effective

Federal health agencies are consistently faced with the challenging situation whereby their KM systems are put to the test of meeting the current and the enhanced needs of the healthcare environment. The challenge is to make their KM systems more effective and more able to transcend local foci and to become inter-agency systems of knowledge sharing and of strategic intelligence for the government organizations (Davenport and Jarvenpaa, 2008; Nicolini et al., 2008).

The challenge of the need for added effectiveness is compounded by the poor track record of KM contractors. Although strewn with good intentions, these contractors are unlikely to improve their KM systems to a level where they could successfully manage the added knowledge that the reform in health care will generate in the foreseeable future.

c) The Challenge of Learning from Other Health Organizations

The literature and the author's experience suggest very few cases of successful KM systems in health organizations. Government agencies face the challenge of learning from the experience of private companies and foreign government agencies.

Respondents in the cases of federal health agencies are not open to lessons from others. They seem to overly rely on their agency's experience and the support offered to them by KM contractors. The phenomenon of "not invented here" is prevalent in this case of KM systems. Although the agencies are apprehensive about the challenges of their KMS, there is a limited willingness to learn from others and to integrate such lessons into the future structuring and operation of their KM systems.

d) Lessons Learned and Recommendations

Although respondents in our study do not believe that the added knowledge requirements—due to healthcare reform—represent a pressing challenge to their current systems, the expanded involvement of government in the national healthcare sector is a strong possibility. Added regulations and an increased role in the funding of health care are foreseeable consequences of the reform. This added involvement of government agencies in the sector would soon engender added cooperation and a host of necessary, interlocking cooperative relations among the many federal and state agencies in the national health arena. Whatever format the final reform bill will take, the expanded role of government in the health sector will become a reality.

There are four lessons to be learned from the literature on KM, the eight cases above, and the experiences of private and public organizations. These lessons are described in summary form to provide managers in the federal health system with the extract of what we can learn from best practices in the health sector.

1. *Tailoring KMS to the Specific Nature and Needs of Federal Health Organizations*

There is a need to tailor the KMS for each government health organization, according to its structure, function, and purpose or goals. The implementation of the standardized KM systems is a poor practice. Federal health organizations, such as those described in the eight cases above, are a myriad of centers, offices, and institutes—each with different missions, objectives, and types of contributions to the federal government and to the American public.

2. *The Successful Adoption and use of Health KMS Requires Effort beyond the Installation by Contractors*

As contractors install the 'latest versions" of their hardware and software, the agency must undertake a substantial program to "rally the troops" and to continuously market the redesigned KM system to all levels and members of the organization. This effort must include an adequate basket of incentives for employees to use the KM system and to continue using it. The effort must also strive to change negative perceptions that people tend to have of how effective their KM system seems to be by an ongoing campaign that emphasizes positive experiences with and potential benefits from these systems.

3. *The Successful Utilization of Health KMS Requires Cooperation, Coordination, and Networking within the Agency and with other Health Organizations*

Federal health organizations must break down the "silos" that prevent sharing of knowledge among offices, centers, and specialties within the parent organization and between this and other organizations. The persistent existence of independent knowledge systems ("silos") separated by organization or professional specialty is not only unwarranted but, more importantly, is harmful to the effectiveness of the KMS. Silos produce unacceptable behavior whereby employees are reluctant to share their knowledge and are motivated to hoard what they know, thus effectively counteracting any benefits from an organization-wide KM system.

Because of the complexity of the national health sector and the very large number of private and public stakeholders and direct participants, federal health organizations—in their complex capacity and responsibilities in the national arena—must focus on their KM cooperation and networking with other stakeholders. The federal government is now a major player in the national health sector; therefore, its agencies must enhance and support the flow of knowledge within the sector. It is no longer sufficient to limit the flow and the management of knowledge within the confines of the government. There is a notable increase in the interdependence of private and public constituents in the national healthcare arena. Therefore, for the effective functioning of the delivery of care, there must be an effective flow of knowledge among the participants in the sector.

4. *The Evaluation of Federal Health KMS and the Choice of Metrics for this Activity Must Account for Both Measures of use and Benefits*

Federal health organizations are bound to redesign their KM systems. In so doing, they should focus on the link of KMS to their processes of decision and policy making. This entails the design of an evaluation framework for KMS that contains metrics of the benefits, contributions, and value of KMS. Best practices of other organizations have shown that the evaluation of KMS must answer such questions as: "How did our KMS contribute to the strategic objectives, the mission, and the performance of the organization?"

In theory, KM systems are considered strategic assets to the organization. In practice, however, organizational members tend to view these systems unfavorably and with distrust. This third lesson on the evaluation of KMS offers a mechanism by which the focus on benefits and contributions—in addition to the usual measures of cost and operation—help people in the organization to appreciate the positive outcomes and the value they can derive from their KM system.

5. *Recommendations*

What should decision-makers in federal health organizations do to: (1) *rectify* the prevailing climate in which their personnel distrust their KMS; (2) *enhance* the role of their KMS to shoulder their mission and objectives; and (3) based on best available practices, *reinvent* their KMS as an effective intra- and inter-agency mechanism. The following are useful recommendations for decision-makers at all levels in the federal health network. They summarize the essence of the best practices reviewed in this paper.

Recommendation One: Reformulate the Process by which KM Systems are Acquired and Tailored to Specific Needs of the Organization

Federal health organizations are dependent on contractors with the result that most KM systems are standardized with the purpose of facilitating connectivity and coordination among organizations. Cost considerations are also taken into account for this type of solution to KM requirements. However, the different needs and characteristics of each federal health organization calls for the acquisition and implementation of more specific KM systems in order to make these systems more effective by serving the unique needs and requirements of each organization. It is recommended that an analysis of these needs be conducted before a KM system is installed, so that necessary adjustments can be made in the system. If a system has already been installed, this analysis should take place to modify the system as needed.

Recommendation Two: Work with Contractors to Implement a KM System with Capabilities to Manage Internal and External Objectives

Decision makers in federal health organizations should not consider their KM system as simply a warehouse of knowledge for the periodic use of internal employees/customers. The KM system must be a dynamic system that links the organization to the health sector within and outside the federal network, and continually provides updated knowledge from all sources—internal and external to the organization and to government.

It is recommended that the KM system be considered as a fundamental instrument in the health decisions and policies of the organization—rather than a marginal technique or information warehouse.

Recommendation Three: Establish a Comprehensive Program of Adoption and Adaptation of KMS

With all the good intentions, most organizations install a robust KMS, then simply "forget it" by saving on training and other elements of the "learning curve" for users. This practice leads to failure. KMS thus installed become obsolete, unimportant, and eventually ignored by actual and potential users. Managers in federal health organizations must approach the adoption of KMS with dedication and long-term commitment. KMS should be viewed as a "work in progress" rather than a system we install, let run, and don't bother with until or unless it breaks down.

It is recommended that decision makers in federal health organizations work very closely with contractors and consult with other government managers as they adopt and use their KMS, with vigor and on a continuous basis.

Recommendation Four: Conduct Periodic Audits and Evaluations of the KMS

The KMS must be evaluated to assess the operations and impacts of the system. This audit should be done in terms of the costs, benefits, and contributions to the focal organization as well as the parent federal organization. It is recommended that such audits be conducted periodically by using metrics listed in this report. These audits will provide feedback that will allow decision makers to introduce necessary modifications to the KMS itself, and to better assess the contributions of KMS. These include: problems identified, classified, or solved with the help of the KMS; mistakes and potential disasters avoided thanks to the KMS; communication across silos; and contributions to the mission of the organization and the parent federal department.

These audits are not simply exercises in evaluation. They are crucial elements of the effort needed to keep the federal health organizations current, connected, and effective.

Recommendation Five: Establish a KMS for Each Federal Department

Individual offices, institutes, and centers in the federal health departments have their own KMS, designed to accomplish the organization's unique goals and functions. It is recommended that a comprehensive KMS be established for each department of the federal government in which knowledge from all subordinate organizations can be collected. Health knowledge is essential for the wellbeing of the nation. Hence, such central KMS will allow each department to possess and to share knowledge in a timely and comprehensive manner. Exchange of health knowledge among diverse government departments such as the Department of the Army, HHS, and the Veterans Affairs would facilitate currency of the flow of health knowledge and more effective modes of reaction to threats to the health of Americans in situations such as epidemics or terror acts on a national scale.

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Histogram Filter with Adjustment of the Smoothing Parameter based on the Minimization of the Chi-Square Test

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Abstract- For the formation of adequate models of objects of statistical research, with the possible high cost of a measuring experiment or the process of obtaining data, fast and "correct" identification (recognition) of the probability distribution density (PDD) based on the construction of simple histogram estimates is required. The requirement for rapid identification can be considered equivalent to having a limited and small amount of data. The article proposes a theoretically substantiated method for constructing a histogram filter (HF), which is a linear combination of the amount of data in adjacent intervals with constant weight coefficients, which can be expressed in terms of a single coefficient k - the smoothing parameter. The estimation of the smoothing coefficient is based on the minimization of the modified chi-square test. The theorem given in the article establishes that the value of the mathematical expectation of the chi-square test, after applying the HF, decreases by k times compared to the standard mathematical expectation of the criterion with a unit inclusion function.

Keywords: *distribution density, density identification, histogram filter, smoothing factor.*

GJRE-J Classification: *DDC Code: 020.3 LCC Code: Z1006*

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Histogram Filter with Adjustment of the Smoothing Parameter based on the Minimization of the Chi-Square Test

Гистограммныйфильтрснастройкойпараметрасглаживаниянаосновеминимизациик ритерияхи-квадрат

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Реферат- **Для формирования адекватных моделей объектов статистических исследований, при возможной высокой стоимости измерительного эксперимента или процесса получения данных, требуется быстрая и «правильная» идентификация (распознавания) плотности распределения вероятности (ПРВ) на основе построения простых гистограммных оценок. Требование быстрой идентификации можно считать эквивалентным наличию ограниченного и малого объема данных. В статье предлагается теоретически обоснованная методика построения гистограммного фильтра (ГФ), представляющего собой линейную комбинацию количества данных на соседних интервалах с постоянными весовыми коэффициентами, которые могут быть выражены через один коэффициент *k*– параметр сглаживания. Оценка коэффициента сглаживания осуществляется на основе минимизации модифицированного критерия хи-квадрат. Приведенная в статье теорема устанавливает, что значение математического ожидания критерия хи-квадрат, после применения ГФ, уменьшается в *k*раз по сравнению со стандартным математическим ожиданием критерия с единичной функцией включения. Коэффициент сглаживания определяется сложной зависимостью числа данных, параметров идентифицируемой ПРВ (информационные коэффициенты Фишера первого и второго порядка) и ГФ (количество и ширина интервалов группирования). В статье показано, что взаимосвязь между числом данных, количеством и шириной интервалов группирования является нелинейной и имеет только численное решение. Рассмотренные примеры моделирования работы ГФ характеризуют эффективность идентификации ПРВ, целесообразность его применения в научных и прикладных статистических исследованиях.**

Ключевые слова: *плотность распределения, идентификация плотности, гистограммный фильтр, коэффициент сглаживания.*

Abstract- For the formation of adequate models of objects of statistical research, with the possible high cost of a measuring experiment or the process of obtaining data, fast and “correct” identification (recognition) of the probability distribution density (PDD) based on the construction of simple histogram estimates is required. The requirement for rapid identification can be considered equivalent to having a limited and small amount of data. The article proposes a theoretically substantiated method for constructing a histogram filter (HF), which is a linear combination of the amount of data in adjacent intervals with constant weight coefficients, which can be expressed in terms of a single coefficient k - the smoothing parameter. The estimation of the smoothing coefficient is based on the minimization of the modified chi-square test. The theorem given in the article establishes that the value of the mathematical expectation of the chi-square test, after applying the HF, decreases by k times compared to the standard mathematical expectation of the criterion with a unit inclusion function. The smoothing coefficient is determined by a complex dependence of the number of data, parameters of the identified PDD (Fisher information coefficients of the first and second order) and HF (number and width of grouping intervals). The article shows that the relationship between the number of data, the number and width of grouping intervals is non-linear and has only a numerical solution. The considered examples of modeling the work of the HF characterize the effectiveness of the identification of the PDD, the expediency of its application in scientific and applied statistical research.

Keywords: distribution density, density identification, histogram filter, smoothing factor.

I. Введение

Проблематика гистограммных оценок плотности распределения вероятности (ПРВ) хорошо известна: отсутствие единых взглядов на определение числа интервалов группирования данных (ГОСТ Р 50.1.033-2001 Прикладная статистика) и сильная изрезанность гистограммы при относительно малом числе наблюдений [1,2].

Особую важность и актуальность точные гистограммные оценки закона распределения приобретают в случае требований его быстрой идентификации (распознавания), возможной высокой стоимости измерительного эксперимента или процесса получения данных. Требование быстрой идентификации (распознавания) закона распределения в данном случае можно считать эквивалентным малому объему данных.

Устранение проблем изрезанности гистограммы заключается в применении гистограммных фильтров (ГФ), например, усредняющего, медианного, гауссовского и др. [1,3-5]. В то же время, их применение эмпирически

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интуитивно и исходит, в основном, из практических соображений. В работе предлагается теоретически обоснованная методика реализации ГФ, работающего на небольшом количестве данных, устраняющего изрезанность гистограммы, дающего «правильную» идентификацию закона распределения, ослабляющего зависимость «правильной» идентификации от числа интервалов группирования данных.

В работе развиваются идеи, предложенные в [6]. Прежде всего, предполагается отказаться от единичной функции включения данных в интервал группирования: данные могут находиться вблизи границ интервала и при изменении числа интервалов оказаться в соседнем интервале; для относительно небольшого количества данных, устранение эффекта изрезанности гистограммы может быть осуществлено сглаживанием данных на нескольких соседних интервалах.

В этом случае целесообразно заменить единичную функцию включения взвешенной функцией, учитывающей возможный вес «ошибочно» попавших в соседние интервалы данных. Физический смысл такой функции может быть охарактеризован нечеткой принадлежностью данных конкретному интервалу группирования.

Наиболее простой, с точки зренияреализации, весовой функцией удобно выбрать ступенчатую функцию.Тогдаматематическая модель гистограммного фильтра может быть представлена в виде: $u_j = \alpha_j \nu_{j-1} + k_j \nu_j + \beta_j \nu_{j+1}$, $\alpha_j + k_j + \beta_j = 1$, где ν_j – число данных попавших в *j*-тый интервал группирования, $\{\alpha_j; k_j; \beta_j\}$ – весовые коэффициенты интервалов (параметры сглаживания). В простейшем случае весовые коэффициенты являются постоянными величинами и могут быть выражены через один коэффициент *k* – параметр сглаживания.

Введение весовых коэффициентов для малых объемов данных позволяет перегруппировать эти данные так, чтобы обеспечить меньшую изрезанность гистограммы, увеличив при этом ее сглаженность и быструю идентификацию.

Вычисление параметра сглаживания, очевидно, требует некоторой априорной информации о идентифицируемой ПРВ. В работе предполагается, что такая идентификация проводится с помощью критерия согласия хи-квадрат, использование которого также основано на предположении о возможном виде идентифицируемой ПРВ. Таким образом, априорная информация является естественным и необходимым элементом построения ГФ.

Цель работы состоит в реализации гистограммного фильтра с настройкой параметра сглаживания на основе минимизации критерия хи квадрат с учетом априорной информации об идентифицируемой ПРВ.

II. Определение коэффициента сглаживания гистограммного фильтра

Пусть имеется выборка случайных данных $\{x_i\}. i = \overline{1,n}$ и определено разбиение числовой прямой на *m* непересекающихся и примыкающих друг к другу интервалов A_j , $j = \overline{1,m}$ равной длины $\Delta_x = X_{j+1} - X_j = R/m$. $X_{m+1} = x_{\max} = \max\limits_i x_i$. $X_1 = x_{\min} = \min\limits_i x_i$. где X_j – границы интервалов, $R = x_{\max} - x_{\min} = m\Delta_x$ – размах диапазона данных. Заменим обычную индикаторную функцию, используемую при стандартном способе построение гистограммы,весовой ступенчатой функцией $\mu_j(x_i)$, $0 \le \mu_j \le 1$, с областью определения $\Delta_\mu = 3\Delta_x$ и которая будет характеризовать принадлежность данных интервалу группирования A_j . При этом выбор весовой функции должен осуществляться с учетом условий нормировки:

$$\begin{cases} \sum_{t=j-1}^{j+1} \mu_{j,t} = 1, \quad j,t = \overline{2,m-1}, \\ \sum_{t}^{(t-m)(m-3)/(m-1)+(m-1)} \mu_{j,t} = 1, \quad j,t = 1,m. \end{cases} \tag{1}$$

Положимвесовые значения $\mu_{j,t}$ постоянными, не зависящими от индекса номера интервала:

$$\begin{cases} \mu_j(x) = \{k \text{ для } A_j;\ \alpha = (1-k)/2 \text{ для } A_{j-1} \text{ и } A_{j+1}\}, \quad j = \overline{2,m-1}, \\ \mu_j(x) = \{(1-\alpha) \text{ для } A_j;\ \alpha \text{ для } A_{(j-m)(m-3)/(m-1)+(m-1)}\}, \ j = 1,m, \end{cases} \tag{2}$$

где параметр *k*– коэффициент сглаживания. Условия нормировки (1) при этом выполняются автоматически. Тогда уравнение, реализующее алгоритм ГФ имеет вид

$$\begin{cases} u_j = \alpha v_{j-1} + k v_j + \alpha v_{j+1}, \quad j = \overline{2, m-1}, \\ u_j = (1-\alpha) v_j + \alpha v_{(j-m)(m-3)/(m-1)+(m-1)}, \quad j = 1, m, \\ \alpha = (1-k)/2. \end{cases} \tag{3}$$

Таким образом, задача построения адаптивного ГФ сводится к вычислению коэффициента сглаживания по информации о числе данных и априорной информации об идентифицируемой ПРВ..

Используя в качестве критерия оценки коэффициента сглаживания критерий хи-квадрат и заменив число v_j в критерии $\chi^2(v)$ на число $u_j = \alpha v_{j-1} + k v_j + \alpha v_{j+1}$ для $j = \overline{2, m-1}$ и $u_j = (1-\alpha) v_j + \alpha v_{(j-m)(m-3)/(m-1)+(m-1)}$ для $j = 1, m$, получим

$$\chi^2_{\text{гф}}(u) = \sum_{j=1}^{m} \left[u_j - n p_j \right]^2 / n p_j \to \min_k \tag{4}$$

Решение оптимизационной задачи (4) приводит к выражению для коэффициента сглаживания по выборке данных

$$\begin{aligned} k_{\text{выб}} &= 1 + 2 \left[\sum_{j=1}^{m} U_j^{\,2} / n p_j \right]^{-1} \sum_{j=1}^{m} (v_j - n p_j) U_j / n p_j = \\ &= 1 + 2 \left[\sum_{j=1}^{m} U_j^{\,2} / n p_j \right]^{1-} \sum_{j=1}^{m} v_j U_j / n p_j, \end{aligned} \tag{5}$$

где $U_j = v_{j-1} - 2 v_j + v_{j+1}$ – конечная разность второго порядка для индексов $j = \overline{2, m-1,}$ и $U_j = -v_j + v_{(j-m)(m-3)/(m-1)+(m-1)}$ для индексов $j = 1, m$; $\sum_{j=1}^{m} U_j = 0$; p_j – гипотетические вероятности.

Статистическая конкретизация формулы (5) приводит к соотношению

$$k_0 = 1 - \frac{1}{1{,}5 + 0{,}5(\Delta_x^2 I_1 + 0{,}25 \Delta_x^4 I_2) + 0{,}25 \Delta_x^4 I_2 n (m-1)^{-1}}, \tag{6}$$

где $I_1^* = \int_R \left(f'^* / f^* \right)^2 f dx$, $I_2^* = \int_R \left(f''^* / f^* \right)^2 f dx$ –информационныекоэффициенты ПРВ, эквивалентные информации Фишера первого и второго порядка [7], $f = \lim_{m \to \infty, \Delta_x \to 0} \left[p_j / \Delta_x \right]$ – гипотетическая ПРВ, $f^* = \lim_{m \to \infty, \Delta_x \to 0} \left[v_j / n \Delta_x \right]$ – эквивалент идентифицируемой ПРВ, $\int_R f dx = \gamma$ – доверительная вероятность.

Проведем упрощённое обоснование формулы (6), для чего последовательно рассмотрим компоненты, входящие в (5). Совокупность статистическо-экспериментального метода, инженерного подхода и практических представлений приводит к следующим выражениям:

$$\lim_{\substack{m\to\infty\\ \Delta_x\to 0}} \sum_{j=1}^{m} U_j / np_j = (R/m)\int_R (f''^* / f)dx,$$

$$\mathbf{M}\left(\sum_{j=1}^{m}\frac{v_j U_j}{np_j}\right) = -2(n+m-1) + \mathbf{M}\left(\sum_{j=2}^{m-1}\frac{(v_{j-1}+v_{j+1})v_j}{np_j} + \frac{v_1 U_1}{np_1} + \frac{v_m U_m}{np_m}\right) = -2(m-1) \qquad (7)$$

$$a = \left(\frac{f^*_{j-1}}{f^*_j}\right) = \left(1 - \frac{f'^*}{f^*}\Delta_x + \frac{1}{2}\frac{f''^*}{f^*}\Delta_x{}^2\right) \qquad b = \left(\frac{f^*_{j+1}}{f^*_j}\right) = \left(1 + \frac{f'^*}{f^*}\Delta_x + \frac{1}{2}\frac{f''^*}{f^*}\Delta_x{}^2\right),$$

$$\lim_{\substack{m\to\infty\\ \Delta_x\to 0}} \mathbf{M}\left(\sum_{j=1}^{m}\frac{U_j{}^2}{np_j}\right) = \lim_{\substack{m\to\infty\\ \Delta_x\to 0}} \mathbf{M}\left(\sum_{j=2}^{m-1}\frac{v_{j-1}{}^2 + 4v_j{}^2 + v_{j+1}{}^2}{np_j}\right) -$$

$$-2\lim_{\substack{m\to\infty\\ \Delta_x\to 0}} \mathbf{M}\left(\sum_{j=2}^{m-1}\frac{2v_{j-1}v_j - v_{j-1}v_{j+1} + 2v_j v_{j+1}}{np_j}\right) + \lim_{\substack{m\to\infty\\ \Delta_x\to 0}} \mathbf{M}\left(\frac{(-v_1+v_2)^2}{np_1} + \frac{(-v_m+v_{m-1})^2}{np_m}\right) \approx$$

$$\approx \left[4 + M(a^2+b^2)\right](n+m-1) + \left[2M(ab) - 8\right]n =$$

$$= 6(m-1) + 2\Delta_x{}^2 I_1^*(m-1) + 0{,}5\Delta_x{}^4 I_2^*(m-1) + \Delta_x{}^4 I_2^* n$$

Далее, подставляя выражения (7) и (8) в (5), получим непосредственно формулу (6).

Формула (6) позволяет сделать ряд важных выводов.

Во-первых, при неограниченно возрастающем числе данных $n \to \infty$, очевидно, коэффициент сглаживания должен стремиться к единице, что и следует из формулы (6). В этом случае целесообразность применения ГФ исчезает. При значении компоненты знаменателя $\delta = 0{,}5(\Delta_x^2 I_1^* + 0{,}25\Delta_x^4 I_2^*) + 0{,}25\Delta_x^4 I_2^* n(m-1)^{-1}$ меньше единицы или $\delta \to 0$ коэффициент сглаживания стремиться к 1/3. Такое значение коэффициента сглаживания отвечает случаю сильной изрезанности гистограммы, возможно вследствие неправильно выбранного (относительно большого) значения количества интервалов при относительно небольшом количестве данных. ГФ, в этом случае, преобразуется в обычный усредняющий фильтр. Таким образом, диапазон изменения значений коэффициента сглаживания лежит в пределах $1/3 \le k \le 1$.

Во-вторых, подставляя значение коэффициента сглаживания (5) в формулу (4) для критерия согласия хи-квадрат получаемвыражение $\chi^2_{\text{ГФ}}(u) = \chi^2(v) - \left(\sum_{j=1}^{m} U_j{}^2 / np_j\right)^{-1}\left(\sum_{j=1}^{m} v_j U_j / np_j\right)^2$, из которого следует соотношение между математическими ожиданиями критерия хи-квадрат: $\mathbf{M}\left(\chi^2_{\text{гф}}\right) = k\mathbf{M}\left(\chi^2\right)$, $\mathbf{M}\left(\chi^2\right) = m-1$.

Таким образом, применение ГФ позволяет уменьшить значение стандартного критерия согласия в *k* раз. Соотношение входящих в коэффициент параметров характеризует целесообразность применения и эффективность идентификации ГФ. Так, при небольших значениях компоненты знаменателя $\delta < 1$, значение критерия хи-квадрат после применения фильтра практически уменьшается в 3 раза, в противном случае при $n \to \infty$ ($k \to 1$) значение критерия хи-квадрат стремится к стандартному $\mathbf{M}\left(\chi^2_{\text{гф}}\right) \to (m-1)$ и применение ГФ нецелесообразно.

Следовательно, эффективность ГФ можно оценивать величиной обратной значению коэффициента сглаживания: $Э_{гф} = k^{-1}$.

В-третьих, предположив высокую апостериорную точность оценки ПРВ, плотность f^* винформационныхкоэффициентах формально можно заменить гипотетической f и, следовательно, величины I_1^* и I_2^* будут совпадать с вычисляемыми теоретически информациями Фишера первого и второго порядка $I_1^* = I_{1\gamma}$, $I_2^* = I_{2\gamma}$ для диапазона *R*(таблица 1). В этом случае, формула (6) становятся полностью определенной. Замечаем, что вычисление коэффициентов $I_{1\gamma}, I_{2\gamma}$ требует существование первой и второй производной ПРВ. Однако, если такой производной не существует, следует воспользоваться инженерными соображениями практической реализации. В частности, для равномерной ПРВ можно принять $f' = 0$, $f'' = 0$ и, следовательно, $I_{1\gamma} = I_{2\gamma} = 0$. Тогда численное значение коэффициента сглаживания будет равно 1/3 и ГФ преобразуется в обычный усредняющий фильтр, что в случае идентифицируемой равномерной ПРВ вполне очевидно.

В таблице 1 приведены также теоретические значения информационных коэффициентов I_1, I_2, вычисленных по области определения аргумента ПРВ.

Таблица 1: Значения информационных коэффициентов

	№1. Гауссовская плотность: $e^{-\frac{x^2}{2D}} / \sqrt{2\pi D}$
I_1	D^{-1}
$I_{1\gamma}$	$\frac{Erf\left[\frac{Erf^{-1}(\gamma)}{\sqrt{D}}\right]}{D} - \frac{2e^{-\frac{Erf^{-1}(\gamma)^2}{D}} Erf^{-1}(\gamma)}{D^{3/2}\sqrt{\pi}}$
I_2	D^{-2}
$I_{2\gamma}$	$\frac{2Erf\left[\frac{Erf^{-1}(\gamma)}{\sqrt{D}}\right]}{D^2} - \frac{2\ e^{-\frac{Erf^{-1}(\gamma)^2}{D}} Erf^{-1}(\gamma)\left(D + 2Erf^{-1}(\gamma)^2\right)}{D^{7/2}\sqrt{\pi}}$
	№2. Лапласовская плотность: $\lambda e^{-\lambda\lvert x\rvert} / 2$
I_1	λ^2
$I_{1\gamma}$	$-\left(-1+(1-\gamma)^{\lambda}\right)\lambda^2$
I_2	λ^4
$I_{2\gamma}$	$-\left(-1+(1-\gamma)^{\lambda}\right)\lambda^4$

Продолжение Таблицы 1. Значения информационных коэффициентов

f	№3. Логистическая плотность: $\alpha \operatorname{sech}^2(\alpha x)/2$
I_1	$4\alpha^2/3$
$I_{1\gamma}$	$\frac{4}{3}\alpha^2 \tanh\left[\frac{2\sqrt{3}\alpha ArcTanh[\gamma]}{\pi}\right]^3$
I_2	$16\alpha^4/5$
$I_{2\gamma}$	$\frac{1}{5}\alpha^4 Sech\left[\frac{2\sqrt{3}\alpha ArcTanh[\gamma]}{\pi}\right]^5 \times \left(30\sinh\left[\frac{2\sqrt{3}\alpha ArcTanh[\gamma]}{\pi}\right] - 5\sinh\left[\frac{6\sqrt{3}\alpha ArcTanh[\gamma]}{\pi}\right] + \sinh\left[\frac{10\sqrt{3}\alpha ArcTanh[\gamma]}{\pi}\right]\right)$
	№4. Коши плотность: $s(s^2+x^2)^{-1}/\pi$
I_1	$0{,}5s^{-2}$
$I_{1\gamma}$	$\frac{4\arctan\left[\tan\left[\frac{\pi\gamma}{2}\right]\right] - \sin[2\pi\gamma]}{4\pi s^2}$
I_2	s^{-4}
$I_{2\gamma}$	$\frac{48\arctan\left[\tan\left[\frac{\pi\gamma}{2}\right]\right] + 24\sin[\pi\gamma] + 6\sin[2\pi\gamma] + 8\sin[3\pi\gamma] + 3\sin[4\pi\gamma]}{24\pi s^4}$

III. Соотношения между числом данных, числом интервалов группирования и их шириной

Показатель эффективности ГФ может быть использован в целях нахождения оптимального соотношения между числом данных, числом интервалов группирования и шириной этих интервалов. Зафиксировав некоторое желаемое значение эффективности фильтра $Э^0_{гф}$, на основании (6) получим

$$\Delta_x^2 I_1 + 0{,}25\Delta_x^4 I_2 + 0{,}5\Delta_x^4 I_2 n(m-1)^{-1} = K^0, \quad \text{где } \Delta_x = R/m, K^0 = (Э^0_{гф} - 1)^{-1}(3 - Э^0_{гф}). Э^0_{гф} = k_0^{-1} \tag{9}$$

В приведенную формулувходят точные теоретические значения информационных коэффициентов по всей области определения аргумента, однако для практических расчетов следует использовать значения с учетом реального диапазона данных *R*, т.е. $I_{1\gamma}$ и $I_{2\gamma}$.

Уравнения (9) нелинейное, требующие численных методов решения в общем случае.

Анализ уравнения (9) показываетсложную взаимозависимость параметров идентифицируемой ПРВ и ГФ. Это, в частности, объясняет большое количество работ, посвященных тематике взаимосвязи этих параметров и рассматривающих проблему их выбора с тех или иных позиций.В этом смысле данная работа расширят подход [9,10], учитывая информацию Фишера первого и второго порядка относительно идентифицируемой ПРВ.

В некоторых частных случаях, с целью получения простых аналитических выражений взаимосвязи параметров ПРВ и ГФ, уравнение (9) возможно упростить.

Во-первых, если выполняется соотношение между информационными коэффициентами $I_2 = cI_1^2$, $c = \text{const}$ и число интервалов группирования значительно больше единицы, то обозначив $x = \Delta_x^2 I_1$, уравнения (9) можно записать в виде

$$a(n)x^{5/2} + bx^2 + x - K^0 = 0, b = 0,25c,\ a(n) = 2b(R\sqrt{I_1})^{-1}n \tag{10}$$

Уравнение (10) компактно и позволяет получать семейства зависимостей связывающих параметры идентифицируемой ПРВ и ГФ.

Во-вторых, анализируя вклад компонент знаменателя (6) в коэффициент сглаживания замечаем, что с увеличением числа данных возрастает влияние компоненты, содержащей параметр *n*. Тогда уравнение (9) можем преобразовать к виду

$$\frac{n}{m^4(m-1)} = \frac{2K^0}{R^4 I_2} \tag{11}$$

Для случая $m >> 1$ возможно приближенное аналитическое решение нелинейного уравнения (11): $m = \sqrt[5]{nR^4 I_2 / 2K^0}$. Последняя формула близка к выражениям вида $m \sim n^{0,2}$, приведенным в [1,8] с коэффициентом пропорциональности зависящим от параметров ПРВ и априорных установок ГФ по его эффективности $Э_{гф}^0$.

В-третьих, перераспределение части данных между соседними интервалами, не только уменьшает изрезанность гистограммы, но и способствует ослаблению требований к выбору числа интервалов группирования. Фиксируя некоторую нижнюю границу значения эффективности ГФ ($Э_{гф}^0$), можем определить значение числа интервалов группирования по формулам (11) из условия $m^4(m-1) \geq 0,5nR^4 I_2 / K^0$.

IV. Рекомендации по реализации гистограммного фильтра

Полученные теоретические результаты показывают целесообразность применения ГФ с целью эффективной и быстрой (на малых объемах данных) идентификации изменяющихся законов распределения в описательной статистике, при обработке гистограмм изображений. Программная реализация ГФ легко встраивается в существующие открытые алгоритмы построения гистограмм, например, в функции hist, histfit платформы Matlab.

Структура алгоритма идентификации (распознавания) ПРВ следующая.

1. Получение выборки данных, объемом *n*, определение размаха выборки *R*.
2. На оснований предположений о идентифицируемой ПРВ, вычисление информационных коэффициентов $I_{1\gamma}$ и $I_{2\gamma}$.
3. На основании выбранного числа интервалов группирования данных, размаха выборки, объема данных, информационных коэффициентов вычисляется значение коэффициента сглаживания (6).
4. Применение ГФ (3).
5. Вычисление критерия согласия хи-квадрат. На основании заданного уровня значимости принятие решения о идентификации.

Заметим, процедуру идентификации ПРВ можно сделать многоканальной, где каждый канал будет ориентирован на определенный заранее возможный вид ПРВ. Принятие решения о идентификации в этом случае может быть реализовано различными методами, например, простым или взвешенным голосованием.

V. Моделирование гистограммного фильтра

На рис.1 ($n = 100, m = 9$, количество серий экспериментов 100) приведены примеры работы ГФ для ПРВ: нормальной (рис.1,а, $k_{выб} = 0.64$, $Э_{выб} = 1,56$), логистической (рис.1,б, $k_{выб} = 0.74$, $Э_{выб} = 1,35$), экспоненциальной (рис.1,в, $k_{выб} = 0.53$, $Э_{выб} = 1,89$), равномерной (рис.1,г, $k_{выб} = 0,36$, $Э_{выб} = 2,78$). На рис.1 верхняя часть соответствует обычной гистограмме, нижняя – результат обработки ГФ. Во всех

приведенных на рис.1 случаях выполняется соотношение $\chi^2_{гф} < \chi^2_{кр} \leq \chi^2$, где $\chi^2_{кр}$ – критическое значения критерия согласия при заданном уровне значимости (0,05). Результаты моделирования, наглядно подтверждают идею применения ГФ. Эффективность применения ГФ на отмеченных плотностях указывает на существенное его превосходство перед стандартной гистограммной оценкой.

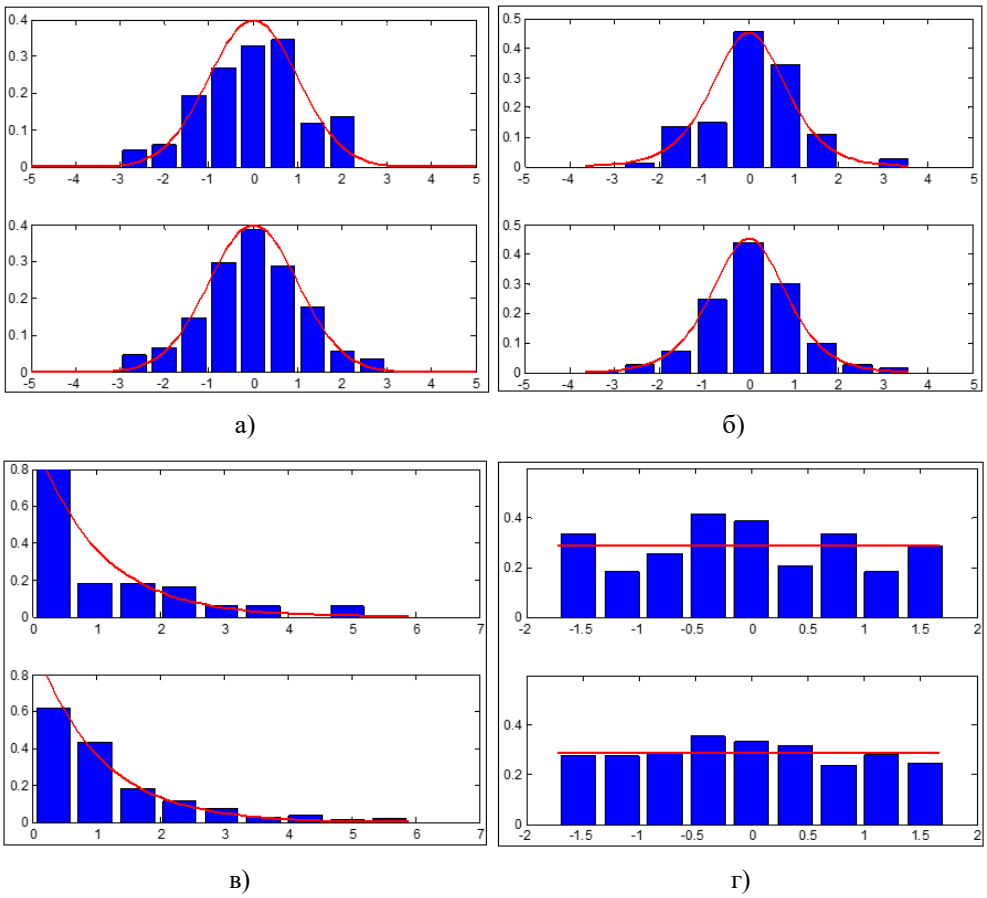


Рис.1: Результаты работы ГФ

В табл.1 (количество серий экспериментов 100) содержаться некоторые результаты моделирования работы ГФ (4) в сопоставлении с теоретическими результатами, полученными на основе формулы (6) для трех ПРВ: нормальной, логистической, лапласовской. На рис.2 приведены зависимости коэффициента сглаживания (6) от количества интервалов группирования для двух ПРВ: нормальной (кривая 1, $n=100$; кривая 2, $n=500$) и лапласовской (кривая 3, $n=100$; кривая 4, $n=500$). Численные (таблица 2) и графические результаты (рис.2) позволяют сделать вывод о том, что значение коэффициента сглаживания нелинейно уменьшается с уменьшением объема данных. Это объясняется тем, что при уменьшающемся объёме данных увеличивается изрезанность обычной гистограммной оценки ПРВ и, следовательно, требуется ее большая сглаженность, стремящаяся к равномерному (усредняющему) сглаживанию ($k \to 1/3$) при одном и том же числе интервалов группирования.

На рис.3 (количество серий экспериментов 100) на основе формулы (9) (кривые 1.1-1.3), приведены зависимости меду числом данных и числом интервалов их группирования для двух плотностей: гауссовской – рис.3,а и логистической – рис.3,б для различных значений коэффициента эффективности: $Э^0_{гф}=1,5$ ($k^0=0,(6)$) – кривая 1.1, $Э^0_{гф}=1,3$ ($k^0=0,77$) – кривая 1.2, $Э^0_{гф}=1,1$ ($k^0=0,91$) – кривая 1.3. На тех же рисунках приведены для сопоставления стандартно используемые формулы Старджеса $m=1+\log_2 n$ (кривая 2) и формулы, приведенной в [1,8] $m=C(E_x)n^{0,4}$ (кривая 3), где $C(E_x)=(E_x+4,5)/6$, E_x– коэффициент эксцесса ПРВ.

Таблица 2: Коэффициенты сглаживания и эффективность ГФ, $n = 100$

№	m	Нормальная ПРВ, $A(f) = 1,73$			Логистическая ПРВ, $A(f) = 2,14$			Лапласовская ПРВ, $A(f) = 0,99$		
		$k_{выб}$	k_0	$Э_{гф}$	$k_{выб}$	k_0	$Э_{гф}$	$k_{выб}$	k_0	$Э_{гф}$
1	5	0,8	0,96	1,04	0,96	0,98	1,02	0,98	0,99	1,01
2	7	0,81	0,81	1,23	0,90	0,92	1,09	0,94	0,97	1,03
3	9	0,66	0,61	1,64	0,75	0,77	1,30	0,86	0,91	1,10

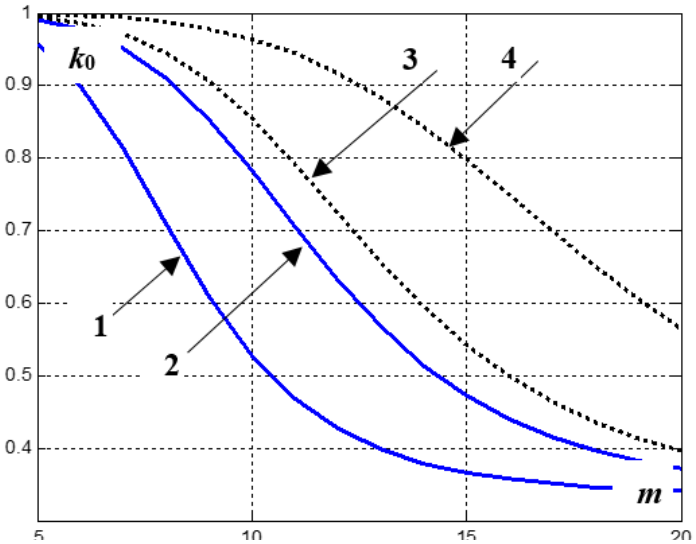
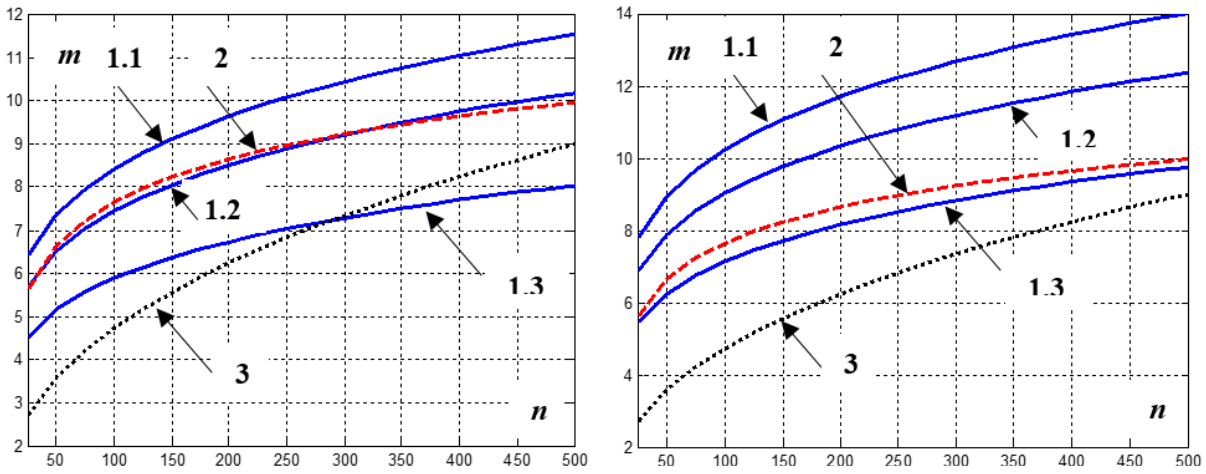


Рис.2: Коэффициенты сглаживания ГФ



а) б)

Рис.3: Зависимость числа интервалов группирования от объема данных

VI. Выводы

Рассмотренный в статье ГФ (3) с настройкой параметра сглаживания может быть эффективно применен в задачах идентификации (распознавания) ПРВ для малых объемов данных с учетом имеющейся в наличии априорной информации о предполагаемой ПРВ.

Установлено соотношение между математическими ожиданиями согласия критерия хи-квадрат при стандартном подходе построения гистограммной оценки и с использованием ГФ. Такое соотношение определяется коэффициентом сглаживания (5), (6). Численное значение коэффициента сглаживания зависит от параметров: объема данных, числа интервалов группирования, информационных характеристик ПРВ (таблица 1). Зависимость коэффициента сглаживания от указанных параметров позволяет определить взаимосвязь между количеством

интервалов группирования данных и их объемом. Эта зависимость нелинейная, не имеющая аналитического решения.

Гистограммный фильтр является простым для реализации инструментом, который легко может быть встроен в любой открытый алгоритм идентификации (распознавания) ПРВ.

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The Approach to Fire Safety in the Curriculum Map-Matrix of Engineering Courses at a Federal University According to the Parameters of Law 13.425: A Systematic Review

By Stefania Chaves Ferreira, Priscilla Chantal Duarte Silva, Anna Rita Tomich Magalhães Felippe & Ricardo Luiz Perez Teixeira
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Abstract- Fire protection has gained the spotlight, in large part, as a result of some disasters that have occurred in recent years. The subject has evolved and gained considerable prominence, thus requiring changes in current legislation, as well as the formulation of new Standards and Laws, capable of mitigating the risk of fire occurrence. It is necessary to understand the role of the future engineer on the fire protection policy, to avoid possible fire occurrences in institutions. Therefore, the goal of this study is to analyze how and how often the fire protection approach is included in the curriculum of engineering courses. To achieve it, a systematic review in the Google Academic, Scielo and Eric databases was carried out in a quantitative analysis. Secondly, in a qualitative analysis, a case study was carried out, starting with an investigation of the curriculum of nine engineering courses at a Brazilian university, to verify the consistency of the fire protection approach and compliance with the "*Kiss* Law" in the courses studied.

Keywords: fire safety. kisslaw. engineering courses. curricular structures.

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The Approach to Fire Safety in the Curriculum Map-Matrix of Engineering Courses at a Federal University According to the Parameters of Law 13.425: A Systematic Review

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Abstract- Fire protection has gained the spotlight, in large part, as a result of some disasters that have occurred in recent years. The subject has evolved and gained considerable prominence, thus requiring changes in current legislation, as well as the formulation of new Standards and Laws, capable of mitigating the risk of fire occurrence. It is necessary to understand the role of the future engineer on the fire protection policy, to avoid possible fire occurrences in institutions. Therefore, the goal of this study is to analyze how and how often the fire protection approach is included in the curriculum of engineering courses. To achieve it, a systematic review in the Google Academic, Scielo and Eric databases was carried out in a quantitative analysis. Secondly, in a qualitative analysis, a case study was carried out, starting with an investigation of the curriculum of nine engineering courses at a Brazilian university, to verify the consistency of the fire protection approach and compliance with the *"Kiss* Law" in the courses studied. The results indicate a certain insufficiency of disciplines when analyzing the curricular matrices of each course. In most cases, the adoption of contents or disciplines that address the topic present fire protection generically and inconsistently. It is concluded that there is still a lack of knowledge about the relevance of the topic and effective non-compliance with legislation on the subject. There is, therefore, a need for implementation measures in the learning topics of engineering curricula.

Keywords: fire safety. kisslaw. engineering courses. curricular structures.

I. Introduction

The history of tragic accidents involving fires leaves irreparable marks on the people involved (Pereira, 2007). According to the author (2007), large fires can be linked to causes such as failures during the execution of the initial combat, or when there is an absence of public policies in the management of prevention and control of fires in buildings. According to Braga (2018), before the events with fire occurred in São Paulo in the 70s, the current regulation related to the subject of Fire Safety (SCI) in Brazil was little addressed, and the scarce mentions to it were only present in the building codes of some municipalities. The occurrence of these tragedies brought about a change in SCI requirements in Brazil.

Virginio (2013) states that there is an intense debate on the application of new laws, standards and technologies. The difficulty grows from the perspective of legally qualified professionals (engineers and architects), who, in some cases, are responsible for preparing fire-fighting projects that comply with current legal and technical requirements.

The general purpose of fire safety is to reduce the property damage risk, while its main objective is to be applied to the safety of people. According to Virginio (2013), in Brazil, the fire safety theme has evolved and gained considerable prominence, going through a continuous improvement of the current legislation, which brought the themes of quality and safety to it. According to Lazaroto (2004), people's attitudes when faced with emergency situations, whether individual or collective, are often desperate and irrational, so they need to have prior knowledge on how to operate firefighting equipment, for it to have some practical effect on their actions.

Higher Education Universities have a social fundamental role not only in the training of human, but also with the education, being agents capable of acting in the process of creating and propagating new knowledge, teaching new technologies, through basic research and applied research. Every year, universities and undergraduate institutions train dozens of new engineers for the job market, who are responsible for developing projects and applying new technologies.

For Franco (2019), the issue of Fire Safety (SCI) is approached in some countries as a science, becoming an area with a fundamental role in research,

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development, and teaching. The demand for professionals working in the SCI area is growing among engineers, researchers, and technicians, but there is still a lack of manpower in the market. Brentano (2015) and Seito et al (2008) attest that the greatest difficulty presented by professionals in the elaboration of projects comes from the deficiency during their training in higher education institutions. Braga (2020) states that as the teaching of Fire Safety is still deficient in the training of qualified professionals, the sanctioned Law 13,425 define that engineering and architecture courses in Brazil would have to address themes related to SCI in their curricula.

The loss of human life and material (economic) damages involved in fires enabled the development of research and investigations in the areas of engineering, as well as in firefighting safety in recent decades. Law No. 13,425, enacted on March 30, 2017, became known as the "*Kiss Law*", in reference to the fire at the *"Kiss"* nightclub, which took place in the city of Santa Maria (RS), where 242 people died in January 2013. The referred Law aims to tighten the rules on safety, prevention and protection against fire.

Negrisolo (2011) states that 88% of engineers and architects, in their graduation courses, had not learned anything or only had basic notions about fire safety, its objectives and regulations. According to the "*Kiss Law*", engineers from any segment must know what is necessary when it comes to fire protection, jointly applying their scientific methods on research and on engineering practices to safeguard life, and to protect movable and immovable property against fire. The present work seeks to analyze the fire safety approach in the curricular structures of engineering courses at a Federal University in Minas Gerais countryside, using the provisions of article 8 of Law 13.425/2017, also known as the "*Kiss Law"*, as parameters.

The main goal of this study is to check how the subjects present in the curricular structures of all engineering courses at a Federal University address the theme of "fire safety", and how they provide technical qualification to the professionals graduated in these engineering courses, enabling them to design projects and to adopt measures aimed at protection against fire, according to the parameters set out in art. 8°, established in the "*Kiss Law*". From this point on, the study will verify the presence of disciplines related to the technical and legal aspects of fire safety that meet the specification of article 8 of Law 13,425/2017; and will analyze the existing failures on fire safety in the elaboration of the curriculum structures of the engineering courses of our study subject and evaluate if the content of the "*Kiss Law*" meets the educational demands.

II. Major Accidents Involving Fire in Brazil

For Mentz (2017), the 70s and 80s were a milestone for the change in the paradigms of perception about fire prevention, resulting from tragic facts related to large fires that occurred in Brazil, such as those in the Andraus buildings in 1972, due to an overload in the internal electricity system in São Paulo (16 dead); and Joelma, in 1974, due to a short circuit in an air conditioning unit on the 12th floor, also in São Paulo (188 dead and more than 300 injured). All these events had great repercussions and an inestimable loss of life, not only for their victims, but also for all the people whose lives were directly affected by these fires, in the form of behavioral changes and psychological trauma.

According to Lima Neto (2020), failure to comply with fire safety standards causes serious and irreversible inconveniences. Another remarkable event was the tragedy of the Gran Circus Norte-Americano, in 1961, when a former employee acted criminally by setting fire to the canvas of the circus in Niterói, killing 503 people.

Lima Neto (2020) also states that, although the vast majority of fires occurred decades ago, it is noteworthy that, at the time, some resources could have been used to increase fire safety, such as fire doors, among other simple measures of fire prevention. Even without today's technological advancements in fire safety, these simple measures were still quite effective and could prevent loss of lives and property damage in the event of accidents. According to Carlo (2008), a large number of countries have learned from the great fires, and Brazil was no different. These tragedies caused changes in legislation, motivated the creation of fire brigades and the investment in fire safety research institutes and, above all, it started the practice of training technicians and researchers concerned with the area of fire and panic safety.

III. The *"Kiss"* A Nightclub Disaster and its Socio-Economic Impacts

One of the greatest fire accidents of Brazil's history happened in 2013, at *"Kiss",* a nightclub in the city of Santa Maria, Rio Grande do Sul. The incident marked Brazilian history and is considered the biggest fire in the last 50 years, causing 242 deaths and 680 injuries, most of them young students from the town's university (Previdelli, 2013).

According to Palma (2016), there were several design errors and failures in the adequacy of fire-fighting equipment that contributed to the intensity of this fire accident. Luiz (2015) states that, according to the Report carried out by the Regional Council of Engineering and Agronomy (CREA-RS), the conflagration was caused by a succession of primary

errors. One of the failures that culminated in the incident were found in the preventive fire-fighting systems, such as: problems with fire extinguishers; sirens; fire alerts and emergency lighting that did not work, and other specifications that were inadequate, such as the size of the emergency exit, the acoustic lining without the anti-flame treatment and poor signalization.

Another factor observed, according to Rebello and Cavalheiro (2013), was the maximum capacity of the site. According to the Fire Prevention and Protection permit, the place could accommodate only 691 people. However, on the day of the accident, the Military Police found that there were more than 1000 people inside. Thus, such failures, combined with the divergences of an effective Fire Fighting and Panic Safety Project (PSCIP) were fundamental to cause this fire accident.

Orlandini (2018) provides, as a justification in his research, that failures such as those that occurred in the "Kiss" Nightclub fire prevention have many origins: the lack of knowledge and negligence of the organizations' owners regarding the current norms of Protection against Fire and Panic; the lack of expertise in PSCIP and the limited qualification of many graduated professionals of this field of knowledge. Shortly after the tragedy at the *"Kiss"* Nightclub, there was a large national mobilization, boosting the support for the bill that has been in the National Congress since 2007. According to Almeida (2017), this bill culminated in the approval of the Law No. 13,425, also known as the "*Kiss Law*", which was edited on 30th of March 2017. This law establishes the general guidelines on measures to prevent and combat fire accidents in establishments, buildings and public gathering areas.

IV. Legislation Applied to Fire Safety: Legal Speech in Favor of Safety

There is an interdependence between the major accidents involving fires in the 70s and the emergence of laws and their regulations, technical-scientific forums, changes in procedures (Rodrigues, 2016). According to Braga (2018), after the fire in the Joelma Building, the first concrete measure regarding Fire Safety was incorporated, instituting special rules for the safety of buildings, into the Building Code of the Municipality of São Paulo (Law No. 8,266, of 1975).

According to Xavier (2018), laws are commonly developed by the State to establish and centralize the rules that must be followed, thus creating a structure and giving the maximum power to the Federal Constitution. Braga (2018) explains that, after the implementation of Law No. 8,266/75, each Brazilian state defined its own SCI standard, based on the Brazilian Standards (NBR) and Regulatory Standards (NR).

Some municipal and state agencies are responsible for drafting laws and regulations on the subject of "fire safety". According to Brentano (2015), the only federal fire safety regulation would be Regulatory Norm 23, but this law still shows a generic background in terms of fire safety for the work activity. Xavier (2018) says in his study that the NBR's aim is to foster the improvement of information, the establishment of rules, and the implementation of effective guidelines with the main objective of maintaining a standard of quality and efficiency.

> None of the articles of the Federal Constitution that deal with the competences of federative entities specifically deals with fire safety, unless we take this matter to civil defense matters (private competence of the Union, in accordance with item XXVIII of art. 22), for the protection of the environment (common competence of the Union, States, Federal District and Municipalities, in accordance with item VI of art. 23, is concurrent competence of the Union, States and Federal District, in accordance with the item VI of art. 24) and the urban planning law (concurrent jurisdiction of the Union, States and Federal District, in accordance with item I of art. 24).

Negrisolo (2011) also states that the regulation on this subject is still insufficient, relying only on the Work Codes of each municipality and their Fire Departments, which had their regulation coming from the security field, presenting fire control measures, a concern in hydrants and fire extinguishers, in addition to the signaling of these kinds of equipment. According to Brentano (2015), the existence of this legislative variety ends up demanding a greater effort of compliance from the professionals and from inspection organizations, as these requirements change in each state. This whole panorama also ends up forcing professionals in the field to be constantly studying and learning, and to be always attentive to new developments (Xavier, 2018) in the legislation.

Law 13.425/17 leaves it to the Municipal Government to establish specific rules and to the Military Fire Department, the most executive part, according to Articles 2 and 3 of Law No. 13.425 (Brasil, 2017). A very important point in the development of this law is the implementation of article 8 and its sole paragraph, relating to the training of engineering and architecture professionals, which includes:

> Art. 8 Undergraduate courses in Engineering and Architecture in operation in the country, in universities and public and private education organizations, as well as related technology and secondary education courses, must include content related to the prevention and fight against fire and disaster in their curricula.

> Single paragraph. Those responsible for the courses referred to in the caput of this article will have a period of six months, counted from the entry into force of this law, to promote the necessary complements in the content of the subjects taught, in order to comply with the provisions of the caput of this article (Brasil, 2017).

For Braga (2020), the creation of this law highlights the importance of learning the SCI theme in Engineering and Architecture courses in Brazil. This helped to mitigate the negligence of Educational Institutions in the egress of professionals unprepared for the labor market, even with the existence of ABNT technical standards and specific state and municipal regulations for the SCI. Lima Neto (2020) believes that the measures included in the Law 13.425/17, in its art. 8th, will bring advances to professionals working in the area, thus providing a good evolution and improvement in the subject of fire protection. However, Lima Neto (2020) emphasizes that it would still be essential for this law to have its own regulation for an effective implementation to be carried out. Silva (2019) addresses another opinion regarding that applied by Law 13,425/17, highlighting the fact that, as it was restricted to public meeting establishments, it did not encompass other economic activities that are also subject to risks.

Xavier (2018) exposes the existence of this variety of standards and points out that, while some laws provide more detailed and current content, others still have an old and vague approach to fire safety content, leaving gaps for interpretation which culminates in errors and, consequently, greater risks. As for Silva (2018), the fact addressed in the issue exposed by art. 8 of Law 13,425/17, on mandatory education on fire and disaster prevention, is still ignored.

V. Curriculum Map-Matrix in Engineering Courses

According to Brasil (2020), all content determined to be part of the training of an engineer and knowledge of the curricular structure - the so-called curriculum matrix or curriculum map-matrix - follow a pattern and formative logic to present their themes. Brasil (2020) also argues that, in order to carry out the creation of the curriculum map-matrix, the organization of contents can either meet regulatory documents, such as curriculum guidelines, or be defined based on the understanding of a group responsible for developing the curriculum map-matrix. All these contents must always be focused on the student's egress profile.

When it comes to the profile of graduates of undergraduate courses in engineering, it is necessary to understand some of its main characteristics. According to Brasil (2019), engineers must be critical, creative and capable of doing research, of developing new technologies, and of adopting transdisciplinary perspectives in their professional practice. For Brasil (2020), when defining the profile of the graduate, he/she must present consistency in all aspects and be aligned with the National Curriculum Guidelines for the Undergraduate Course in Engineering (DCNs of Engineering).

With the establishment of article 53, paragraph II of Law No. 9,394, it was determined that the guidelines and bases of national education, together with the autonomy of universities, would define the fixed attributions to be implemented in the curricula of their courses and programs (Brasil, 1996).

Brasil (2020) states that the DCNs have the role of guiding the courses in the development of their students' competences, which have as a guiding axis the elaboration of the text of the Pedagogical Project of the Course (PPC). According to Brasil (2019), the PPC is responsible for presenting strategies and intends, based on the reality in which the course is inserted, and in view of the profile of the incoming student, to analyze the egress profile, and the description of the skills that must be developed, from general or specific characteristics, considering the qualification of the course and the professional market.

Brasil (2019) brings in its 6th article, that undergraduate courses in engineering "must have a PPC that covers the set of learning activities and ensures the development of competences". Brasil (2020) considers the PPC as a guiding document for the development of the course and its structure must be followed by a transparent, broad standard, which matches reality and with quality, guiding actions related to student education. According to Brasil (2019), the document must also present the instruments and actions necessary for the training of the engineer, which, in addition to a solid technical training, should also include a generalist, humanist, critical, creative and reflective training.

According to Brasil (2020), all the actions that are contained in the PPC also serve to motivate and engage students in their training process, in line with the skills expected for the labor market. The initial formulation and periodic review of this project are the responsibility of the Structuring Teaching Nucleus (NDE) made up of professors, masters and doctors, with experience in the fields of knowledge of the course. Normally, any changes regarding the curriculum of the undergraduate courses of the university under study are periodically evaluated and structured by the NDE, meeting the institution's demands and the MEC's determinations.

Medeiros (2020) points out that, in the texts of the DCNs of the architecture courses (Resolution CNE/CES No. 2/2010) and engineering (Resolution CNE/CES 2/2019), the mandatory content for fire safety

is not explicit. In this regard, it is observed that there is a need for reformulation in response to reality and the national legislative demand. Perrenoud (1990) recalls that curricula in higher education must first define the skills needed for professional training, in order to later outline the contents. In this sense, the curriculum is, therefore, a continuous construction and an ordering of competences, which must be guided by the demands of the current market.

The curriculum is the essential component to understand how pedagogical practices work. In general, these practices are governed or guided by the curriculum. Therefore, the curricula of engineering courses should follow the changes, molding their competences according to the established parameters. For this, the assessment of the approach to the content must be continuous, allowing for more frequent updates. In this aspect, the author draws attention to a competency-based curriculum. Normally, competency-based curricula are more open to the possibility of changing traditional methods, allowing for greater reformulation of teaching methodologies (SOUZA; VARELLA and BRANCO, 2015). Thus, once fire protection or safety is established as a necessity, curricula can insert it as one of the essential skills for the future engineer.

VI. Teaching Fire Safety in Engineering Courses

According to Silva and Cecílio (2007), perhaps more than in other times, engineering education must conform to the needs that the market has in seeking professionals with the capacity to perform activities inherent to different development sectors. According to Crivelli (1998), a large part of the changes that take place in the curriculum structures of engineering courses in Brazil is derived from a concern of the Federal Government in promoting technical training to meet the demands of industry and the market, also aiming to integrate the professionals with the international scenario. Domitiano (2017) points out that fire prevention is a matter of paramount importance, being referred to as a set of procedures that must be respected, in order to prevent dangerous situations from getting out of control. Observing the aspect of professional qualification, Silva (2014) says that higher education institutions have a substantial role in the education and training of engineers, who will be the professionals responsible for implementing actions and fire prevention systems, and that these help to prevent accidents and conflagrations in buildings, or if these accidents happen, they would guarantee the safety of their occupants. According to Seito et al (2008), fire safety is considered a science, which requires investments in research, teaching and new technologies. Franco (2019) emphasizes that this field has a very broad labor market and growth possibilities, since the demands for preventive safety measures on the part of organizations has been increasing. Reis (2019) states that engineering professionals must have a good fire safety education, and that the SCI market is very promising.

For Santos (2018), a correct guidance is needed to implement the teaching of Fire Safety in the curriculum, as Brazilian universities keep delivering to the job market professionals who are not yet prepared when it comes to fire protection, who are not attentive to the fire safety legislation and who do not pay attention to what is demanded in inspections and regulations. Rodrigues (2016) states that the association of technical-scientific evolution with legal instruments is essential, since a minimum knowledge of regulations, a good understanding of the development, structuring and interpretation of laws is essential for professionals working in the Fire Safety area.

Rodrigues (2016) says that the development of Fire Safety education and the filling of existing regulatory gaps can only be done if combined with three factors, which are: the professional education, formalized through teaching and improvement actions of skills; the effective and clear structuring of regulations and the investigation and improvement in the field of research, which will provide a continuous advance in the knowledge of the management system in SCI.

Due to the responsibilities assigned to engineering professionals, Jesus (2017) addresses how important it is to have a good understanding of the risks to which your team is exposed, and to have adequate knowledge of how to efficiently prevent fire and raise awareness to fire safety. Medeiros (2020) states that students put into practice what they learn, with preliminary information. Negrisolo (2011), in his thesis concluded that 17.8% of the universities still do not include the fire safety theme in their curricular matrices, and, in the ones that include it in their curricula, fire safety is not developed in an effective or solid way. Negrisolo (2011) points out that there is also no consolidated workload or a completely accepted analogous bibliography, and the theme is not a consecrated focus.

When the engineer gets his degree, according to Silva (2018), from him to learn about the SCI field, it is necessary to seek this knowledge as a complement, by a subsequent education, training or updating. Furthermore, the legislation does not require the architect or engineer to have this additional training to carry out the projects, monitor the building constructions, and to develop the application of technologies and action plans that are within their area of competence.

Ongaratto (2017) points out that the subject, when taught in courses, has insufficient study hours for the complexity that the fire safety theme presents. Xavier

(2018) says that most universities in the country still do not effectively address the topic of fire safety in their curriculum, which ends up leaving a gap in the professional's knowledge when they complete their graduation, making it necessary to seek this training in other places and in other circumstances. For Ongaratto (2017), the professional, upon completing his training, ends up having to seek professional courses and specializations on the subject. He must always be aware of new laws, decrees, standards, which are constantly being updated.

According to Silva (2018), when it comes to teaching fire safety, each educational institution was tasked with introducing in its curriculum subjects on safety, prevention and protection against fire. However, reality shows the, up to now, the teaching of the content in undergraduate courses in engineering and architecture, when it exists, is presented in an insufficient way.

VII. Methodology

The study focuses on the systematic literature review method, whose methodological principle is the synthesis of scientific literature focused on a scientific issue, in an attempt to identify, select, evaluate and synthesize the evidence of high-quality research relevant to the issue. (Bettany-Saltikov, 2012). The high quality of the research, according to the author, is related to the explicit methodological rigor that allows for an effective understanding of the research conclusions. Systematic reviews differ from narratives in that they adopt a more rigorous method, a transparent scientific process in order to minimize bias through exhaustive research in the literature, providing an audit trail of the reviewers' decisions, procedures and conclusions (Cook, Mulrow and Haynes, 1997). Furthermore, systematic reviews play an important role in evidence-based practices[1].

For this study, the following steps were followed, based on a systematic review of the literature: (i) choice of theme and elaboration of the research question; (ii) establishment of inclusion and exclusion criteria for studies; (iii) categorization of selected studies; (iv) analysis and interpretation of results; (v) presentation of the review and synthesis of knowledge. The guiding question presented at the end of the introduction was elaborated from the PI(E)CO strategy, for framing the research, whose letters indicate: Problem or Population, Intervention, Indication of interest or exposure, Comparison/Standard procedure and Outcomes/expected results.

The PI(E)CO strategy calls for a complete search on research platforms, directing the question to obtain keywords that point to answers (Santos; Pimenta; Nobre, 2007). In this context, it was adopted as PI(E)CO: Population/Problem > the lack of parameterization of engineering courses regarding the implementation of a curriculum that addresses and contemplates the requirements of the "*Kiss Law*" in the courses of future engineers; Intervention > exposure to a curriculum that does not meet the requirements of a fire safety or protection approach, and the need for NDE intervention to enforce regulatory requirements; Comparison/Standard Procedure > establish a comparison between the curricula of engineering courses and check the procedures of each course regarding the approach to fire protection; Outcome/expected results > it is expected to infer not only the importance of implementing fire protection in engineering curricula, but also to identify the possibilities of compliance with the "*Kiss Law*" in the school environment, studying and pointing out measures for the application of educational content aimed at this end.

Therefore, the guiding question of this one focuses on: how and how often is the fire protection approach inserted in the curriculum in engineering courses? In a second moment, the relevance of the theme "protection or safety against fire" for engineering curricula was discussed.

The next step refers to data crossing. For that, an extraction of data from the researchers was carried out, in order to minimize their relevant information about the topic in focus. The selected research, therefore, answered the guiding question, made available in full and published in the period from 2016 to 2021 (the last 5 years). The selection of this period is due to the fact that the "*Kiss Law*", which guides the entire study, dates from 2017, which justifies the lack of literature on legislation prior to that date. All studies of the bibliographic research were selected, from an analysis of the topics, containing as search key terms on the research theme, whether in the title, abstract or keywords. The search keys and logical Booleans adopted were: fire protection [MesSH Terms] OR fire safety AND curriculum AND engineering. In Portuguese: ("fire protection" OR "fire safety" AND "curricular matrix" OR "curriculum" AND "engineer" OR "engineering"). At first, the search was carried out in English. However, in a second moment, the refinement in Portuguese was chosen due to the fact that the research discusses the curricular matrices of Brazilian undergraduate courses in engineering and Law 13,425/17 is also national.

The following databases were selected for consultation: Google Academic; ERIC; Scielo. These databases were chosen due to the scope and dimension of the databases indicated, as in the case of Google Academic and Scielo, as well as the affinity of studies, as in the case of ERIC, which normally publishes studies focused on the area of Education. Scielo was selected because it is a database that brings

[1] Methodology for clinical practice disseminated among health professionals. It consists of the use of scientific evidence, produced by studies developed with methodological rigor

together many essays from Latin America, which could include essays in the Portuguese language.

The consultation sample was determined based on the following inclusion criteria, which comprised the cluster of this study: i) scientific studies with a publication date between 2016 and 2021; ii) scientific studies published in peer-blind or double-blind journals; iii) empirical and descriptive studies; iv) the language used for selection was Portuguese, since it is a Brazilian law and the study refers to the curriculum of engineering courses nationwide; v) original research and review studies were included, whose theme answered the guiding question; vi) studies that contain in the title, abstract or keywords the search terms according to the logical Booleans adopted. As for the exclusion criteria: i) studies without specific methodology were excluded; ii) other studies that did not include articles from journals with blind review were excluded; iii) studies published in other languages were excluded; iv) studies that did not focus on the main theme and its connection to an educational approach were excluded. For the selection of studies on the "*Kiss Law*" to cover the review on this theme, in the introductory chapters, the term "*Kiss Law"* was added to the previous search key. Subsequently, duplicate articles were excluded.

The inclusion and exclusion criteria, in this case, was the approach of the "*Kiss Law*" with other areas, prioritizing, in this case, the correlation with the educational area. A systematic review attempted to gather all relevant evidence that fits pre-specified eligibility criteria to answer a specific research question. For data collection and presentation, the PRISMA protocol or recommendation was used, which according to Moher (2015) has the main objective of helping authors to improve the reporting of their systematic reviews and can also be used as a basis for reporting reviews of systematic results of other types of research. The PRISMA-P aims to guide the development of protocols for systematic reviews and meta-analyses.

The PRISMA recommendation consists of a 27-item checklist to be included in the systematic review or meta-analysis report) and a four-step flowchart (Figure 1 - Prisma flowchart). The aim of PRISMA is to help authors improve reporting in systematic reviews and meta-analyse.

In a second moment, a documented case study was carried out, selecting a university that had several engineering courses, to observe how fire protection or safety was being addressed in the curriculum of each course, as well as the frequency that this content was included in the curriculum.

According to Yin (2010), the case study refers to a type of empirical investigation that addresses a contemporary phenomenon within a real-life context. The case study method seeks to understand a phenomenon from its in-depth exploration (Costa et al. 2013). Our purpose was to establish whether the topic "Fire Protection or Safety" is taught during the graduation of an Engineer at a Higher Education University, as established by article 8 of Law 13.425/2017, known as the "*Kiss Law*". The Pedagogical Course Project (PPC) of each undergraduate degree in engineering at the institution selected for study was analyzed, based on the curricular structure on the topic of fire safety, and the inclusion or removal of mandatory or optional components in the curriculum. For ethical reasons, the name of the institution was not disclosed.

The information collected through the analysis of the curricular structures referred to the 2015 update of a total of nine undergraduate courses in engineering, all with five years of completion and minimum workload required by the MEC. An analysis of the curricular components in the basic, specific and professional nuclei was carried out, in order to verify if their curricular structures present the competences of the subjects that address the subject fire safety in a mandatory, elective or optional manner, or at least related topics to the subject of Safety for engineering undergraduate courses. Thus, the exploratory character of this study is due to the fact that there is little systematic research focused on the topic. These surveys on fire safety knowledge assessment have been developed with some professional categories in the field of architecture. Thus, we did not find studies that have been carried out with engineering professionals, and even if their graduation courses met the specifications contained in art. 8, of Law No. 13.425/2017 - the "*Kiss Law*".

VIII. Results and Discussions

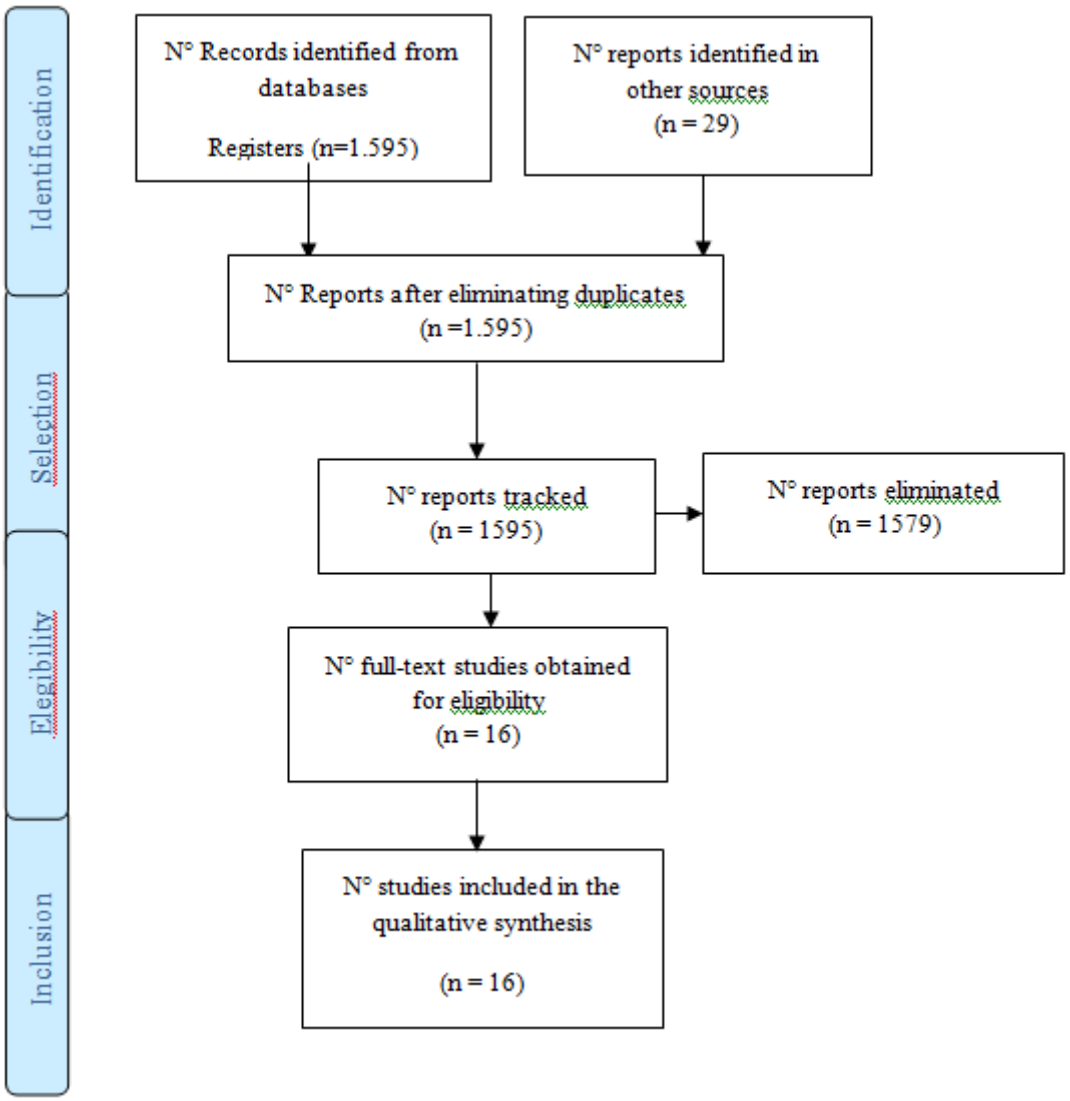
Two results were achieved in this work: the first consisted of a survey of references addressing the topic of Fire Safety, presenting the main causes for disasters involving fire, the accident that occurred at *"Kiss"* Nightclub and its role in the creation of Law 13.425/17, focusing on its article 8, as the development of legislation regarding Fire Protection and the application of the Fire Safety theme in the curricula and teaching of undergraduate courses in Engineering occurred.

The second consists of verifying the fire safety approach in the curriculum of engineering courses at a Federal University, based on an analysis of the PPC's of each course, since, according to what is established by art. 8 of Law 13,425/17, Brazilian universities must include content related to fire safety in their curricula.

a) Systematic Literature Review and Selection of Studies

From the research that took place on the literature research platforms, a total of 1,595 studies were identified that guided the subject addressed in the guiding question. In the end, only 16 relevant studies on the subject were presented, which served as the basis for the creation of the framework. To meet the selection criteria of potential studies, it was necessary to remove

the duplicates. At this stage, no study was found that met the criteria for extraction, as shown in Figure 1 - Prism.



Source: Prisma Group (2015)

Figure 1: Prism Flowchart

As can be seen from Figure 1 - Prism Flowchart, the topic is still very scarce in studies. Even when filtering the searches for after the update of Law 13.425/17, it is noted that researchers still do not address and discuss the subject.

b) Characteristics of Selected Studies

According to Table 1 - Theoretical scientific material analyzed (2016-2021) below, the collection was carried out and organized according to the categorization of the selected studies. The objective was to identify, select and evaluate the studies indicated in the table, based on the presented relevance, while trying to establish a link with the guiding question, related to the Fire Safety approach and the insertion of the discipline in the curriculum map-matrix in engineering courses, according to what is demanded in art. 8 of the *"Kiss Law"*. Thus, it was possible to understand the speeches of the authors implicit in each excerpt.

Table 1: Scientific theoretical material analyzed (2016-2021)

N	Author/Year	Title
1	Lima Neto (2020)	Fire Safety in the Curriculum Matrix of the Electrical Engineering course
2	Franco (2019)	Fire and Panic in Brazil: A systematic study on the role of the Engineer in ensuring safety conditions and measures against fire
3	Jesus (2017)	Teaching Work Safety in Engineering Graduation Courses in Curitiba-PR
4	Pereira (2016)	Fire Safety: an interface between public and private interests under the reflections of teaching in skills training
5	Palma (2016)	The importance of PPCI for society: the perception of professionals, users of buildings and creator of the *"Kiss Law"*
6	Orlandini (2018)	Proposal for a verification tool that acts on the main causes of re-analysis of Fire and Panic Safety projects
7	Xavier (2018)	Development of a Spreadsheet for the preparation of Fire and Panic Prevention and Fighting projects based on the technical instructions of the São Paulo Military Fire Department
8	Reis (2016)	Fire Prevention and Protection Plan: case study of a multi-paved school building - Mechanical Engineering building
9	Rodrigues (2016)	Fire and Panic Safety Management System in Buildings: Rationale for National Regulation
10	Silva (2018)	Risk of fire in cultural heritage: the importance of preventive maintenance actions
11	Braga (2018)	Analysis tool of Fire Safety measures in architecture projects applied to the teaching of Architecture and Urbanism courses
12	Medeiros (2020)	A plan for teaching Fire Safety in the Faculties of Architecture and Urbanism
13	Ongaratto (2017)	Architectural Proselytism and Fire Prevention and Protection Plan
14	Braga (2020)	The teaching of Fire Safety in an Architecture course in Brazil
15	Domiciano (2017)	Verification of Fire Protection in Small Industry in the State of São Paulo
16	Vicente (2017)	Overview of Fire Safety in Buildings: Analysis of Reports in the Military Fire Department in Paraíba

Source: Author's data

The selection of the studies and the absorption of information contained in scientific productions were listed according to the units of interest. In compliance with the checklist of the Prisma protocol, all items on the list were checked, excluding those specific to meta-analysis studies. The risk of bias, systematic error in conducting the study, whether in recruitment, outcome assessment or data analysis, which could lead to incorrect results, was addressed. "The validity of a study is directly related to two dimensions, internal and external validity. The first concerns whether the study answers a research question properly, that is, free from bias" (Carvalho; Silva; Grande, 2013, p.38).

To minimize the risk of bias in data collection, multiple databases were tested and the studies fully verified to ensure that no relevant information was lost. Data extraction was performed independently by two reviewers. Differences were resolved by consensus. The risk of quality bias was considered while analyzing the selection process by titles and abstracts, as well as the evaluation of the full text reported. To minimize the risk of evaluation, the quality of the study was analyzed by the reviewers. A bias to be considered is that of selection regarding the choice of national studies. However, it is believed that it can be addressed in future research.

c) *Analysis of Curricular Matrices According to the Parameters of Art. 8th of the "Kiss Law"*

The deadline established for the implementation of the disciplines in the curricular structures of the undergraduate courses in engineering, as established by art. 8, of the "*Kiss Law*", was stipulated within a maximum of 6 months after the law came into force. However, most engineering education institutions try to give their own interpretation of the law without effectively making a change in the curriculum of said courses.

From the analysis carried out in the graduation PPC of each course, it was possible to ascertain the strategies and actions to be undertaken by students and teachers for the formation of an engineer, in accordance to the objectives proposed by the National Curriculum Guidelines, the Institutional Development Plan and the Institutional Pedagogical Project.

The proposal of modular formation of the curricular structures and the teaching methodologies used during the engineering courses at the University have a main objective of forming the egress profile according to the guidance of the National Curriculum Guidelines for the Undergraduate Course. In principle, the courses constantly update the PPC, according to the institution's demands. Therefore, there is a certain regularity between courses in terms of attendance. However, this approach to the contents of the curriculum matrix deserves further discussion. The base of the curricular components is divided into three training centers: Basic Nucleus, Vocational Nucleus and Specific Nucleus.

Table 2: General Composition of the Pedagogical Course Project

Course	Last update date	Training Centers
Materials Engineering	December 2017	Basic Core Vocational Center Specific Core
Health and Safety Engineering	May 2019	
Environmental Engineering	May 2018	
Control and Automation Engineering	Jully 2020	
Mechanical Engineering	December 2016	
Computer engineering	Octobre 2020	
Mobility Engineering	No date	
Electrical engineering	December 2020	
Production Engineering	November 2016	

Source: Author's data

As shown in Table 2 - General Composition of the Pedagogical Course Project, all courses point to the same division of training nuclei, with variations only with regard to the curricular components (type of activity, menu and minimum workload), this composition being specifically targeted at each course. All courses are organized into ten semesters, and, in nine semesters, the curricular structure is organized into mandatory and optional curricular components. Students must also carry out supervised internship, their graduation's final essay and complementary activities.

According to what was exposed in the column "date of last update" of the PPC of all undergraduate courses listed in Table 2, four courses, equivalent to 44% of the total courses, made some kind of change in the document after the date of the "*Kiss Law*", but only the Undergraduate Courses in Health and Safety Engineering and Environmental Engineering were in strict compliance with Article 8 on the subject of fire safety.

The analysis of the syllabus of all disciplines in the courses active at the University is presented and organized according to their disposition in the curricular structure. In the Environmental Engineering course, as provided for in the PPC, it was planned that Fire Safety would be taught together with the content of the Ecology, Water Management and Environmental Geotechnics disciplines, content related to the prevention and combat of fire and disasters, not specifying the workload for each topic.

However, it could be verified by the analysis of the curricular components, in the syllabus and up to the time of this research, that these have not yet been changed or implemented for the routine of the classrooms.

As for the Health and Safety Engineering course, the importance of analyzing preventive actions is notorious in relation to the topic of fire safety. The subject of Fire Safety is addressed in five curricular components, which are presented in Table 3 - Analysis of the curricular structure that addresses the theme of fire safety, specifying in detail the curricular component, the syllabus and its total workload.

Table 3: Analysis of the curriculum that addresses the topic of fire safety

Curricular component	Menu	Hours total
Security Engineering I	Security Engineering Objectives. Adverse events. Theory of the causes of accidents. Various risks. Technological accidents. Analysis of accidents and accidents without injuries. Accident Investigation and Reports. Regulatory rules of the MTE. Specialized Services in Safety Engineering and Occupational Medicine. Internal commission of accident prevention. Personal protective equipment. Occupational Health Medical Control Programs. Environmental Risk Prevention Program. Hazardous Activities and Operations. Work in the Construction Industry. Explosives. Flammable Liquids and Fuels. Outdoor work. Occupational health and safety in Mining. Fire Protection. Industrial Waste. Safety Signs. Inspection and Penalties. Safety and health in port and waterway work. Confined spaces. Safety and Health in health care establishments. Health and Safety in shipbuilding. Standards in public consultation.	64h
Fire Engineering I	Concept, importance and participation of work safety engineering in fire protection. Fire protection legislation and regulations. Study on fire, fire and combustion and their effects. Active protection – fire and explosion protection and fighting equipment. Passive protection – structural protection. Explosives – conceptualization, identification and control. Rescue techniques. Fire Brigades.	64h
Fire Engineering II	Practical activities involving concepts of Concepts for Fire Safety Projects. Passive Protection Elements. Active Protection Elements. Fire Risk Management. Extension projects.	64h
Fire Engineering II	Practical activities involving concepts of Concepts for Fire Safety Projects. Passive Protection Elements. Active Protection Elements. Fire Risk Management. Extension projects.	64h
Fire Engineering II	Practical activities involving concepts of Concepts for Fire Safety Projects. Passive Protection Elements. Active Protection Elements. Fire Risk Management. Extension projects.	64h
Risk Control Engineering Methods I	Removal and control of industrial contaminants; measurement, isolation, dilution and exhaustion strategies. Industrial ventilation. Risk control technologies: noise, vibration, heat, explosions, fire. Fire prevention and fighting.	64h
Risk Control Engineering Methods II	Methodology of environmental risk control engineering projects. Economic aspects in engineering projects. Development of engineering projects for risk control: noise, vibration, heat, explosion, fire, radiation and biological hazards.	64h

Source: Author's data

It is possible to observe that there are two subjects which their titles refer to the analyzed context, Fire Engineering I, which belongs to the 2015 curriculum structure presented in a mandatory manner and Fire Engineering II, which is usually approached as an optional course, but which was planned by the Structuring Teaching Nucleus (NDE) of the course with the objective of inclusion in the next update of the curricular structure, both with a workload of 64 hours focused on the topic of Fire Protection and Firefighting. The disciplines of Safety Engineering I, Risk Control Engineering Methods I and Risk Control Engineering Methods II are related to the theme of fire safety, addressing topics such as: fire protection, development of projects, fire risk control engineering, fire risk control technologies, with an average workload of 2 hours on each subject.

As for the approach to fire safety, regarding the syllabi of other courses, it was evident that there is no such discipline in their curricular structures, in the basic cores and/or specific cores, topics directed to the subject, as well as matters related to the theme, thus

signaling the need for curricular revision in view of the importance of this discipline in the training of these professionals.

IX. Final Considerations

Law 13,425 of March 30, 2017, known as the "*Kiss Law*", has been in force for more than four years. In addition to establishing stricter fire safety, prevention and protection standards in establishments, the "*Kiss Law*" proposes that the development of fire prevention projects must be done by professionals of this field.

In addition to these issues, our research also focused on art. 8, of the "*Kiss Law*", which made inspection more rigorous and determined that universities and/or organizations that have graduate courses in Engineering and Architecture, have disciplines with content related to prevention and combating fire and disaster.

According to this study, the theme "fire safety" is still not present in a systemic way in the curriculum structures of undergraduate courses in engineering at the analysed federal university. In this university, only one of the undergraduate courses offered has addressed the theme in its curricular components, researching and teaching about the subject. Among the curricular components and syllabus analyzed, fire safety is specifically expressed in a subject called Fire Engineering I, in an optional subject called Fire Engineering II, and in some topics in the syllabus of three subjects in the course of Health and Safety Engineering, where it is presented with an approach with a minimum workload of 128 hours, which was considered complete and engaged to the referred subject.

It is undeniable that there are few undergraduate courses in engineering that are concerned with researching and teaching about fire prevention. Therefore, untrained professionals are being delivered to the job market. However, the fire safety issue has evolved quickly and these new professionals need to cope with this reality, being attentive to legislation, inspections, having a vision profile and with the ability to develop new technologies throughout their professional life, acting as a builder and multiplier of knowledge, regardless of their specialization, being proactive and ethical in society and intervening in it with a sense of responsibility.

It is also important to emphasize the need to address this issue in the curriculum structures of the engineering courses at this Federal University, as not only the legitimacy brought by the law is being discussed, but also the amount of information and studies that have been produced in this area, as well as the surveys carried out. Therefore, there is a need for rapid changes to take place in the curriculum, so that fire safety is addressed with due importance in the courses and with the main focus on graduates of engineers trained to deal with their various possibilities of action.

The engineering profession has become more and more requested to update themselves and present themselves open to the incorporation of technical innovations and scientific research methods. Thus, as these changes are taking place, the engineering profession needs this training in its undergraduate courses. However, despite fire safety being a fundamental discipline, which has also been changing due to the new conceptions of work and technology, it is evident that essential particularities are still lacking for the effective realization of what was determined in art. 8, of the "*Kiss Law*".

It is important to highlight the fact that article 8, of the "*Kiss Law*", is presented in a generic way, containing flaws in the details, notably, in relation to what could be the established disciplines and the minimum contents adopted. Therefore, there is no understanding about the contents and the stipulation of a minimum total workload, and which professional is qualified to teach the content, thus resulting in dubious and imprecise interpretations.

Another fact is that the law 13,425/17 is silent with regard to the specific or optional character of the subjects that would integrate the curricular structure, according to the types of courses, since there are numerous specializations in engineering.

It was understood that Universities do not effectively change their curricular structures of undergraduate courses with the inclusion of any discipline that deals with the subject of fire safety, as they do not interpret the provision of the law that determines the obligation of the inclusion of disciplines with content related to fire disaster prevention and combat, together with the lack of knowledge on the subject.

In short, taking into account the analysis of art. 8, of the "*Kiss Law*" and the observations made in the curricular structures of the aforementioned courses, it was found that a legislative review is necessary to remedy the omissions in the aforementioned article, with regard to the mandatory inclusion of subjects in the curriculum. In addition to this fact, it was found that there is an insufficiency of content and of the teaching hours on Fire Safety in the undergraduate courses in engineering at the University studied, as 88% of the courses of this institution have not enabled their undergraduates for technical qualification on the subject and, consequently, do not train them to prepare of a fire-fighting project.

In view of the results obtained in this work, it was possible to establish some suggestions for future research. It is suggested a study involving the knowledge acquired by the students from different periods of undergraduate courses in engineering on the

topic of Fire Safety, and from its analysis and corresponding NDEs, to address the decision-making process on this subject in curriculum structures. Another suggestion would be the adoption of a minimum content, a minimum workload and the professional qualified to teach Fire Safety topics, based on methodological studies brought by the "*Kiss Law*".

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Semantic Web Model to Contact Music Bands in Bogotá, Colombia

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Abstract- This research shows the development of a semantic web model whose objective is to create a knowledge base of traditional groups and music genres of the city of Bogota, the method in which the information is transmitted to and from the knowledge base created is through the use of an API based on REST architecture, which uses the HTTP protocol, this information is presented in a web portal.

Visitors and users who visit the portal can carry out searches that are based on SPARQL, to contact music groups according to a series of filters such as: geographical location, music genre, market background, rates among others, this project becomes a digital alternative for musical groups in the city of Bogota to promote their services and provide a virtual channel of contact quickly and safely, this aims to improve the quality of life of members of musical bands.

Keywords: *semantic web, ontology, apache jena, SPARQL, ontological model.*

GJRE-J Classification: *DDC Code: 401.43 LCC Code: P325*

Strictly as per the compliance and regulations of:

Semantic Web Model to Contact Music Bands in Bogotá, Colombia

Juan Esteban Katz Delgado [α] & Ana Maria López Barrera [σ]

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I. Introduction

The Semantic Web's ability to organize information, ensuring more accurate searches by meaning and not by textual content, is one of the advantages of the Semantic Web. [1], this strength can be used to create a knowledge base of the traditional genres and groups of the city of Bogota from an Ontology, however, one of the biggest challenges in building it is the informal nature of this economic activity, since there is no website where the musical groups are registered, neither is there an official census by government entities of the groups, Although there are approximate data from 2006 [2] and 2012 [3] and a Colombian Popular and Artistic Movement (MOPAC) which attempted to bring together these artists, there are no exact information, considering that it is easy for a group of artists to create a new group just by inviting colleagues to be part of it, as it is also true that, as a result of discussions among their members, musical groups may disappear.

As a result of the informality previously described and that in the city of Bogotá, citizens frequently contact musical groups to celebrate special dates and events, it is in certain circumstances a complex task to contact them, given that most of these musical groups at the time of offering their services do so through traditional channels such as: business cards, advertising on billboards, posters in the streets, few have their own website, do not make efficient use of social networks and often have outdated contact information, these shortcomings were the ones that motivated the development of a semantic web model which creates a knowledge base on the genres and traditional musical groups in the city of Bogota, such information is displayed on a website, so that both users and musical groups can offer or take the service.

This paper is divided into the following parts: section 2 presents the theoretical framework where the main concepts of the research are presented, the methodology for the construction of the semantic model is presented in section 3, section 4 shows the results obtained, and finally, the conclusions of the research are shown in section 5.

II. Theoretical Framework

For the development of the Semantic Web model, it is relevant to show that it uses a set of protocols and components which make its implementation and use possible [4]. Figure 1 shows how these technologies work together, which is commonly called a Stack of protocols.

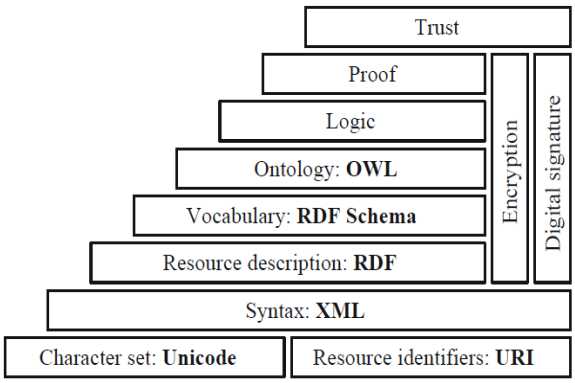

Fig. 1: Stack of Semantic Web protocols, taken from [4]

The main part in the construction of this model is the creation of the ontology, which is a fundamental piece in the construction of the Semantic Web, since it allows to add semantics to concepts of a knowledge domain and to create a hierarchy of concepts. Ontologies are defined as extensions of the RDF (Resource Description Framework) branch, but mainly the OWL language (Ontology Web Language) is used. [4], in turn an ontology has five types of components

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which are: classes, relations, formal axioms, instances and concepts. [5]

Several methodologies exist to design, develop and manage ontologies, some of the most widely used are SENSUS, which is a Top-Down approach to derive domain-specific ontologies from large ontologies; in this methodology, a set of seed terms that are relevant in a particular domain are identified. Such terms are manually linked to a broad coverage ontology, users automatically select the relevant terms to describe the domain and narrow down the ontology, this algorithm returns the set of hierarchically structured terms to describe a domain, which can be used as a skeleton for the knowledge base [6].

The ACO methodology, is a methodology for automatic ontology construction supported by natural language processing and machine learning techniques, which was inspired by existing manual methodologies for ontology construction. [6]

The Methontology methodology was developed by the Polytechnic University of Madrid and is one of the most complete ontology methodologies, because it has its roots in the activities identified by the software development process proposed by the IEEE [7]. it also allows creating new ontologies or reusing others.

Methontology is composed of activities for project planning, result quality, documentation, a life cycle based on evolved prototypes and the methodology itself, which specifies the steps to be executed in each activity, the techniques used, the results to be obtained and their form of evaluation, [8], this methodology proposes the following stages: specification, conceptualization, formalization, implementation and maintenance.

There are many other existing methodologies for the design and construction of Ontologies, however, in the present research it is decided to use Methontology given the large existing bibliographic material, in addition it has been recommended as a methodology for the construction of ontologies by the Foundation of Intelligent Physical Agents. [7]

III. Methodology

Figure two shows the activities used in the development of the ontology.

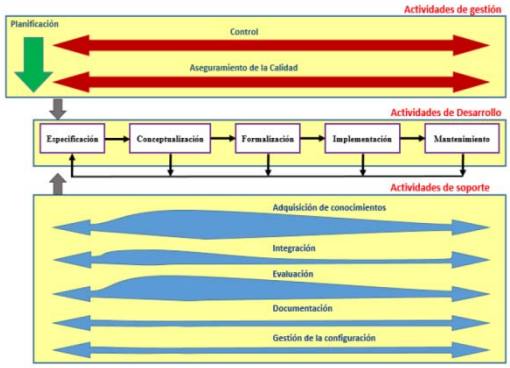


Fig. 1: Ontology development activities proposed by Methontology, taken from [7]

a) Specification

In This first activity aims to find out why the ontology is being built, what its use will be and who will be the end users. In response to these questions, we propose an ontology to create a knowledge base of the traditional musical genres of the city of Bogota, in order to present them on a Web portal, so that the members of these groups can offer their services and update their contact information constantly.

b) Conceptualization

This activity seeks to organize and build the informal perception of the domain in a semi-informal specification, for this purpose the methodology proposes a series of 11 tasks, in a non-sequential order [7], the present research shows the development of the most important tasks.

c) Formalization

This activity aims to transform the conceptual model previously developed to the formal model, to achieve this goal we used the ontology editor Protégé version 5. 2, this is an open source editor, it was developed by Stanford University, it provides the necessary tools for the development of ontologies on the web [10], the first step in the construction of the ontology was the creation of hierarchical classes, as shown in figure 5, For example, it is observed that mariachi is a subclass of a musical genre of Mexican origin, which is disjunct with its counterpart of norteña type and in turn with those of Colombian origin, this means that if a musical group belongs to the mariachi genre, it cannot belong to a vallenato group or any other.

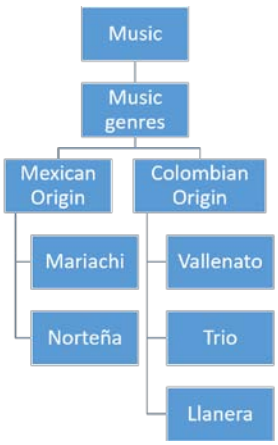
Task 1 and 4, Glossary and dictionary of terms, are built by the terms of interest of the present research, Table 1 shows the elements, concepts and essential attributes that are used as a basis for the construction of

the ontology and constitute the terms of interest of the domain.

Table 1: Glossary and dictionary of terms

Name	Description
Music	*Represents the concept and completion of the art.*
Musical genres	*It is the way in which the different kinds of music can be classified, according to their country of origins, instruments used, rhythm, melody or lyrics.*
Mariachi	*It is a Mexican musical genre, whose origin dates back to the XVII century, its main instruments are the trumpet, vihuela and guitarron.*
Norteña	*It is a Mexican musical genre, whose origin dates back to the 20th century, its main instruments are the bass and the accordion.*
Vallenato	*It is a Colombian musical genre; its main instrument is the accordion.*
Trio	*It is an unknown origin musical genre, its main instruments are the guitar and the voice, in the present investigation it will be assumed that it is originally from Colombia.*
Llanera	*It is a Colombian and Venezuelan musical genre, whose origin dates back to the 19th century, its main instruments are the harp and maracas.*

Task 2, Taxonomy of concepts, Figure 3 shows the hierarchy of concepts that was defined and created from the glossary of terms of the domain.



Source the author

Fig. 2: Taxonomy of concepts

Task 3, Diagram of binary relationships, Figure 4 shows the types of relationships that exist between the previously defined concepts.

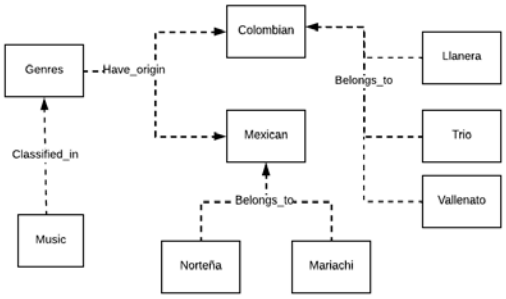


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Fig. 4: Diagram of binary relationships

Task 6, attributes of the instances, in Table 2 will describe how each of the instances of the ontology will be defined and what their predefined values will be.

Table 2: Attributes of instances

	Attribute	Value
Musical genre	Description Origin	String String
Musical group	Geographic zone Description Manager Price Contact number	Integer String String Integer String

Task 9, formal axioms, a musical genre has a unique origin, moreover this origin is unique, this is to simplify the model and make the relationships simpler.

d) Implementation

This activity aims to transform the conceptual model. This activity illustrates the final result of the formal model developed. Fig. 5, shows the summary of the Ontology developed thanks to the OntoGraf tool, which is included in the Protégé editor, version 5.2.

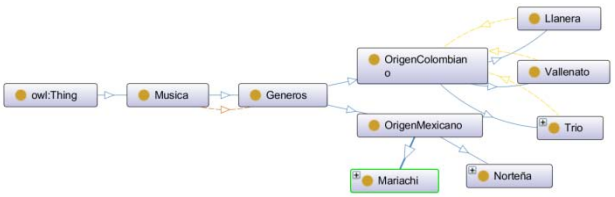

Fig. 5: Ontology Overview in OntoGraf

Once the ontology was developed, it was exported in OWL format, and deployed in the Apache Jena ontology server, which allows the entry of instances to the ontology created, the advantages of using this server is that it serves as an inference engine to reason about ontologies, provides compatibility of queries with different SPARQL specification and allows to persist the data in a relational base [9], this server will be responsible for storing the information of each musical group that is registered in the web portal, which will be known as a new instance, it stores information of

the group such as: genre to which it belongs, description of the band, contact number, price of the service, geographic location and a manager.

After creating the class hierarchy, the properties of the objects were created, which describe relationships between individuals, the next step was to describe the data properties, for fields such as price, contact number, description, manager and other data described in table 2.

Finally, we validated that the Ontology created does not contain syntax or logic errors, for which we used a tool that is included in the Protégé editor called Reasoner.

IV. Results

In order to allow the members of the different traditional musical groups of the city of Bogota to offer their services, a Web portal was developed, using the framework developed by Google Angular, version 6, a registration form was designed requesting a description of the musical group, genre to which it belongs, years of career in the market, contact number and name of the manager of the band, the geographic location is taken using GPS either from the Web browser or the cell phone.

When the grouping finishes the registration in the Web Portal, the form data is sent using the HTTP protocol in the PUT operation, this information is inserted in the ontology previously created that is in the Apache Jena server, each band that is registered in the portal is a new instance in the ontology, this information is stored, in the same way when a user wants to perform a search a GET request is made which is processed by the server who performs a SPARQL query that returns the data which is displayed in the Web portal, Fig 6, shows the architecture of the server which is always listening to requests via HTTP and depending on the operation a SPARQL CRUD is performed.

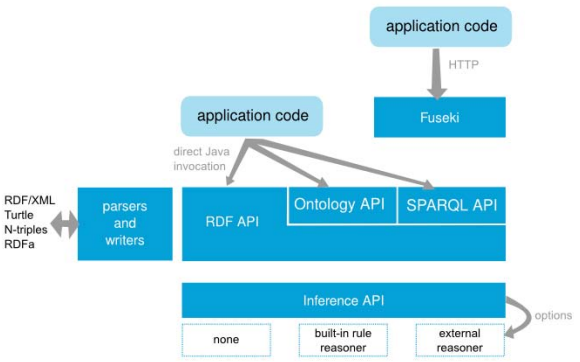

Fig. 6: Server architecture from [9]

When a user wants to search for a group according to the musical genre, a tab was created in the Web Portal called search in which the different genres are shown and the user clicking on any of these genres makes a GET type request to the server with the parameter of the musical genre as shown in Fig 7, the server makes a SPARQL type SELECT to all the instances present in the Ontology and this returns the result of the query, this information is shown in the view and the user can contact the musical group.

Fig. 7: SPARQL query result

V. Conclusion

The use of an ontology instead of a traditional relational database allows the creation of inference rules in the portal, since the creation of concept relations and a hierarchy of classes generates explicit knowledge that can be processed by computers.

When using Protégé as a tool in the construction of the Ontology and apache Jena as a server, it is recommended to use Java technology to insert, update and read data since they are written in this language and could generate compatibility errors or make the software development even more complex.

The use of the ontology allows enriching and adding metadata which adds information that is presented in the portal, allows the information to be extensible, in the future new musical genres can be added, to enrich the information shown in the Web Portal.

The ontology created contains the existing relationships between the groups and the musical genres to which they belong; therefore, a musical group cannot belong to two different musical genres and each musical genre can only belong to one origin, thus simplifying the ontological model, although a musical genre may have one or several shared origins.

It is planned to develop a version of the portal in a productive environment so that it can be used by more users and musical groups in the city of Bogotá, since in the present research a functional prototype was developed in a local server.

The present research intends to use technology at the service of the population to improve their quality of life and thus make digital contact allows them to attract, capture and retain new customers.

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Identification of Tectonic Weak Zones of the Earth's Crust According to Remote Sensing Data

By Eysfeld Olga A.

Introduction- Satellite imagery data and divorce methods of their processing and interpretation are used in geological, environmental and hydrological studies, monitoring of land use, urban planning and building. Remote sensing data in geology, along with geochemical and geophysical investigations, are used in conducting precursory investigation geological work, which makes it possible to assess the prospects of the territory for more detailed geological exploration. According to the results of processing and interpretation of remote sensing data, are determined metamorphism zones and hydrothermal changes, the material composition and landscape features of the territory, and also tectonic disturbances (dislocations, faultings).

Estimating the degree of tectonic disturbances, or tectonic fragmentation, is of importance in different fields of research and planing. For example, in of tectonic fragmentation zones of rocks, their permeability for liquid and volatile substances (groundwater, oil and gas deposits, etc.) increases. By searching for commercial minerals, zones of tectonic fragmentation, represented by ore nodes at the intersection of ore-bearing and ore-controlling faults (lineaments), characterize the concentration places of commercial minerals.

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Current multispectral and radar space images after their preprocessing allow searching for lineaments (linear textures) and annular structures, which are used to determine disjunctive or plicative dislocations of tectonic faults and related geological patterns. Researching of tectonic dislocations of the Earth's crust according to the remote sensing data are based on the analysis of lineament tectonics [1], that is linear or annular geological objects mapped from a satellite image and reflecting tectonic disturbances at plan. At regional and local scales of research, the most informative for solving this problem spectral bands of images of such satellite systems as Landsat, Sentinel-2, ASTER, SRTM are used. MODIS data can be used to highlight global tectonic fractures. Linear objects in geological researching can reflect fractures, dislocations or tectonic disturbances of rocks in plan, their stratigraphic unconformities, boundaries of soil and material compositions. Annular structures, when displayed in plain view, designate folded zones, troughs, or uplifts, as well as ancient and modern volcanic cones.

Use of *spectral imagery data* is due to a significant difference in the brightness reflective characteristics in the spectral ranges. This difference makes it possible to more accurately determine the presence of a lineament, provided that lineament (after preprocessing of image spectral bands with convolution filters) is present in each spectral range (Fig. 1).

Use of a *digital elevation model (DEM)* according to SRTM data is due to the morphostructural and geomorphological features manifested in the relief. For visual interpretation of DEM, the most informative and detailed is the use of the Hillshade function (intensification of shadow effects), in azimuths 0^0; 45^0; 90^0; 135^0; 180^0; 225^0; 270^0; 315^0. Each range of the azimuth when processing the DEM by Hillshade function shows the edge between uplifts and subsidence (overthrusts, slides, thrust-fault and etc.), expressed in the terrain. To merge the DEM images obtained by azimuth, the Principal Component Analysis (PCA) algorithm is used, as a result of which a single-band raster is created taking into account all input raster data (in this case, information from each azimuth raster with hillshading relief by an azimuth step of 45^0).

For mapping lineament tectonics and annular structures, are used filters of matrix transformations of the edge detections of the image (Fig. 2) applied to satellite image and DEM [2, 3]:

– use of shadow effects (Hillshade relief) for DEM according to radar imagery data applying the PCA algorithm;

– Convolution filters with matrices 3x3, 5x5, 7x7, etc., with edge detection in selected directions - Left Diagonal Edge Detect, Right Diagonal Edge Detect, Vertical Edge Detect, Horizontal Edge Detect [4, 5].

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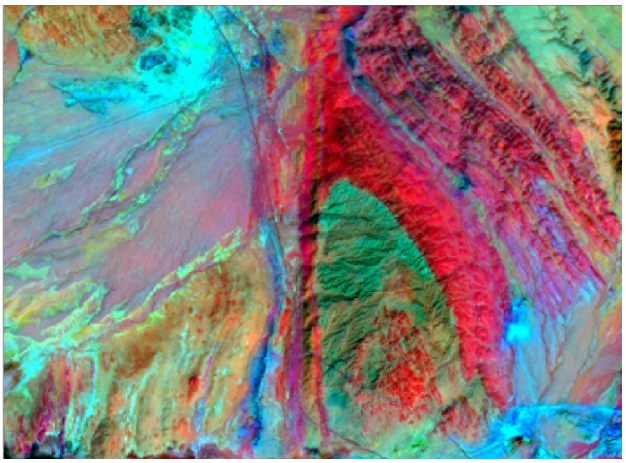
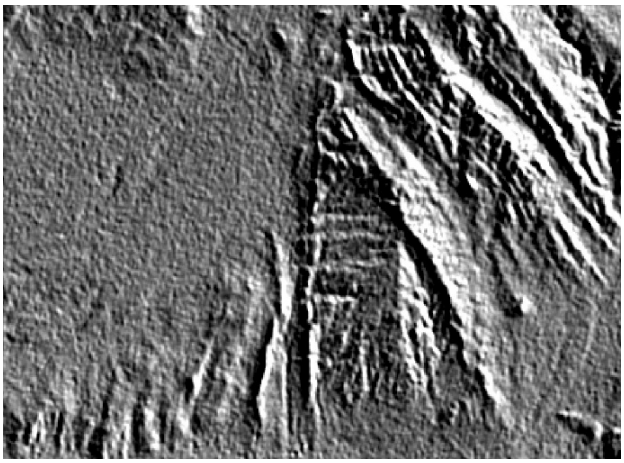


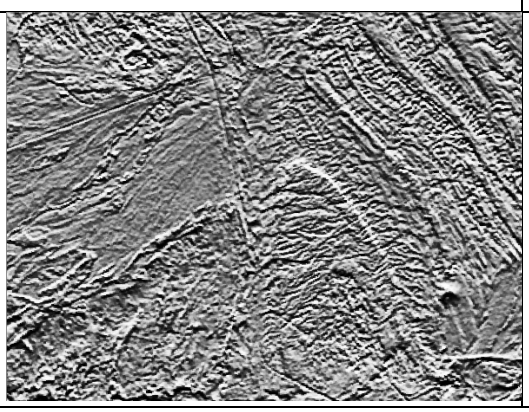
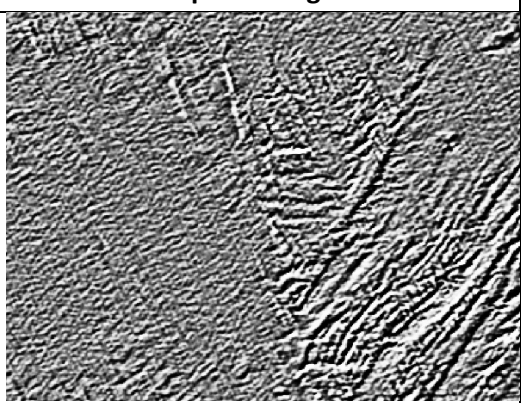
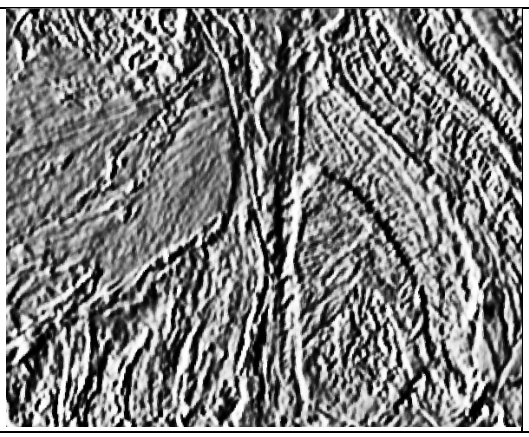
Landsat8 in band combination R=1(RED), B=7(SWIR), G10(TIR)



DEM in processing PCA algorithm by azimuths 0^0; 45^0; 90^0; 135^0; 180^0; 225^0; 270^0; 315^0

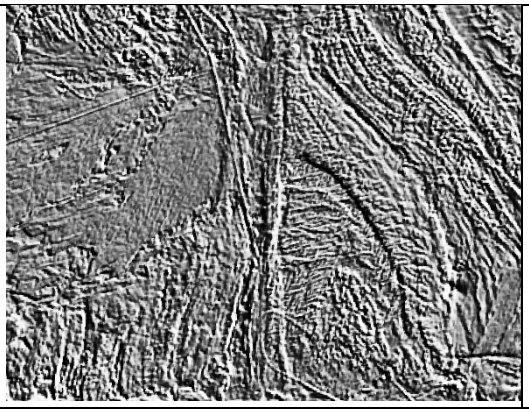
Fig. 1: Primary data for detection of tectonic faults, Aktau intrusive massif, Sultanuvais mountains, Uzbekistan

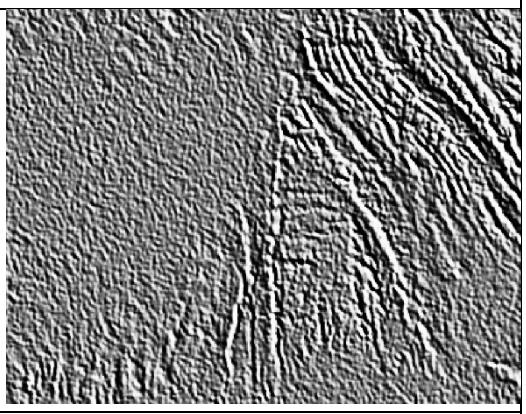
The use of Convolution filters allows to distinguish texture elements of the image, represented by gradients zones, in different directions (vertical, horizontal or diagonal), that permit to obtain data on the length and azimuthal direction of lineaments and zones of fracturing. On filtered images, lineaments identified as tectonic fractures are seen mainly as black segments crossing light zones or (less often) white segments on a black background (Fig. 2).

Matrix type	Convolution Filter Results	
	For Landsat 8 image	For hillshaded DEM data in PCA processing
Matrix 3x3 Horizontal Edge Detect -1 -2 -1 0 0 0 1 2 1		
Matrix 3x3 Vertical Edge Detect -1 0 1 -2 0 2 -1 0 1		

Matrix 3x3
Left Edge Detect

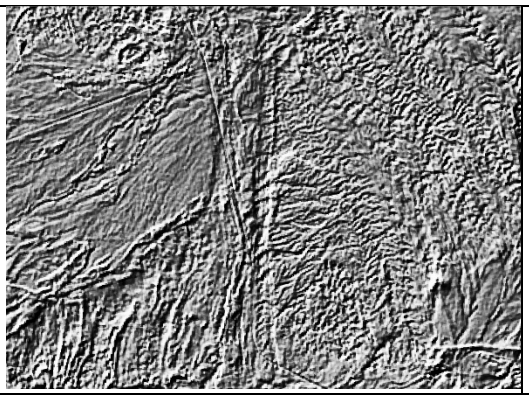
0	1	2
-1	0	1
-2	-1	0





Matrix 3x3
Right Edge
Detect

-2	-1	0
-1	0	1
0	1	2



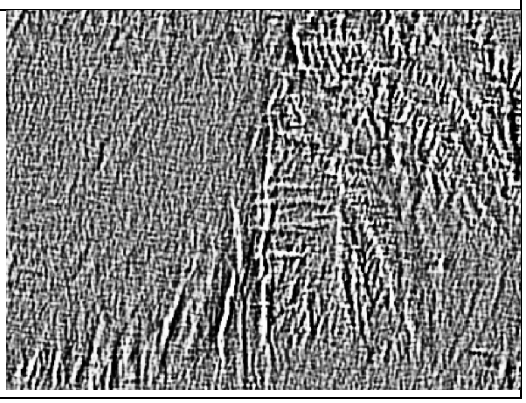


Fig. 2: Results of applying edge detect convolution filters to find lineaments (image of 16- bits pixel depth)

Mapping of lineaments using filtered images is carried out to create a 2D model of the Fault density field of territory, using geographic information systems, with recording in attribute table data for the identified lineaments and annular structures. For linear structures are calculated geometric parameters such as length and direction angle, which can be used to determine the general direction of the lineaments, for example, north-east, sublatitudinal or submeridional. For annular structures, length and diameter are calculated.

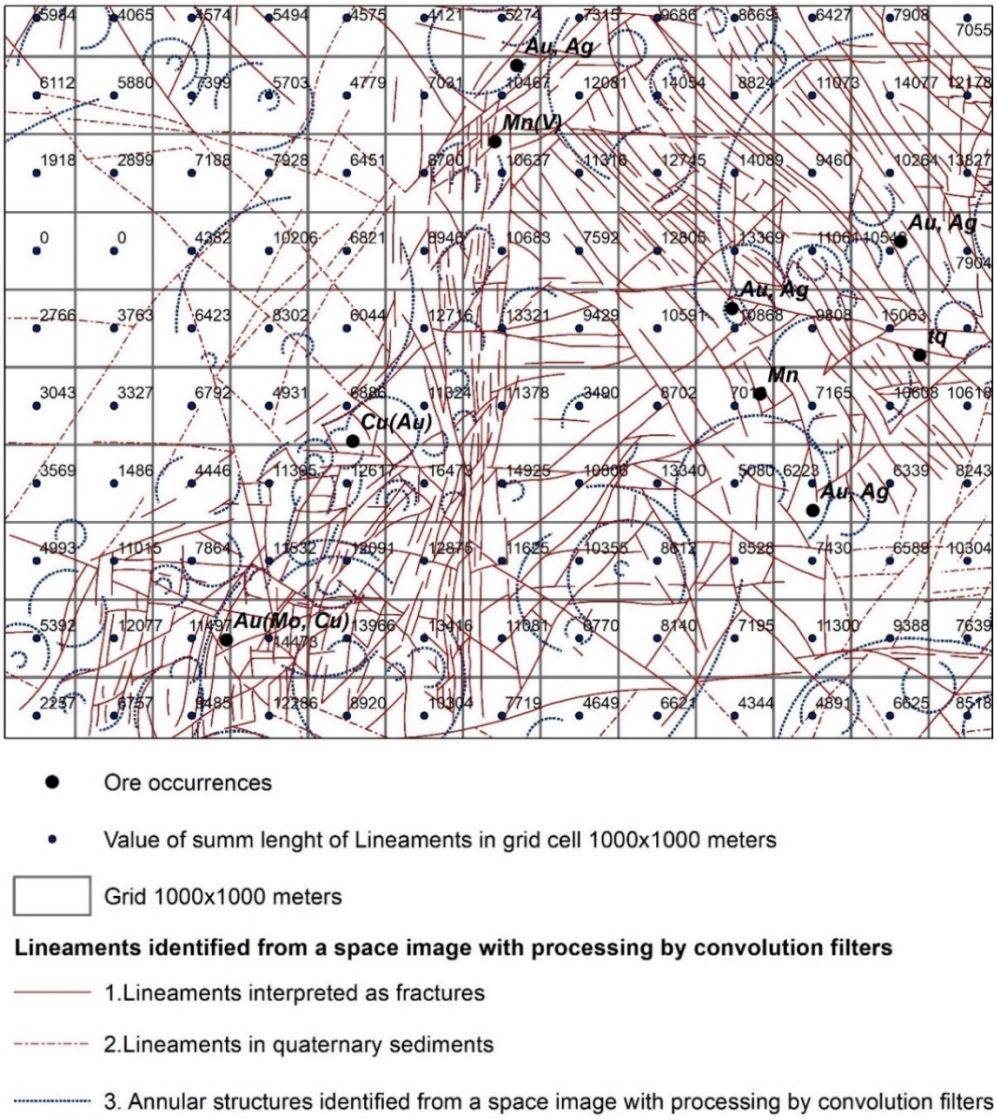


Fig. 3: Lineament's system identified from satellite images with convolution filters. Aktau intrusive, Sultanuvais mountains, Uzbekistan

The determination of tectonic weak zones is based on a statistical analysis of the geometric parameters of lineaments per unit area, by interpolating the values of the summary length of lineament segments that located in one cell of a regular grid of 1000x1000m, using the natural neighborhood interpolation method, for a set of points of a regular network with a uniform step (Fig. 3). The raster, which is obtained by interpolation of regular points with a summary segments lengths value per unit area, displays the density field of tectonic disturbance (fault density field), or identified tectonic weak zones, and shows a qualitative assessment of tectonic fragmentation degree in territory (Fig. 4).

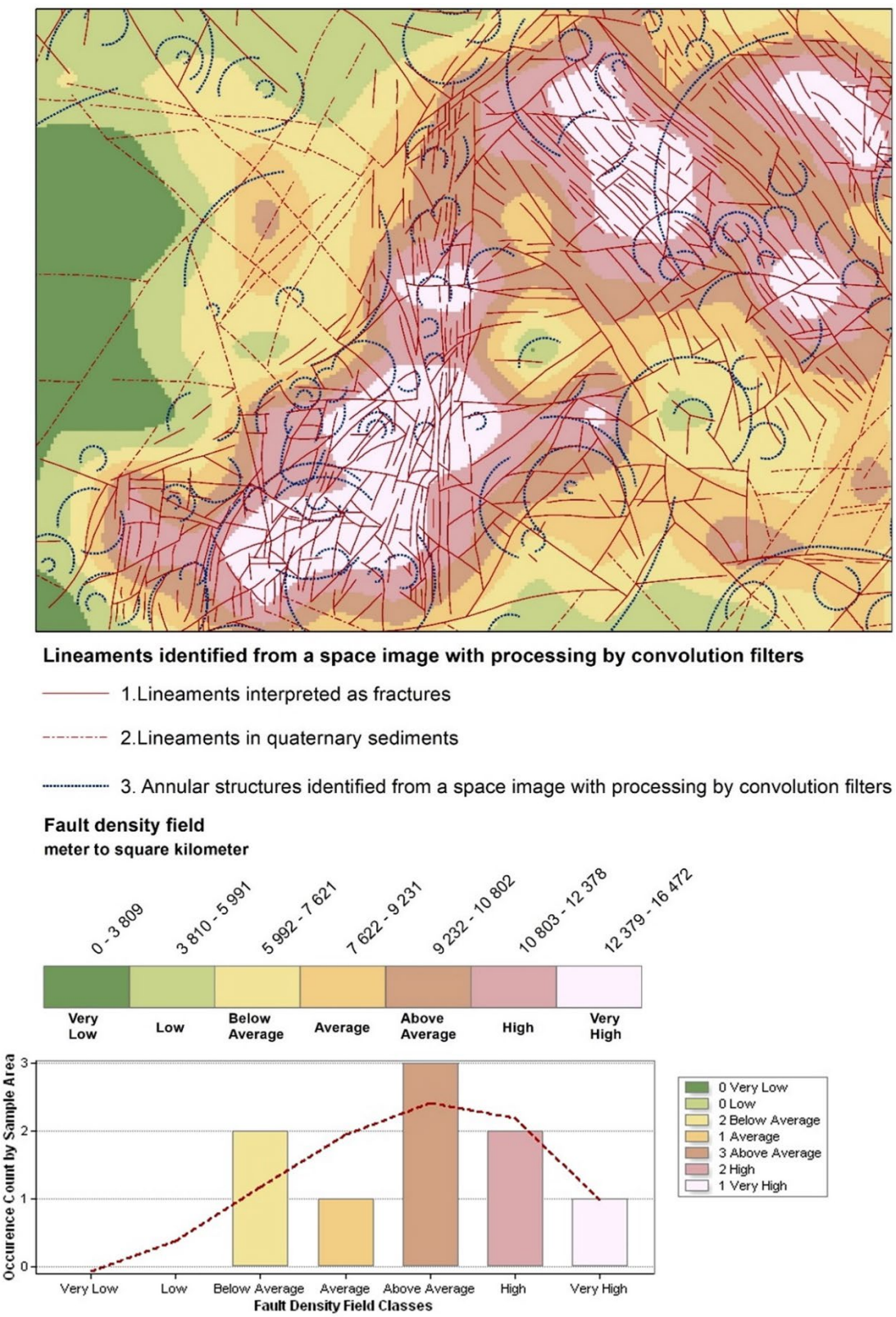


Fig. 4: Faults density field (degree of tectonic fragmentations and Diagram of belonging of ore minerals to tectonic fragmentation zones with approximation curve. *Aktau intrusive, Sultanuvais mountains, Uzbekistan*

On Figure 4, "Very low" and "Low" values of the tectonic fault density field mean that there actually no tectonically weakened zones in these places. Most often, such areas have a clear spatial correlation with loose Quaternary deposits (sands, loams, etc.), which can mask the fracturing of the underlying rocks. "High"

and "Very High" values of the Fault density field mapping zones of high tectonic fragmentation and, accordingly, extremely of tectonic weak zones, which serve as pathways for chemical elements migration from deep horizons to the surface [6]. The areas designated as "Below Average", "Average" and "Above Average" values of the fault density field mapping a relatively moderate of tectonic fragmentation degree, or moderately tectonic weak zones, which can be interpreted as localization zones of endogenous mineralization.

Near the Aktau intrusive, given in the article as the main example of applying the algorithm to determine tectonic weak zones, there are only 9 known occurrences of endogenous minerals that have a clearly expressed spatial correlation with medium and enhanced values of tectonic fragmentation (most of values correspond to from "Below average" to "High"), while only one of the occurrences corresponds to very high values, and none of occurrences belongs to very low or low values of the tectonic fragmentation. However, such a position of ore occurrences is not quite typical due to the small count of ore occurrences and the small study area (insignificant count of selection). More typical is the ratio of endogenous occurrences and the degree of tectonic fragmentation, shown in the diagrams of Figs. 5 and 6.

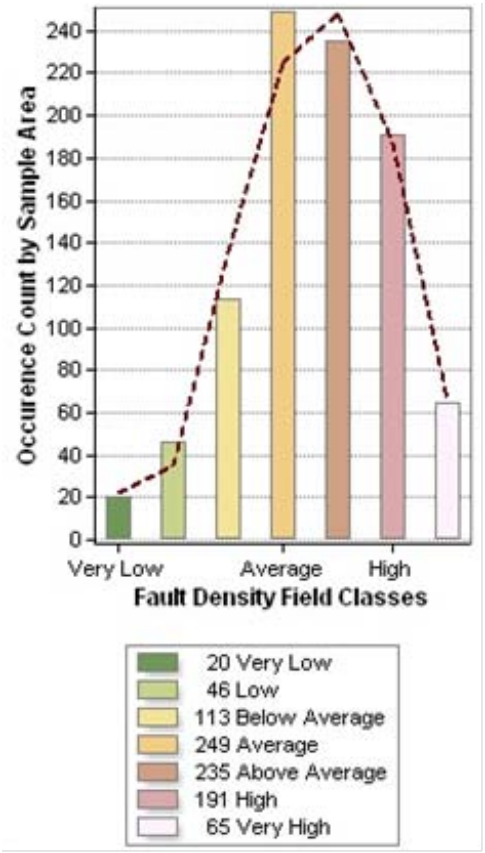


Fig. 5: Diagram of belonging of ore minerals to tectonic fragmentation zones (with approximation curve). *Nuratau Ridge, Uzbekistan*

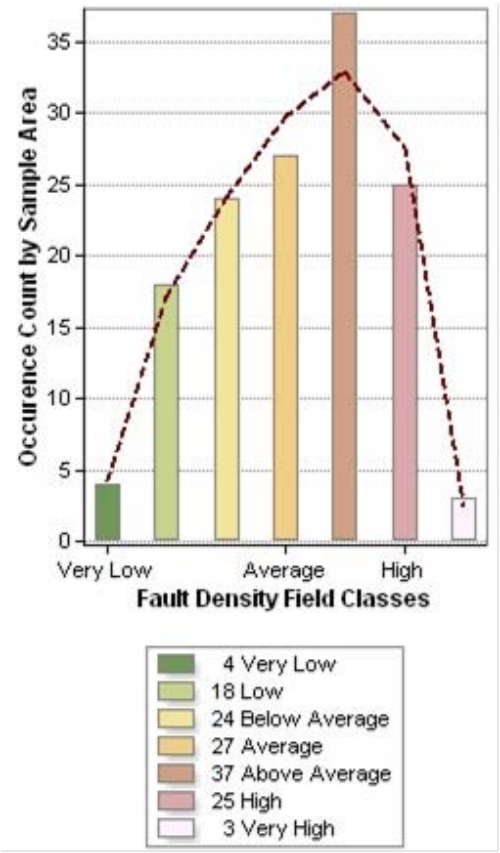


Fig. 6: Diagram of belonging of ore minerals to tectonic fragmentation zones (with approximation curve). *Bukantau mountains, Uzbekistan*

The data in the diagrams of Fig. 5 and 6 are given for the territories of the Central Uzbekistan. The statistical selection for the Nuratau Ridge consists of 919 endogenous occurrences positions distributed over an area of 28,800 square kilometers; for the Bukantau mountains is 138 positions of endogenous occurrences positions distributed over an area of 11,200 square kilometers. According to these selections, a high correlation is observed in the distribution of endogenous ore occurrences in areas with a moderate or slightly increased degree of tectonic fragmentation, that is, in medium values of tectonic weak zones.

Use of Convolution filters for satellite images, as well as the function of hillshading for DEM with various azimuths of directions, makes it possible to identify a largest count of tectonic disturbances in the study area in the form of lineaments, compared to automatic methods or images without use of any filters. Statistical analysis of lineaments identified from filtered images makes it possible to build a map of tectonic weak zones of the crust (faults density field, or degree of tectonic fragmentation), as well as to identify systematical relationships between these zones and positions of endogenous mineralization. A large count position of

endogenous mineralization on the territory of Central Uzbekistan and their comparison with the qualitative characteristics of tectonic fragmentatuion values admit to conclude that the concentration of endogenous mineralization belongs on medium or enhanced tectonic weak zones. This is confirmed by diagrams of ore positions and the degree of tectonic fragmentation, which in total obey the normal gaussian distribution.

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Water Resources Potential and Development in Marathwada Region (Maharashtra State -India)

By Dr. S. A. Nagre & Dr. S. T. Sangle
Dr. Babasaheb Ambedkar Marathwada University

Introduction- Maharashtra is the second highest populated, third largest in area and the second most industrialized state in India. The state of Maharashtra came into existence on 1st May 1960. The Geographical location of the Maharashtra is bounded between latitude 16.40 to 22.10 N and longitude 72.60 to 80.90 E. As per 2011 census, the total population of Maharashtra is 112.37 Million, which is 9.29% of the India's population (1210.19 Million). The State has the geographical area of 0.307 Million Sq. Km., which is about 9.4 per cent of the total area of India. The average rainfall of the State is approximately 1360 mm. The maximum rainfall, about 88 per cent occurs in four months between June to September, about 8 per cent between October to December and remaining 4 per cent after December. Further, rainfall is ranging from 400 mm to 6000 mm in different parts of the State. It is revealed from this, that there is significant variation in rainfall distribution and its occurrence. The State witnesses frequent drought conditions. Almost 42.5% area of the State is drought prone.

GJRE-J Classification: DDC Code: 300

WATERRESOURCESPOTENTIALANDDEVELOPMENTINMARATHWADAREGIONMAHARASHTRASTATEINDIA

Strictly as per the compliance and regulations of:

Water Resources Potential and Development in Marathwada Region (Maharashtra State -India)

Dr. S. A. Nagre [α] & Dr. S. T. Sangle [σ]

I. Introduction

Maharashtra is the second highest populated, third largest in area and the second most industrialized state in India. The state of Maharashtra came into existence on 1st May 1960. The Geographical location of the Maharashtra is bounded between latitude 16.4^0 to 22.1^0 N and longitude 72.6^0 to 80.9^0 E. As per 2011 census, the total population of Maharashtra is 112.37 Million, which is 9.29% of the India's population (1210.19 Million). The State has the geographical area of 0.307 Million Sq. Km., which is about 9.4 per cent of the total area of India. The average rainfall of the State is approximately 1360 mm. The maximum rainfall, about 88 per cent occurs in four months between June to September, about 8 per cent between October to December and remaining 4 per cent after December. Further, rainfall is ranging from 400 mm to 6000 mm in different parts of the State. It is revealed from this, that there is significant variation in rainfall distribution and its occurrence. The State witnesses frequent drought conditions. Almost 42.5% area of the State is drought prone.

Water is a prime natural resource, used for multiple uses as domestic, irrigation, industry, power generation, navigation etc. Water is fundamental resource to life, livelihood, food security and sustainable development. Water which was once considered as abundant has now become a scarce & economic resource. Water should be used in judicial and integrated manner to maximize economic and social welfare.

The distribution of water resources is uneven over a large part of the State. Such area is therefore, water deficit whereas a small part is bestowed with abundance in water. The State Water Policy formulated by the Government of Maharashtra in year 2003 envisages that, the water resources of the State shall be planned, developed & managed with a river basin and sub-basin as the unit. This policy states that, the distress in water availability during deficit period shall be shared equitably amongst different sectors of water use and also amongst upstream and downstream users.

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II. Water Resources in Maharashtra

Total water resource on earth is estimated to be about 1400 million cubic Km, which is 0.25% of the planet's mass and if spread evenly over its surface, it would cover the planet to a height of 2.7 Km. But more than 97% is in the form of oceans and seas, 2% is locked in ice-caps and glaciers and a large portion of remaining 1% lies far too deep in the ground to exploit. Thus only 0.2 million cubic km is fresh water in rivers, lakes, swamps, reservoirs and 23.4 million cubic km is ground water which is mostly saline.

India is second largest populated country in the world, having 16% of the world's population with just 4% of water resources. The main source of water is annual precipitation including snow fall, has been estimated to be of the order of 4000 Billion Cubic Meter (BCM). More than half of that, returns to atmosphere by evaporation and seepage in to the ground. The balance water resource, which occurs as natural run off in the rivers is estimated to 1869 BCM, considering both surface and ground water.

a) Surface Water Allocated by the Tribunal

There are different Tribunal Awards, Committee reports or Agreements between the party States regarding water disputes or water sharing of interstate rivers. These awards/reports/agreements are binding on the State. The water allotted basin wise to the State by the Tribunal is shown below for six river basins in Maharashtra named Godavari, Tapi, Krishna, Narmada, Mahanadi and West Flowing rivers. The geographical areas, water availability, water available for use as per Tribunal award are given in the Table no. 1.

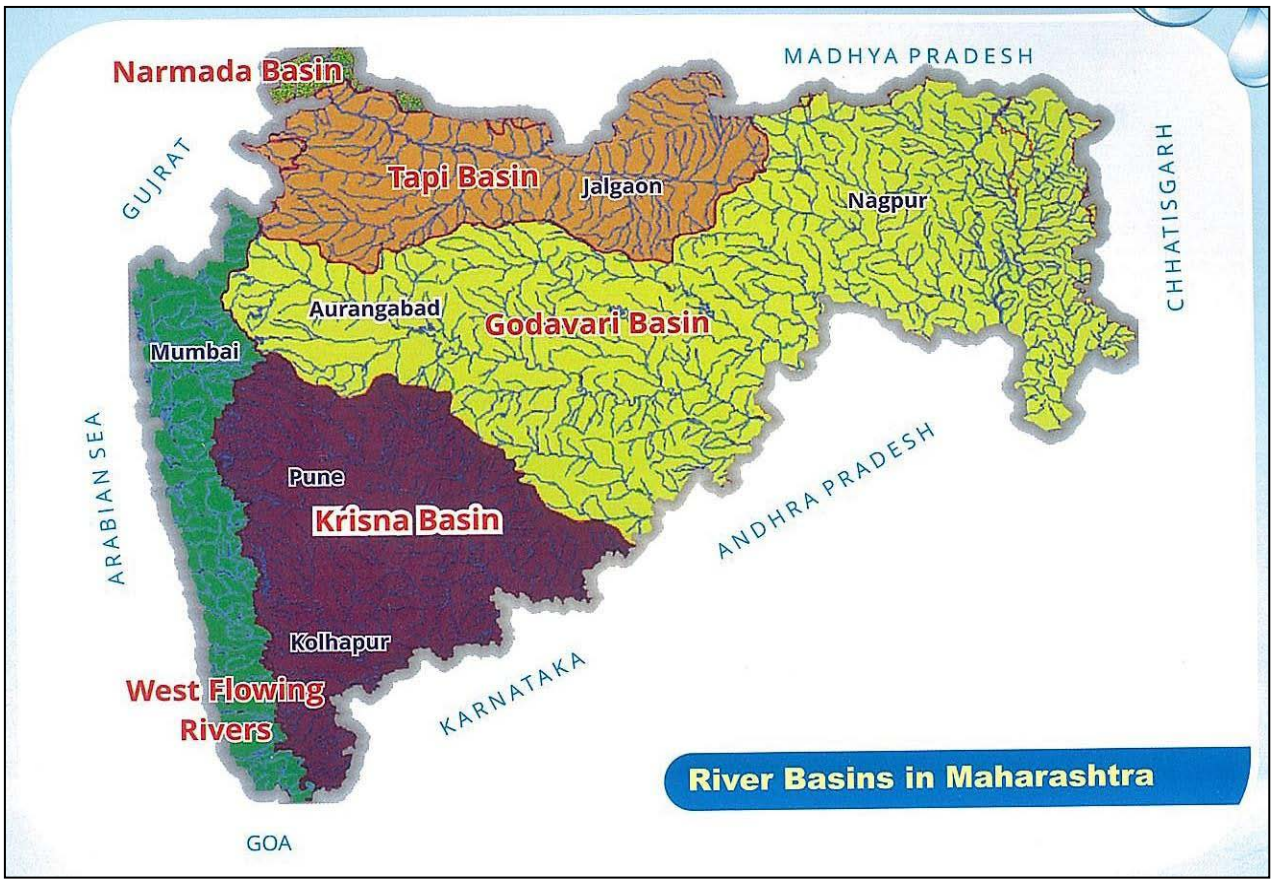


Table No. 1: Water Allocated to State of Maharashtra in Different Basins

Sr. No.	Basin	Avail. Water in Mcum	Allocated by	Water Allocated in Mcum(a)/ TMC(b) (By Tribunal/Committee/Agreement)			
				Water Allocation Mcum (TMC)		Total Water with Regeneration	
(1)	(2)	(3)	(4)	5(a)	5(b)	6(a)	6(b)
1	Godavari	38607	GWDT	29023	1024.93	29023	1024.93
2	Krishna	29300	KWDT-I	15854	560	16562	585
			KWDT-II	18855	666	18855	666
3	Tapi	7027	Iyyengar Committee 5420 and Ukai Dam-141.6	5561	196.40* (191.4+5)	5995	211.71
4	WFR (Konkan)	64218	WFRB Master plan	64219	2267.86	64219	2267.86
5	Narmada	308	NWDT	308	10.88	308	10.88
6	Mahanadi	102	-	102	3.60	103	3.64
7	Total	1,39,562	(Excluding KWDT-II)	115067	4063.67	116210	4104.02

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, Vol.-I Page No. 264 & 265

*(*196.40 TMC Water allocation includes 5 TMC from Narmada basin at Ukai Dam as per MOU with Gujarat; Total in row no.7 is excluding KWDT II; WFR – West Flowing Rivers.)*

All available water cannot be used altogether because all basins are interstate basins except west flowing rivers (WFR). There are Tribunal constraints on water use of these interstate basins. The west flowing basins lies in Konkan, where Catchment Area is very less as compared to water available & 90% of water flows to Arabian Sea.

b) Ground Water Availability in Maharashtra

Groundwater is one of the most important natural resources on the earth. It plays important role in maintenance of economy, environment and standard of living of any society in the state. In absence of immediate availability of surface-water sources, a large population depends upon groundwater. It is equally important in a river basin management. It has been the primary source of water supply for domestic, agriculture and industrial purposes.

Table No. 2: Details of Ground Water Available in Maharashtra

(Figure in Col. No. 5 to 6 in Mcum)

Sr. No.	Sub basin	No. of Water sheds	Catchment area (sq.km)	Net Recharge	70% of Net GW Recharge	Categorization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Godavari	807	152598	17498	12248	Safe
2	Krishna	315	69425	7817	5479	Critical
3	Tapi	299	52058	4651	3256	Critical
4	WFR (Konkan)	91	31780	2264	1583	Safe
5	Narmada	8	1048	35	25	Safe
6	Mahanadi	4	354	27	19	Safe
	Total	1524	307263	32292	22610	Semi critical

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, Vol.-I Page No. 148,180

Groundwater Surveys & Development Agency (GSDA) and CGWB have carried out the Groundwater Assessment, in the Year 2011-12, watershed-wise recharge, and annual gross groundwater draft and groundwater availability. Details of the Ground Water Availability are given in the Table no. 2. As per this assessment, total annual groundwater recharge is 32292 Mcum. However, in view of "safe" groundwater withdrawal only 70% of net groundwater should be utilized so as to avoid any undesired effect on groundwater potential.

c) Basin wise Total Water Available and Allotted

Total water availability comprises of surface as well as ground water. Surface water availability is considered on the basis of natural water available at 75% dependability and the restrictions imposed by different tribunals/committees. Regarding Ground Water, though the Tribunals have permitted 100% use of ground water, State Water Board (SWB) has recommended 70% of groundwater for actual use and 30% to be allowed for ecological purposes. Thus basin/sub basin wise total water availability is given in the Table no. 3.

Table No. 3: Basin-wise Surface & Ground Water Available in Maharashtra

Sr. No.	Basin	Catchment Area (Sq. km)	%	Surface Water Available (Mcum)	Surface water allotted (Mcum)	GW Avail. In Mcum	Total Water Avail. (Mcum) (6+7)	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Godavari	152598	49.8	38607	29023	12248	41271	29.7
2	Krishna	69425	22.7	29300	16562	5479	22041	16.0
3	Tapi	52058	16.8	7027	5995	3256	9251	6.6
4	WFR	31780	10.3	64219	64219	1583	65802	47.4
5	Narmada	1048	0.3	308	308	25	333	0.2
6	Mahanadi	354	0.1	102	103	19	122	0.1
	Total:	**3,07,263**	**100**	**1,39,562**	**1,16,210**	**22,610**	**1,38,820**	**100**

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, Vol.-I Page No.264, 265 & 271

III. Water Potential in Marathwada

The sub basin wise surface and ground water potential available in Marathwada is given below.

a) Surface Water Potential in Marathwada

The yield calculated for various dependability, is the surface water available on the ground in the number of sub basins. The yield at 75% dependability is generally considered for the design of the projects. But, whole quantity of surface water available cannot be

used in the respective sub basins for the inter-state rivers like Godavari. And hence the tribunal has put some restrictions on the use of available surface water. The details of Surface Water Available & Allotted by the Tribunals are given in the Table no.4.

Table No. 4: Details of Surface Water Available & Allotted in Marathwada

Sr. No.	Sub Basins	Cultivable Area (LHa)	Surface Water (Mcum)	
			Avail.	Allotted
1	2	3	4	5
1	Middle Godavari	15.88	2720	1826
2	Dudhana	4.49	398	368
3	Purna	8.06	1829	1338
4	Sudha-Suvarna	0.38	171	56
5	Manjra	6.86	758	623
6	Terna	3.01	274	226
7	Lendi	1.45	316	212
8	Manar	2.27	247	247
9	Kayadhu	1.88	333	333
10.	Penganga (Ptly)	3.85	2055	869
11.	Bhima (Up) (Ptly)	5.54	1543	1468
	Total	53.67	10644	7566

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, vol. I. Page No. 227 & 281

b) Ground Water Potential in Marathwada

The ground water is one of the most important natural resources on the earth. It is the single largest and most readily available source of irrigation and large irrigation (above 50%) is depending on the ground water. In Maharashtra, a rapid growth of population and the consequent increase in irrigated agriculture, drinking water supplies and industrial needs have focused the attention of concerned to developed new water sources. The sub basin wise ground water potential in Marathwada region is given in the Table no. 5.

Table No. 5: Sub-basins wise Ground Water Potential in Marathwada

Sr. No.	Sub Basins	No. of water sheds	Geographical area in LHa	Net Recharge G.W. in Mcum	
				100%	70%
1	2	3	4	5	6
1	Middle Godavari	82	17.21	2551	1768
2	Dudhana	38	6.04	629	440
3	Purna	68	10.25	1409	986
4	Sudha-Suvarna	03	0.80	98	69
5	Manjra	37	7.23	860	602
6	Terna	16	3.24	383	268
7	Lendi	12	2.01	202	141
8	Manar	14	2.86	305	232
9	Kayadhu	09	2.24	360	252
10.	Penganga (Ptly)	20	3.80	364	250
11.	Bhima (Up) (Ptly)	35	5.83	612	417
	Total	341	61.51	7773	5425

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, vol. I. Page No.

c) Total Sub Basin-wise Water Available in Marathwada

Total water availability comprises of surface as well as ground water. Surface water availability is considered on the basis of natural water available at 75% dependability and the restrictions imposed by different tribunals/committees. Regarding Ground Water, though the Tribunals have permitted 100% use of ground water, State Water Board (SWB) has recommended 70% of groundwater for actual use and 30% to be allowed for ecological purposes. Thus basin/sub basin wise total water availability is arrived as given in the Table no.6.

Table No. 6: Basin-wise Surface & Ground Water Available in Marathwada

Sr. No.	Sub Basin	Surface water Allotted (Mcum)	GW Avail. (70 % of Recharge) In Mcum	Total Water Avail. (Mcum) (3+4)
(1)	(2)	(3)	(4)	(5)
1	Middle Godavari	1826	1768	3594
2	Dudhana	368	440	808
3	Purna	1338	986	2324
4	Sudha-Suvarna	56	69	124
5	Manjra	623	602	1225
6	Terna	226	268	494
7	Lendi	212	141	353
8	Manar	247	232	479
9	Kayadhu	333	252	585
10.	Penganga (Ptly)	869	250	1119
11.	Bhima (Up) (Ptly)	1468	417	1885
	Total:	**7566**	5425	**12991**

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, Vol.-I Page No.264, 265 & 271

IV. Water Resources Development in Marathwada

a) Surface Water Development in Marathwada

Water resources Development planning for each sub-basin is based on the available water resources in the Sub-Basin subject to the allocation within framework of the tribunal award, present scenario and future planning so as to obtain the optimal utilization of available water resources. The details of sub-basin wise irrigation development and water use are given in the Table no.7.

Table No. 7: The details of irrigation projects and water use in Marathwada

Sr. No.	Sub Basin	Nos. of Projects		Total	Irrigation in Hectare	Water use in (Mcum)
		Completed	On-going			
1	Middle Godavari	331	46	377	224577	1292.09
2	Dudhana	106	16	122	92019	498.50
3	Purna	181	53	234	141604	1433.37
4	Sudha-Suvarna	17	04	021	5069	30.63
5	Manjra	178	10	188	101493	660.05
6	Terna	104	02	106	63455	312.96
7	Lendi	99	04	103	49040	261.04
8	Manar	215	15	230	82679	537.82
9	Kayadhu	24	07	031	37461	246.79
10.	Penganga (Ptly)	111	19	130	118084	810.0
11.	Bhima (Up)(Ptly)	160	10	170	177971	626.80
	Total	1526	186	1712	1093452	6710.05

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, Vol.-I Page No. 236 & 482

b) Ground Water Development in Marathwada

The ground water assessment is carried out in the State by the Groundwater Survey and Development Agency (GSDA) in the year 2011-12. The information is compiled as watershed-wise recharge annual gross groundwater draft and ground water availability for use of various purposes like driving irrigation and industry.

The assessment of total annual ground water recharge and net annual ground water availability (70%) recharge is given below. Annual gross ground water draft from irrigation wells, domestic wells and bore wells is also given in the table. The allocation for domestic and industrial water supply needs to be kept reserved, based on projected population.

Table No. 8: Sub basin wise Ground Water Development in Marathwada

Sr. No.	Sub Basins	No. of water sheds	Net Recharge G.W. in Mcum 70%	Draft (i.e. GW in use) Mcum	Future use in Mcum (Col. 5-6)	No. of addl. Wells for Irri.
1	2	3	5	6	7	8
1	Middle Godavari	82	1768	1172	596	39765
2	Dudhana	38	440	391	49	3261
3	Purna	68	986	758	228	15201
4	Sudha-Suvarna	03	69	25	44	2928
5	Manjra	37	602	609	-7	0
6	Terna	16	268	322	-54	0
7	Lendi	12	141	87	54	3623
8	Manar	14	232	101	131	8683
9	Kayadhu	09	252	156	96	6426
10.	Penganga (Ptly)	20	250	125	125	8656
11.	Bhima (Up) (Ptly)	35	417	237	180	9520
	Total	341	5425	3621	1442	98063

Source: Integrated State Water plan for Maharashtra (2018), Water Resources Department, Government of Maharashtra, Vol.-I Page No. 204

V. Water Transfer within the State of Maharashtra

The most effective ways to increase the irrigation potential for increasing the food grain production, mitigate floods and droughts and reduce regional imbalance in the availability of water is considered to be the inter-linking of the rivers to transfer water from the surplus rivers to deficit areas.

The criteria for the classification of the basin or sub basin is decided as per the guide lines given in the Report of Maharashtra Water and Irrigation Commission (1999) as given below.

Below 1500 Cum per Ha of cultivable area - Highly deficit

1500 to 3000 Cum per Ha of cultivable area – Deficit

3000 to 8000 Cum per Ha of cultivable area - Normal

8000 to 12000 Cum per Ha of cultivable area - Surplus

Above 12000 Cum per Ha of cultivable area – Abundant

Maharashtra State is covered by six river basins viz. Godavari, Krishna, Tapi, West Flowing Rivers (WFR-Konkan), Narmada and Mahanadi basins. Large variation of natural surface water availability within basins and sub-basins exists in Maharashtra State in general. Average annual surface water availability varies from 0.16 Mm3/Sq.Km. in Tapi basin to 2.07 Mm3/ Sq.Km. in west flowing river basin. Projects for interstate water transfer, inter-basin water transfer within State, as well as inter-sub-basin water transfer, are in existence and are also being planned. Shortage of water resources, continuous drought situations or flood situations, demand planning of such water transfer projects in aggrieved sub-basin or water deficit sub-basin in particular.

In almost all the basins, expect WFR basin in the State, planning of the available water is completed. Some basin and sub-basin are facing the problems of shortage of water due to lesser availability of natural or allotted water, as well as increase in demand both for irrigation and non-irrigation purposes. Whereas some basins e.g. WFR basin in the State have surplus water. In order to meet the demand of deficit basins, intra state water transfer schemes similar on the line of interstate water transfer schemes are porposed. Those schemes include inter basin transfer as well as intra basin water transfer (Inter sub basin) within the State. The details of planning for Transfer of water from surplus sub-basins to deficit sub-basins in the State are given in the Table no.9.

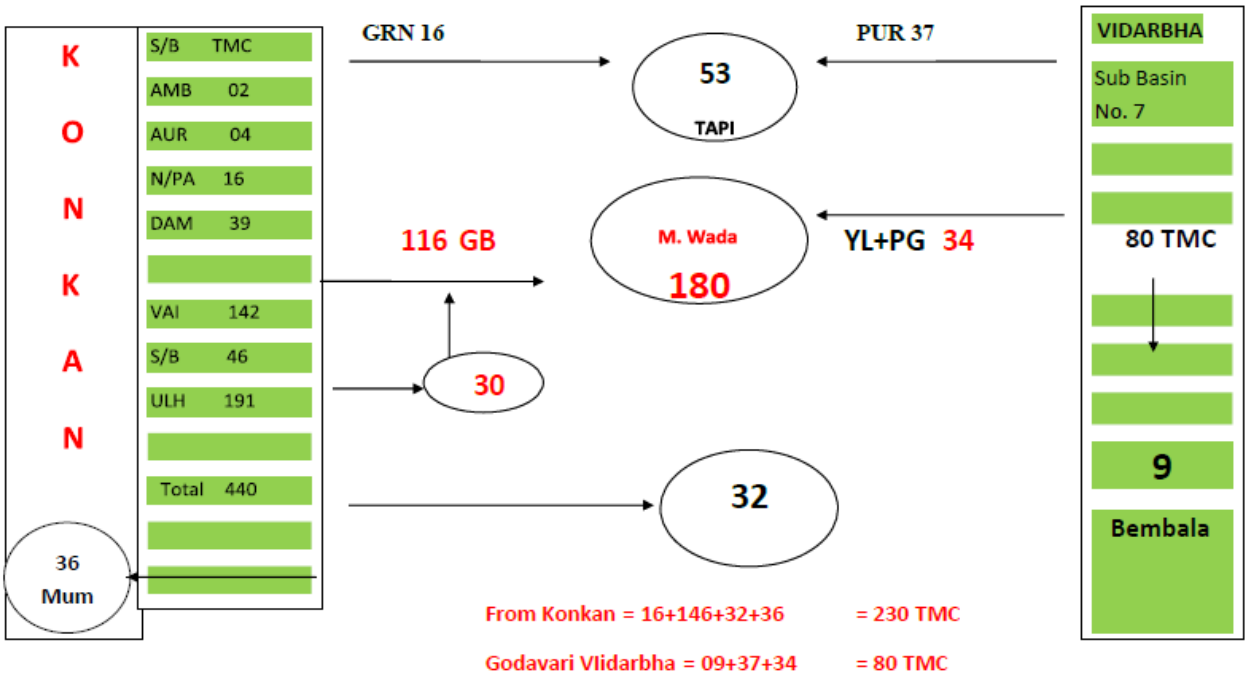
Table No. 9: Transfer of Water from Surplus Sub-basins to Deficit Sub-basins in the State

Sr. No.	Donor Basin (Surplus)		Donee Basin (Deficit)				Total (5+7)
	Basin	Qty. MCum (TMC)	Intra Basin	Qty. Mcum (TMC)	Inter Basin	Qty. Mcum (TMC)	Col. Mcum. (TMC)
1	2	3	4	5	6	7	8
1.	Godavari	2261	Vidarbh (Bembala)	257	Tapi (Purna)	1051	1308
			M.Wada (Penganga) (Yeldari)	553 400	- - -	- - -	- 553 400
	Total	2261 (80)		1210 (43)	-	1051 (37)	2261 (80)
2.	WFR	12448	Mumbai (Domestic Water)	1000	I. Godavari M. Wada Jayakwadi II. Krishna III. Tapi	3297 850 890 463	1000 3297 850 890 463
	Total	12448 (440)	-	1000 (35)	-	5500 (195)	6500 (230)
	G.Total	14709	-	2210	-	6551	8761
	(TMC)	(520)	-	(78)	-	(232)	(310)

(Information compiled from the available details of the Integrated State Water Plan)

Figure: 1

Model for Intra & Inter Basin Transfer of Water



From the above table, it is seen that, the Godavari basin, in Vidarbha region is having 2261 Mcum (80 TMC) of surplus water in some sub basins, after keeping water up to 8000 Cum/Ha of culturable area (Normal Basin) for the use of those sub basins themselves. The surplus water is distributed as below.

257 MCum (9 TMC):- is proposed to be use in Bembala deficit sub basin under Vidarbha region i.e. intra basin transfer of water.

953 MCum (34 TMC):- this is also proposed as intra basin transfer of water to be used in Marathwada as 553 Mcum (20 TMC) for recoupment of Penganga dam storage & 400 Mcum(14 TMC) for Yeldari dam, being replacement of water used by Vidarbha region in the upstream reaches of these dams.

1051 MCum (37 TMC):- This water is also proposed as intra basin transfer of water for the deficit sub basin like Satpuda, Tapi South and Purna of Tapi Basin.

Total: 2261 MCum.(80 TMC):- Proposed use from Surplus water of Godavari Basin for Deficit sub basins as above.

From the above table, it is seen that, the Godavari basin & WFR of Konkan Basin are having surplus water for transfer to other deficit basins.

The WFR of Konkan basin is of very much water surplus or abundant basin. All 28 sub basins are having surplus water of about 54870 Mcum (1940 TMC). But out of 28 sub basins, only 7 sub basins of north konkan are considered for transfer of water to Marathwada area in Godavari Basin, Krishna Basin and Tapi Basin being the nearest or adjacent basins. The Surplus water proposed for transfer is as below.

1000 MCum (36 TMC):- This water will be intra basin transfer from WFR of Konkan Basin which can be use for domestic purpose in Mumbai city.

3297 MCum (116 TMC):- Inter basin transfer of water for Marathwada under Godavari deficit sub basins.

850 MCum (30 TMC):- Inter basin transfer of water for recoupment of Jaykwadi dam storage.

890 MCum (32 TMC):- Inter basin transfer of water for deficit area of Krishna basin.

463 Mcum (16 TMC):- Inter basin transfer of water for deficit Girna sub basin of Tapi basin.

650 Mcum (230 TMC):- Total use proposed from Surplus water of Konkan Basin for Deficit basins as shown above.

Thus the total use of 230 TMC of water will be done from WFR basin out of total available water of 440 TMC in northest Konkan up to Ulhas sub basin.

VI. Way Forward

While studying the water resources development and management in the State the quantity of basin-wise water available is calculated by considering 75% dependable yield, the sub-basin wise catchment area and the respective run-off. As the rivers are flowing Inter-States (except WFR) the water allotted by the Tribunals is considered for utilizing in the respective basins of the State. The surface water is proposed to be used for developing irrigation potential and for Non Irrigation use like domestic and industrial purposes. As per the guidelines for sectoral water use, prescribed by the Maharashtra Water Resources Regulatory Authority (MWRRA) about 25% storage of dams is proposed for N.I. use and rest of storage is used for developing irrigation potential in the command area of the project.

Similarly the inter basin river linking proposals in Maharashtra State are in advance stage of planning for transfer of surplus water from the West Flowing Rivers (WFR) of Konkan Basin to Godavari Basin, Krishna Basin and Tapi Basin. The State has finalized the Integrated State Water Plan (ISWP), and the guidelines for transfer of water from surplus sub basins to deficit sub basins are also given very clearly. Accordingly the sub basin-wise planning is done for all six basins in the State.

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Optimisation of Manufacturing Processes with the Help of Work Measurement Techniques (MOST) - A Case Study

By Mr. Nitish Kumar & Mr. Aditya Raj
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Abstract- "Productivity" in the modern era has become a common term in any sector. Increasing productivity and better use of human and other resources have become a basic need for the development and survival of any organisation. Similarly, in the industrial sector, it holds a very important place. For the enhancement of productivity, targeting the processes and various operations/activities underlying those processes is one of the best ways. This can be achieved by the reduction in non-value-added activities and by developing time standards for the improvement of the processes. Various work measurement techniques can be used to analyse the time being used to perform an operation and critical analysis of them can help in deciding the standard time for a single operation. This study was done to determine the effects of these work measurement techniques on an operation. The study uses detailed activity analysis techniques like micro-motion study and for setting time standards it uses a predetermined motion time systems (PMTS) technique called Maynard Operation Sequence Technique (MOST).

Keywords: productivity, micro-motion study, predetermined motion time systems (PMTS), maynard operation sequence technique (MOST), time standards.

GJRE-J Classification: FOR Code: 091599

Strictly as per the compliance and regulations of:

Optimisation of Manufacturing Processes with the Help of Work Measurement Techniques (MOST) - A Case Study

Mr. Nitish Kumar [α] & Mr. Aditya Raj [σ]

Abstract- "Productivity" in the modern era has become a common term in any sector. Increasing productivity and better use of human and other resources have become a basic need for the development and survival of any organisation. Similarly, in the industrial sector, it holds a very important place. For the enhancement of productivity, targeting the processes and various operations/activities underlying those processes is one of the best ways. This can be achieved by the reduction in non-value-added activities and by developing time standards for the improvement of the processes. Various work measurement techniques can be used to analyse the time being used to perform an operation and critical analysis of them can help in deciding the standard time for a single operation. This study was done to determine the effects of these work measurement techniques on an operation. The study uses detailed activity analysis techniques like micro-motion study and for setting time standards it uses a predetermined motion time systems (PMTS) technique called Maynard Operation Sequence Technique (MOST). Micro-motion study has an added advantage over time study technique in highly repetitive operations and cycle time for whose is just a few seconds. The main purpose of the micro-motion study, however, is to eliminate non-value added activities from the sequence of the operation and resequencing for optimal movement activities. The MOST study is done to set time standards by observing the necessary movements in the sequence of an operation. Different families of MOST can be used to analyse an operation based on various factors that need to be considered beforehand. Due to the high repetition rate and very low cycle times of the operation considered in this study we are using the MiniMOST technique. It is evident from the study done that a considerable reduction in cycle times can be observed going from analysis to standardisation stage. A similar procedure can be used to analyse other operations where human intervention is needed.

Keywords: productivity, micro-motion study, predetermined motion time systems (PMTS), maynard operation sequence technique (MOST), time standards.

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I. Introduction

The definition of "productivity" from a manufacturing perspective can be basically stated as "the ratio of output to input in production" and it is a measure of efficiency which makes both terms distinct. For productivity enhancement, first, we need to measure and analyse the existing processes. In the manufacturing industry, different techniques are undertaken to measure and analyse the productivity of processes undergoing to manufacture a product. Micro motion study of the elements of various operations is one of these techniques.

The operations or activities which are of short duration and are highly repetitive are analysed with the help of micro-motion study. These are the operations or motions which require very small time which makes it very difficult to measure time for these motions accurately and the time required by these motions is needed to be analysed thoroughly due to their repetitive nature. "Thus micro motion study can be defined as the technique of recording and analysing the timing of basic elements of an operation and time involved in doing these operations with the objective of achieving the best method of performing the operation and removing any non-value added activity from the operation." Micro-motion study as a whole involves the following three simple steps:-

i. Filming the operation under analysis.
ii. Gathering of the data from the films.
iii. Making a recording of the data using a SIMO chart.

"SIMO" stands for simultaneous-Motion Cycle chart. It is a micro-motion study recording technique devised by Gilbreth and it presents graphically the separable elements of each limb of the operator under study along with the time taken to perform these activities. It is an extremely detailed left and right-hand operation chart which uses various therbligs to define each activity with certain symbols and legends. It records simultaneously the different therbligs performed by different parts of the body of one or more operators on a common time scale. The movements involved in any operation are recorded against time measured in "Winks" (1 wink= 1/2000th of a minute). SIMO Study is

done in order to carry out a critical analysis of elements in an operation to explore the possibility of the following-

- Removing any type of non-necessary and non-value added activity out of the sequence of steps in an operation.
- Resequencing of the elements in an operation to decrease cycle times of an operation.

For the standardization of the steps or elements and to determine the time standards we can further improve the processes by performing a technique called pre-determined motion time system (PMTS). A predetermined motion time system may be defined as a procedure/method which can be used to analyse any manual activity/human motion in terms of the basic or fundamental motions required to perform it. Each of these activities is assigned a predetermined or a previously established standard time value in such a manner that on the addition of these time values provides a total time for the performance of an activity.

Time measurement unit (TMU), defined as 0.00001 hours, or 0.036 seconds, is used as the basis for the time values of these activities in many cases. Measuring work in TMUs, allows the measurer to make very accurate calculations without lengthy decimals. This technique is especially helpful in high-volume production environments. There are different predetermined motion time systems developed after their introduction in the 1920s.

Some of the Motion time analysis techniques along with their time of origin and developers-

Table 1: History review of motion time analysis techniques

PMTS	Developer	Time	Speed
MTA	Frank Bunker Gilbreth and Lilian Gilbreth	1924	
MTM-1	Maynard, Stegemerten and Schawb	1948	
MTM-2	International MTM Directorate	1965	3-4X
MTM-3	International MTM Directorate	1970	7X
MTM-V	Swedish MTM Association		23X
MTM-C	International MTM Directorate	1978	
MTM-M	International MTM Directorate		
MOST	Zandin (1980), originally applied in Saab-Scania in Sweden in 1967	1980	
MODAPTS	Chris Heyde	1983	

Maynard operation sequence technique (MOST) is a predetermined motion time systems technique that concentrates on the movement of objects. The repetition of the movements can be variable and is used to define the MOST family to be used for analysis. Repetition of movements can be based on certain accuracy and confidence level on the basis of which the number of repetitions under consideration can change. It is used to analyse work and to set the time standards that it would take to perform a particular process/operation. MOST is a powerful analytical tool to measure and analyse all the time spent on a task. It makes the analysis of work an approachable, practical, manageable and cost-effective task. MOST analysis is a complete study of an operation or sub-operation typically consisting of several method steps and a corresponding sequence model. It is comprised of work study, method study, and work measurement tools. In the organization under study, the excess time in operator's activity and fatigue of a worker.

In the BasicMOST we need three activity sequences for describing manual work, and a fourth is used for measuring the movements of objects with manual cranes.

- The *General Move Sequence Model* is used for the analysis of the spatial movement of an object freely through the air.

The sequence model is a series of letters or parameters that are used for representing the various sub-activities of General Move.

The General Move Sequence Model with the definitions for each parameter is as follows:

A B G A B P A

Where:

A =Action Distance
B =Body Motion
G = Gain Control
P = Placement

- The *Controlled Move Sequence Model* is used for the analysis of the movement of an object when it remains in contact with a surface or is attached to another object during the movement (e.g., the movement of the object is controlled by some constraints).

The sequence model is a series of letters or parameters representing the various sub-activities of Controlled Move and is listed below:

A B G M X I A

Where:

A = Action Distance
B = Body Motion
G = Gain Control
M = Move Controlled
X = Process Time
I = Alignment

- The ***Tool Use Sequence Model*** is used for the analysis of movements while using common hand tools.
- The *Manual Crane Sequence Model* is used for the analysis of the movement of objects using a manually traversed crane.

a) MOST System Families

i. *Maxi MOST (Higher level)*

Used to analyse the operations that are likely to be performed fewer than 150 times a week at an overall accuracy requirement of ±5% with a 95% confidence level. An operation that ranges from more than 2 minutes to several hours falls in this category.

ii. *Basic MOST (Intermediate level)*

Used to analyse the operations that are likely to be performed more than 150 times but less than 1500 times a week at an accuracy requirement of ±5% with a 95% confidence level. An operation that ranges from a few seconds to 10 minutes falls in this category.

iii. *Mini MOST (Lower level)*

Used to analyse the operations that are repeated more than 1500 times a week with an accuracy of ±5% with a 95% confidence level. An operation that lasts less than a few seconds falls in this category.

b) System Family Selection Flowchart

In order to make decision of MOST family to be selected for the analysis of the operation, we need to undergo a quantitative and qualitative analysis of the operation. Below (Fig. 1) is a flowchart prepared to undergo the analysis involved of the operation involved in the MOST study.

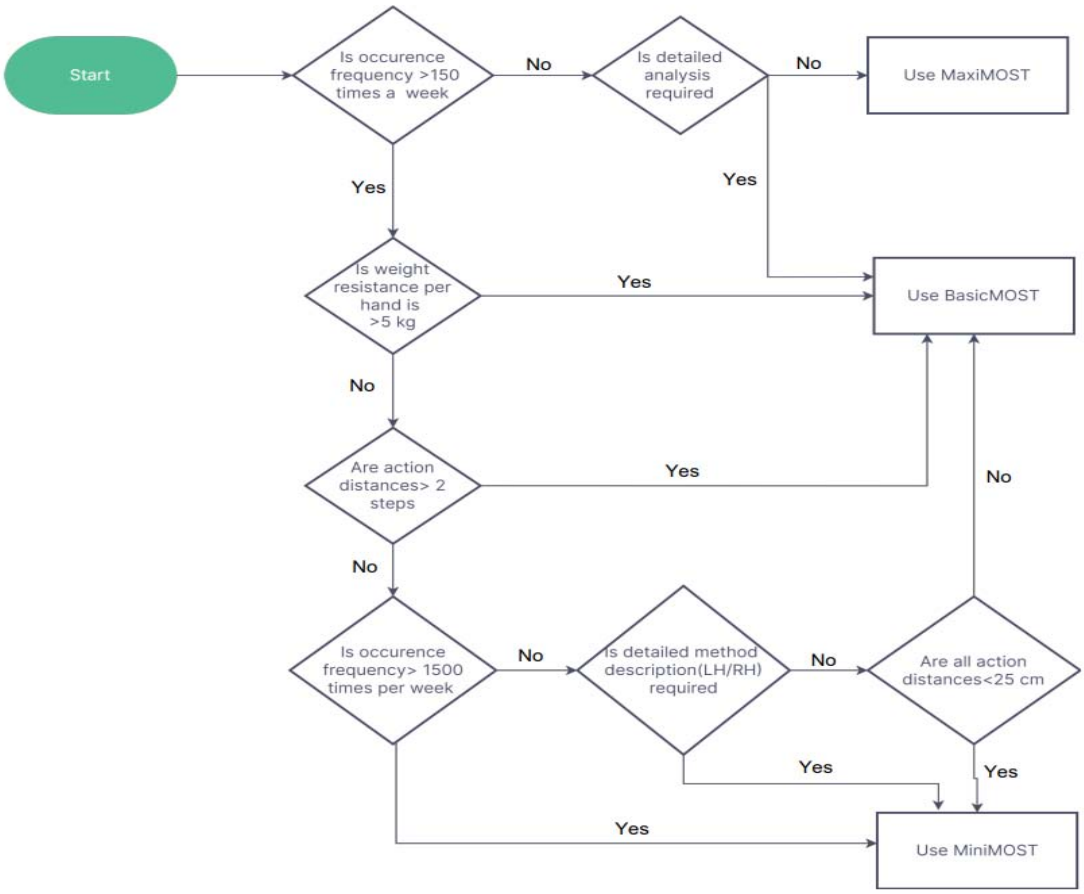

Fig. 1: MOST system family selection flowchart

Procedure for MOST Analysis:

1. Determine job/task and film the operation.
2. Perform a detailed analysis of the operation.
3. Determine sequence(s) to use.
4. Provide index values to each activity. The common scale of index numbers used in all MOST sequence models is 0, 1, 3, 6, 10, 16, 24, 32, 42 and 54.
5. Add index values to determine TMU.
6. Multiply TMU by 0.036. Converting TMU to seconds.

II. Methodology to be used in the Study

a) Micro Motion Study

1. Determine the working perimeter along with the cycle, start and end points of the job.
2. Observation and videography of the operation under study.
3. Critical analysis and breakdown of elements of the job/operation.
4. Assigning therbligs to the elements of the operation and segregating them in effective and ineffective therbligs on a SIMO chart.
5. Analysis of therbligs to eliminate non-necessary non-value added activities from the operation and resequencing of the elements to decrease cycle times on a revised SIMO chart.
6. Calculating observed time and change or reduction of time after study.
7. Application of changes to actual operation.

b) Maynard Operation Sequence Technique (MOST)

1. Determine the working perimeter along with the cycle, start and end points of the job.
2. Observation and videography of the operation under study.
3. Determine the sequence of the operation under study.
4. Determine the type and family to be used in the analysis of the operation with the help of system family selection flowchart.
5. Determination of the type of activity, sequence model and parameter to govern a certain activity.
6. Determination of the general move sequence and index values of the activities of the operations.
7. Calculate normal time in TMU and conversion of TMU to seconds.

III. Case Study

a) Micro Motion Study

Operation name, cycle, end and start points of the operations

Operation:- Grip insertion on the handle
Parts:- Handle sub-assembly, Grip
Operation start:- Handle sub-assembly in the bin, handle grip in the bin
Operation ends:- Handle sub-assembly with grip inserted on conveyor
Operator:- Mr. Nikhil
Charted by:- Mr. Nitish kr & Mr. Aditya
Dated:-25-06-22

Analysis and breakdown of the job into elements

Detailed observation of the video generated can give us an idea of various activities being performed. These activities can then be assigned respective therbligs. The activity differentiation, in this case, needs to be very detailed as it is the basis of the SIMO chart to be prepared.

Table 2: Activity Description chart

Serial no.	Left hand description	Therblig	Type	Time(in winks)	No. of frames in videography	Time (in seconds)	Time (in seconds)2	No. of frames in videography2	Time(in winks)2	Type2	Therblig2	Right hand description
1	Selecting the handle sub assembly in the bin											Idle
2	Idle											Selecting the handle grip from bin
3	Reaching to grasp											Reaching to grasp
4	Grasping the handle sub assembly											Grasping the handle grip
5	Moving the part to position											Moving the grip to position
6	Placing the part in position for further operations											Aligning it according to the position of handle grip
7	Holding the parts in position											Positioning it on the top of handle
8	Releasing the handle sub assembly											Pushing it towards the handle
9	Reaching to grasp the grip											Holding the grip
10	Grasping the grip											Holding the grip
11	Forcing the grip on handle											Forcing the grip on the handle
12	Holding the grip											Releasing the grip
13	Positioning it for checking											Reaching to grasp the handle
14	Holding in position for checking it to be aligned											Grasping the handle
15	Aligning the grip in the position											Holding for alignning
16	Holding the grip											Releasing the grip
17	Positioning it for inspection											Rest
18	Checking and inspection											Rest
19	Moving the part to conveyer											Idle
20	Placing the assembly with grip on the conveyer											Idle

Below is a SIMO chart developed by assigning therbligs to various activities with time analysis and conversion in winks and seconds by analysing the frames/second of the videos. These activities are termed as being effective or ineffective based on the direct value being added to the product.

Table 3: Simultaneous motion chart (Initial)

SIMO Chart(Simultaneous Motion chart)(INITIAL)

Operation:- Grip insertion on handle
Parts:- Handle sub assembly, Grip
Operation start:- Handle sub assembly in bin, handle grip in bin
Operation ends:- Handle sub assembly with grip inserted on conveyor
Operator:-
Charted by:-
Dated:-

Conversion Table
1 wink=1/2000th of a minute=60/2000 of a second
Video recorded at frames/second=30 frames per second
1frame=1.111winks

Serial no.	Left hand description	Therblig	Type	Time(in winks)	No. of frames in videography	Time (in seconds)	Time (in seconds)2	No. of frames in videography2	Time(in winks)2	Type2	Therblig 6	Right hand description
1	Selecting the handle sub assembly in the bin	S	Ineffective	4.444	4	0.13332	0.13332	4	4.444	Ineffective	UD	Idle
2	Idle	UD	Ineffective	4.444	4	0.13332	0.13332	4	4.444	Ineffective	S	Selecting the handle grip from bin
3	Reaching to grasp	TE	Effective	22.22	20	0.6666	0.6666	20	22.22	Effective	TE	Reaching to grasp
4	Grasping the handle sub assembly	G	Effective	4.444	4	0.13332	0.13332	4	4.444	Effective	G	Grasping the handle grip
5	Moving the part to position	TL	Effective	18.887	17	0.56661	0.56661	17	18.887	Effective	TL	Moving the grip to position
6	Placing the part in position for further operations	P	Ineffective	33.33	30	0.9999	1.49985	45	49.995	Effective	PP	Aligning it according to the position of handle grip
7	Holding the parts in position	H	Ineffective	77.77	70	2.3331	1.9998	60	66.66	Ineffective	P	Positioning it on the top of handle
8	Releasing the handle sub assembly	RL	Effective	2.222	2	0.06666	0.26664	8	8.888	Effective	A	Pushing it towards the handle
9	Reaching to grasp the grip	TE	Effective	15.554	14	0.46662	0.29997	9	9.999	Ineffective	H	Holding the grip
10	Grasping the grip	G	Effective	2.222	2	0.06666	0.06666	2	2.222	Ineffective	H	Holding the grip
11	Forcing the grip on handle	A	Effective	75.548	68	2.26644	2.26644	68	75.548	Effective	A	Forcing the grip on the handle
12	Holding the grip	H	Ineffective	2.222	2	0.06666	0.06666	2	2.222	Effective	RL	Releasing the grip
13	Positioning it for checking	P	Ineffective	8.888	8	0.26664	0.26664	8	8.888	Ineffective	Ud	Reaching to grasp the handle
14	Holding in position for checking it to be aligned	H	Ineffective	8.888	8	0.26664	0.26664	8	8.888	Ineffective	I	Grasping the handle
15	Aligning the grip in the position	A	Effective	33.33	30	0.9999	0.9999	30	33.33	Ineffective	H	Holding for alignning
16	Holding the grip	H	Ineffective	5.555	5	0.16665	0.16665	5	5.555	Effective	RL	Releasing the grip
17	Positioning it for inspection	P	Ineffective	7.777	7	0.23331	0.23331	7	7.777	Ineffective	R	Rest
18	Checking and inspection	I	Ineffective	33.33	30	0.9999	0.9999	30	33.33	Ineffective	R	Rest
19	Moving the part to conveyer	TL	Effective	55.55	50	1.6665	1.6665	50	55.55	Ineffective	UD	Idle
20	Placing the assembly with grip on the conveyer	RL	Effective	11.11	10	0.3333	0.3333	10	11.11	Ineffective	UD	Idle
	TOTAL TIME (INITIAL)					12.83205	13.03203					

Below is a revised SIMO chart made by analysing effective and ineffective therbligs to eliminate non-necessary and non-value added activities from the operation. Differentiating these activities is a crucial process as this step adds value to the study being performed. There may be some ineffective activities that assist other effective activities, so we need to consider them accordingly. Resequencing of the various activities can also be performed in this step so that the total cycle time can be decreased.

Table 4: Simultaneous motion chart (Revised)

SIMO Chart(Simultaneous Motion chart)(REVISED)

Operation:- Grip insertion on handle
Parts:- Handle sub assembly, Grip
Operation start:- Handle sub assembly in bin, handle grip in bin
Operation ends:- Handle sub assembly with grip inserted on conveyor
Operator:-
Charted by:-
Dated:-

Conversion Table
1 winks=1/2000th of a minute=60/2000 of a second
Video recorded at frames/second=30 frames per second
1frame=1.111winks

Serial no	Left hand description	Therbligs	Type	Time (in winks)	No. of frames in videography	Time (in seconds)	Time (in seconds)2	No. of frames in videography3	Time (in winks)2	Type2	Therbligs2	Right hand description
1	Selecting the handle sub assy in the bin	S	Ineffective	4.444	4	0.13332	0.13332	4	4.444	Ineffective	UD	Idle
2	Idle	UD	Ineffective	4.444	4	0.13332	0.13332	4	4.444	Ineffective	S	Selecting the handle grip from bin
3	Reaching to grasp	TE	Effective	22.22	20	0.6666	0.6666	20	22.22	Effective	TE	Reaching to grasp
4	Grasping the handle sub assy	G	Effective	4.444	4	0.13332	0.13332	4	4.444	Effective	G	Grasping the handle grip
5	Moving the part to position	TL	Effective	18.887	17	0.56661	0.56661	17	18.887	Effective	TL	Moving the grip to position
6	Placing the part in position for further operations	P	Ineffective	33.33	30	0.9999	1.49985	45	49.995	Effective	PP	Aligning it according to the position of handle grip
7	Holding the parts in position	H	Ineffective	77.77	70	2.3331	1.9998	60	66.66	Ineffective	P	Positioning it on the top of handle
8	Releasing the handle sub assy	RL	Effective	2.222	2	0.06666	0.26664	8	8.888	Effective	A	Pushing it towards the handle
9	Reaching to grasp the grip	TE	Effective	15.554	14	0.46662	0.29997	9	9.999	Ineffective	H	Holding the grip
10	Grasping the grip	G	Effective	2.222	2	0.06666	0.06666	2	2.222	Ineffective	H	Holding the grip
11	Forcing the grip on handle	A	Effective	75.548	68	2.26644	2.26644	68	75.548	Effective	A	Forcing the grip on the handle
12	Holding the grip	H	Ineffective	2.222	2	0.06666	0.06666	2	2.222	Effective	RL	Releasing the grip
13	Positioning it for checking	P	Ineffective	8.888	8	0.26664	0.26664	8	8.888	Ineffective	UD	Reaching to grasp the handle
14	Holding in position for checking it to be aligned	H	Ineffective	8.888	8	0.26664	0.26664	8	8.888	Ineffective	I	Grasping the handle
15	Aligning the grip in the position	A	Effective	33.33	30	0.9999	0.9999	30	33.33	Ineffective	H	Holding for alignning
16	Holding the grip	H	Ineffective	5.555	5	0.16665	0.16665	5	5.555	Effective	RL	Releasing the grip
17	Moving the part to conveyer	TL	Effective	55.55	50	1.6665	1.6665	50	55.55	Ineffective	UD	Idle
18	Placing the assy with grip on the conveyer	RL	Effective	11.11	10	0.3333	0.3333	10	11.11	Ineffective	UD	Idle
	TOTAL TIME(Revised)					11.59884	11.79882					

b) Maynard Operation Sequence Technique (MOST)

Operation name, cycle, end and start points of the operations

Operation:- Grip insertion on the handle
Parts:- Handle sub-assembly, Grip
Operation start:- Handle sub-assembly in the bin, handle grip in the bin
Operation ends:- Handle sub-assembly with grip inserted on conveyor
Operator:- Mr. Nikhil
Charted by:- Mr. Nitish & Mr. Aditya
Dated:- 25-06-22

Determining the type and family to be used in the analysis of the operation:

The observed cycle time from the micro-motion study is 13.53 seconds which is less than 30 seconds.

Calculation of the frequency of occurrence of the operation-

The annual demand for the product is 200000 pieces.

So, the weekly demand for the product=200000/52 = 3,847 (approx.)

That gives repetition of operation as 3847 times per week approximately as the frequency of occurrence of this operation is once for a product which implies it to be more than 1500 repetitions a week.

Developing the decision table for selection of the MOST family to be used-

Below (Fig. 2) is a flowchart prepared to undergo the analysis involved of the operation involved in this study-

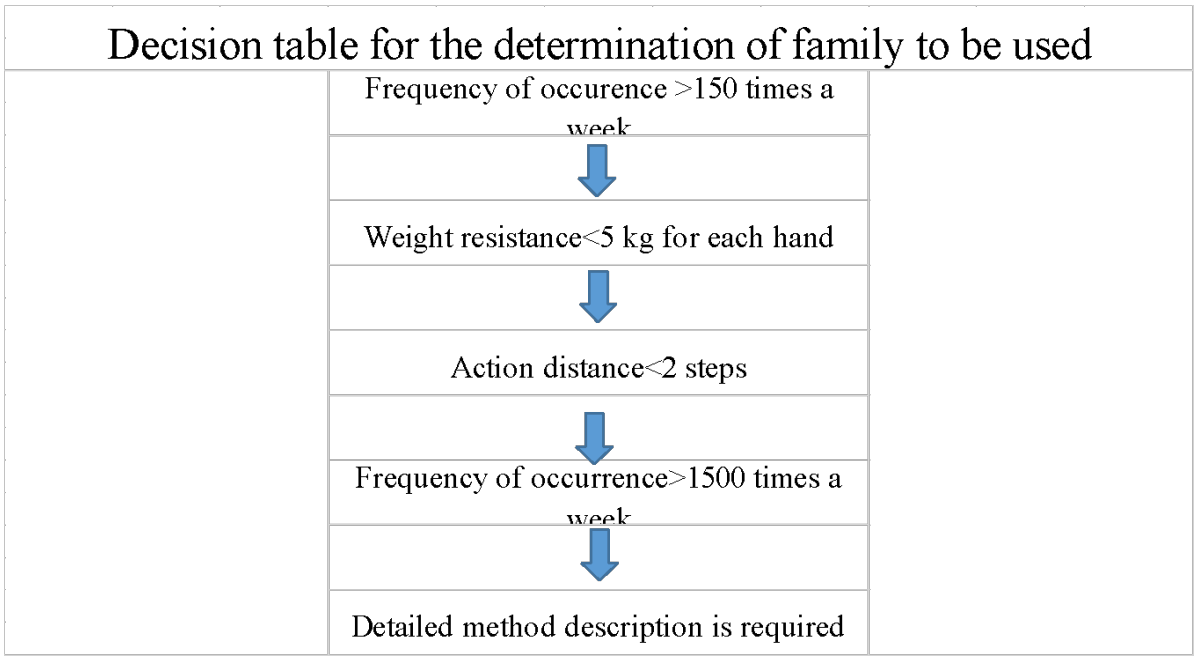

Fig. 2: Decision table for determining family to be used

As evident from the above decision table, we need to perform the MiniMOST technique for the evaluation of this operation with a detailed description of activities.

The move sequences of activities for the operation

1. Keeping the sitting posture, reaching without bending, grasping the handle sub-assembly with the left hand located at around 30 cm from the assembly position, moving it without bending towards the comfortable assembly position and holding and retaining them for further operations.
2. Simultaneously, picking up the handle grip located at 30 cm from the assembly position with the right hand, moving it towards the assembly position and positioning it on top of the handle sub-assembly with precise placement, accuracy less than 4mm and initial insertion of more than 20mm.
3. Releasing left hand and with the movement of more than 10 cm and less than 20 cm again grasping the grip.
4. By applying heavy force with both hands and overcoming friction, positioning of handle grip on handle sub-assembly with a movement of more than 10 cm, aligning it with the pin insertion hole.
5. Un-holding the grip from the right hand and positioning it comfortably at a distance of around more than 10 cm and less than 20 cm.
6. Moving the assembled part to the conveyor belt with the left hand at around 30 cm, setting it on the conveyor belt and moving it back to a comfortable position at around 30 cm.

MiniMOST Analysis sheet based on the sequence of activities:-

Below (Fig. 3) is analysis sheet prepared by analysing activities involved in the operation under consideration of this study-

MAYNARD

MiniMOST® Analysis (Vertical)

DATE: 10/7/2022
ANALYST: Nitish Kumar
PAGE: 1 OF 1

DESCRIPTION: Handle grip insertion on handle sub-assembly

ACTIVITY • OBJECT • IN / ON / FOR • PRODUCT / EQUIPMENT • USING / WITH • TOOL • TO / AT • WORK AREA
INSTRUCTIONS ☐ APPLICATOR (A) ☐ OPERATOR (O) ☐ SAFETY (S)

UNIT OF MEASURE:
TMU FROM PREVIOUS PAGE:

STEP NO.	HAND P/L	METHOD STEP DESCRIPTION	SEQUENCE MODELS	PF	FR	SIMO TO	TMU
1	L	Grasping handle sub-assembly from 30 cm and positioning	A_{10} B_0 G_6 A_{10} B_0 P_3 A_0 A B G M X I A	( )		1-5	26
2	R	Picking handle grip from 30 cm and positioning for further operations	A_{10} B_0 G_6 A_{10} B_0 P_{54} A_0 A B G M X I A	( )		6	54
3	L	Releasing left hand and regrasping handle grip	A_6 B_0 G_6 A_0 B_0 P_0 A_0 A B G M X I A	( )			12
4		Positioning of handle grip on handle sun assembly and aligning	A_0 B_0 G_0 A_0 B_0 P_{32} A_0 A_0 B_0 G_0 M_{30} X_0 I_{60} A_0	( )			32 90
5	R	Unholding grip from right hand and position it comfortably	A_0 B_0 G_0 A_0 B_0 P_0 A_6 A B G M X I A	( )			6
6	L	Moving the assembled part to conveyor belt at 30 cm and moving back	A_0 B_0 G_0 A_{10} B_0 P_6 A_{10} A B G M X I A	( )			26
7			A B G A B P A A B G M X I A	( )			
8			A B G A B P A A B G M X I A	( )			
9			A B G A B P A A B G M X I A	( )			
10			A B G A B P A A B G M X I A	( )			
11			A B G A B P A A B G M X I A	( )			
12			A B G A B P A A B G M X I A	( )			
13			A B G A B P A A B G M X I A	( )			
14			A B G A B P A A B G M X I A	( )			
15			A B G A B P A A B G M X I A	( )			
16			A B G A B P A A B G M X I A	( )			

TOTAL TIME: HOURS: 0.0025 MINUTES: 0.15 SECONDS: 8.9 TMU: 246

Fig. 3: MiniMOST Analysis Sheet

**Remarks:*

As the application of limb force is very high because of the friction between combining parts the indices in the 4th step controlled sequence were considered from the BasicMOST data card instead of the MiniMOST data card. M3 and I6 were used.

Performance Calculations:-

Observed time and change in time after revision and analysis

Observed time before revision and analysis:-

Time (in seconds) (Right hand)	Time (in seconds) (Left hand)
12.83	13.03

Observed time after revision of activities/elements:-

Time (in seconds) (Right hand)	Time (in seconds) (Left hand)
11.60	11.80

Percentage time reduction after analysing

= (Time before- Time after)/ Time before *100%

Percentage % (Right hand)	Percentage % (Left hand)
9.61	9.46

Initial maximum time from micro-motion study and therblig analysis =11.80 seconds.
Time calculations from MiniMOST analysis =8.90 seconds.

Percentage time reduction after analysing

= (Time before- Time after)/ Time before *100%

$= (11.80 - 8.90)/11.8 * 100\%$

= 24.58%

Total reduction in time = 13.03-8.90

= 4.13 seconds

Total percentage reduction in time

= (Time before- Time after)/ Time before *100%

$= (13.03 - 8.90)13.03 * 100\%$

= 31.70%

IV. Results and Conclusion

On the basis of the case study done and calculations performed we can conclude that optimisation of processes can be achieved by directing our interest on individual operations. Advanced work measurement techniques like Maynard Operation Sequence Technique (MOST) can be used along with some detailed method analysis like Gilbreth's micro-motion study to set standards for the workforce to increase productivity to optimal levels. Moreover, it has applications like removing non-value added elements from targeted operations and removing bottlenecks by setting standards. It may face some challenges from the

workforce in the initial phases but with proper training and motivation, it can be effectively implemented in any organisation to improve productivity and increase profits. Increased profits can in turn help the workforce in the form of increased wages and incentives.

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Benefit

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Financial

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Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

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It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

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The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

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Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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