# Intelligent Integrated Information System for Effective Enterprise Management: Designing to Deployment: An Approach

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## ABSTRACT

*Enterprise management has become extremely complex today. The Internet, information and communication technologies, and compulsions from globalisation, pose both opportunities and threats to the enterprise, of dimensions never seen before. Only the techno-savvy, intelligent, and agile enterprises can manage their business effectively. They seek and depend on intelligent information systems for survival and growth. However, the task of designing, building, and adopting one is quite daunting, given the number and complexities of options. It is in this context that 'integrated intelligent information system' [IIIS] assumes importance. Based on literature and experiences published, this paper presents a systematic approach to designing, building and adopting enterprise-appropriate IIIS.*

## Keywords

*K-era, integrated intelligent information systems, borderless economies, mass-customisation, artificial intelligence, business intelligence, data mining, corporate memory, neural networks, learning systems, knowledge-workers, small and medium enterprises, data-information-knowledge-wisdom, enterprise resource planning system, enterprise applications integration tools, business intelligence.*

## 1.0 INTRODUCTION

The knowledge era [K-era] is upon us. It has undoubtedly thrown up many challenges to the enterprise, and changed the way managers manage their businesses today. Information and knowledge have become the most important resource to be intelligently managed, in order for enterprises to manage the other basic resources like money, materials, machines, and men, effectively. Regardless of their orientation [towards profit or otherwise], size, line of business [manufacturing, service], and markets, the one resource with which organizations are most concerned is information. Not because of information scarcity, but because of its abundance with attendant tsunami effects, created by information and communication technologies [ICT]. Indeed, given the emerging supportive powerful technologies, it is quite possible that information deluges could drown and disable ill-equipped and unprepared enterprises.

Take for instance the Internet. It is the most dominant vehicle to store, carry and disseminate information of and about almost anything one can think of. It is open to all. Search for information from the Internet invariably brings out responses [and linkages] running into thousands. Businesses can, and do, take advantage of this power of Internet. Yet, getting the right and correct information with shortest search time at optimal costs falls in the realm of intelligence and knowledge. One of the challenges for the enterprise is intelligent management of information deluges.

Internet, ICT and other related technologies, converging communication, information and entertainment, encompassing almost all sectors of industry and service, have brought about new trends, opportunities and threats for businesses today. Globalisation, borderless economies and therefore markets which are multi-cultural and multi-lingual, mass-customisation, and strategic networking with all stakeholders, constitute some of the trends and opportunities. Increasing global competition, international legal compliances, intellectual property considerations, exposure to and vulnerability from risks in employing and exploiting ICT pose much greater threats of the kind never seen before. These threats, both internal and external, range from disruption of business to disrepute to bankruptcy. Another challenge for the enterprise, therefore, lies in clever exploitation of these trends and opportunities, while averting and minimizing the risks associated with the threats. This again calls for intelligent management of information as a resource.

Also, in terms of modes and methods of information processing per se, we have come a long way from centralized electronic data processing. Today's businesses are driven by information [and knowledge]--collected, compiled, stored, analysed, and used by empowered knowledge-workers through a ICT connecting a variety of computing devices located at different parts of the world in a timeless and borderless

manner. Intelligent information systems [IIS], knowledge-bases, business intelligence, data mining and data warehouses, corporate memory, neural networks, learning systems, are all now part of business management tools and techniques. Success in business seems to depend on a firm's ability to leverage ICT intelligently. The challenge for the enterprise here is to integrate intelligently the multifarious methods, options, and components of ICT, so as to improve its overall productivity and profitability. It is in this context that integrated intelligent information system [IIIS]—with the integrative aspects --becomes important.

Based on literature review and experiences reported, especially from the Indian scenario, this paper presents an approach to designing, developing, and most importantly deploying cost effective IIIS appropriate to the enterprise.

Some of the key questions and issues considered are:

1. What is meant by IIIS?

2. Why should any enterprise consider adopting IIIS?

3. Is there a generic and systematic approach to specifying, designing, and deploying enterprise-appropriate IIIS?

4. What are the options available in the choice and adoption of IIIS? How should expenditure on IIIS be justified?

5. What are the issues beyond technology?

## 2.0 CONCEPTS, TERMINOLOGY, AND MEANING OF THE IIIS

Let us begin with some conceptual clarifications and terminology explanations forming the base of our discussion of IIIS and its relevance to effective enterprise management. First, we choose and explain the four-word-linked term: 'data-information-knowledge-wisdom' [DIKW], as it not only includes 'information' as a link—common with IIIS—but also extends to 'knowledge' and 'wisdom' which have a bearing on 'intelligent information systems'—the object of our discussion in this paper.

While widely accepted common definitions exist for DI--historically the objects of electronic processing--no such clear cut unanimous definitions exist for KW. This is understandable, mainly because of one main distinguishing aspect between the two sets: the former duo exists explicitly [external to and accessible by the user] and is therefore accessible at organization level. The latter duo exists generally implicitly [internal to and accessible by only the individual] and is therefore

not accessible at organization level, except through a process of transfer of what is 'implicit' [tacit] into 'explicit' [and therefore sharable] form. The difference in terms of 'origin' and therefore 'initial ownership' of KW at two distinct levels, viz., organization and individual, is at the core of many issues in interpretation and usage of 'knowledge and wisdom'.

Another concept is that the 'very data and information' of/at an enterprise could progressively 'turn into knowledge and wisdom' of/in individuals through mental and intellectual processes of reasoning, relating, understanding, experiencing, generalizing and so on. It is intuitively appealing for us, as it is to Gene Bellinger (Bellinger, 2004), to see the linking four terms as a 'continuum', rather than discrete unconnected ones. For instance, when one understands the 'data and information', connects [relates] them to environment, previous experiences, leading to and learning from actions—both immediate and futuristic, then one gains 'knowledge'; and 'knowledge refined and synthesized over a period of time' leads one to gain 'wisdom'. While DI thus can exist explicitly both at individual and organization levels, KW is essentially implicit [tacit] in the 'minds' of individuals who may be internal or external to the organization. It is also apt to describe this process as 'knowing the unknowns'. Figure 1 illustrates these terns, concepts and processes.
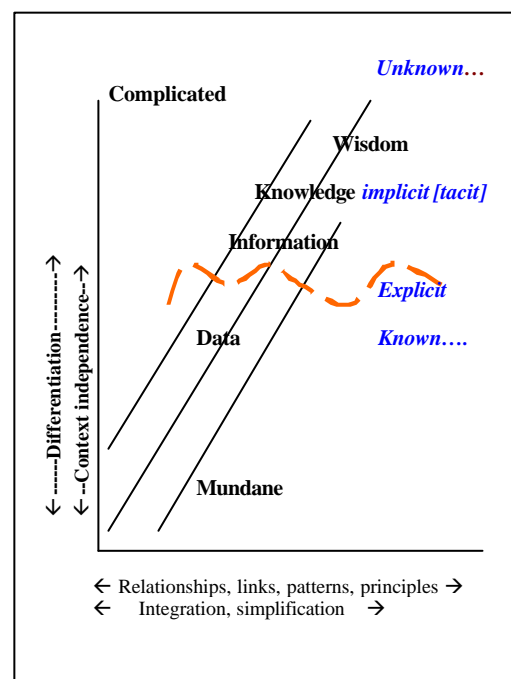


*Figure 1: Data, Information, Knowledge, Wisdom Adopted from Bellinger, and modified.*

In short, supplementing Gene Bellinger, we summarise the DIKW as follows: (Bellinger, 2004) [*italics* mine]:

- **Data** is just a meaningless point …. without reference to either space or time. It is like an event

out of context, a letter out of context, a word out of context….. *is/refers to a number, letter, word, signal…having no meaning or use standing alone.*

- **Information** relates to description, definition, or perspective (what, who, when, where)… *is data related, connected, understood, interpreted, aggregated, analysed in order to be of some meaning and value to the user...*

- **Knowledge** comprises strategy, practice, method, or approach (how)…*is information personalized, memorised, reinforced, rationalised by actions and experiences, with context sensitive revision and re-applicability, including predictive capabilities, yielding higher value to the user in terms of cost, quality, time ...*

- **Wisdom** embodies principle, insight, moral, or archetype (why)… knowledge *simplified, verified, synthesized, crystallised, principled…..yielding satisfaction and value to user and society...*

'Intelligence' in this context refers to the 'mental [intellectual] capabilities of individuals' to learn, to reason, to act and so on, based on 'data, information, and knowledge' (Wikipedia contributors, 2006). Intelligent enterprises see the value of 'knowledge and wisdom' 'tacitly buried in the minds' of its stakeholders [including employees] at individual levels, and are keen on 'transferring' such 'tacit' assets into 'explicit' format, so that such assets become part of the organization, and thereby be sharable, usable, expandable, improving the entire enterprise management. In other words, 'intelligent enterprises' seek to become so, by seeking and using information systems that facilitate transfer and management of 'intellectual assets of its stakeholders' from 'tacit' to 'explicit' format.

Indeed, a gamut of technologies involving artificial intelligence and neural networks are working hard at transforming 'the tacit' into 'the explicit'. Efforts in this direction have brought about 'intelligent' machines and systems, certainly not as a 'substitute' for, but essentially as 'supplement' to, individuals who constitute and contribute to the organization. These 'intelligent machines and systems' use and include: artificial intelligence, expert systems, fuzzy logic systems, hybrid systems, and so on.

Other attributes and qualities of 'intelligent enterprise' include 'capacity to generate and support innovative, pioneering initiatives….leading to significant impact on cost, time, and quality (Network Magazine, 2005).

Based on the foregoing conceptual clarifications and terminology explanations, we define as follows:

- *IIIS is an enterprise-wide information system, made up of several sub-systems and components and devices including intelligent systems,*
- *designed and deployed in harmonious alignment with the enterprise's business goals,*
- *encompassing and improving all enterprise management functions at operations, tactical, and strategic levels, through quick and correct decisions and actions and processes, both immediate and futuristic,*
- *by its empowered, tech-savvy, skilled, responsible, and accountable employees, properly trained in,*
- *leveraging ICT effectively,*
- *facilitating cooperative and collaborative teamwork,*
- *building and sharing knowledge,*
- *yielding significant synergistic benefits in terms of cost, time, and quality to all stakeholders of the enterprise.*

The reader will note that the keywords 'integrated' and 'intelligent' are implied throughout the definition, and also that IIIS goes well beyond knowledge-bases, business intelligence, data mining and data warehouse. While drawing upon ICT, it also emphasizes: the importance of employees in terms of their training, attitude, intelligence, knowledge, skills, and teamwork; alignment of ICT to enterprise goals; and integration of all functions and processes to obtain synergistic benefits for the enterprise. IIIS incorporates intelligence into the enterprise.

With this definition and meaning in place for the 'IIIS', we shall now address in the next sections the other key questions raised in the beginning.

## 3.0 WHY IIIS?

As noted earlier, the need for enterprises to become 'intelligent' and 'knowledgeable' has become all the more great and urgent, given the complexities and challenges in the K-era. Ruggles (1998) notes, quoting Peter Drucker, that "knowledge has become the key economic resource and the dominant - and perhaps even the only - source of comparative advantage".

Cost, time, and quality [CTQ] are key considerations in business today. The enterprise which is agile, sensitive to the environment, and quick to act and pro-act can only distinguish itself from others, survive and grow in the emerging borderless globalised markets.

Intelligent, knowledge-based, wise decisions lead to savings in cost to produce, time to deliver, and thus improve overall quality of service/products. IIIS facilitates such a decision-making process.

There are other emerging factors calling for a variety of responses from the enterprise. For instance:

- global competitive pressures call for alert and pre-emptive strategic initiatives;
- global customer whims call for smart handling of complex demands about quality and price, and involve mass customisation;
- increasing number of compliances with international, national and local agencies, call for prompt and transparent reporting on a large scale;
- intellectual property rights and obligations, call for proper and correct documentation and documents management;
- confidentiality and privacy issues, call for extra care and attention to the way data and information of stakeholders is stored and accessed;

The list is just indicative, and interestingly applies to even small and medium enterprises [SME] as well as not-for-profit [NFP] [both government and non-government [NGO]] organisations. In order to handle the various responses listed, enterprises and organisations should consider using an appropriate IIIS.

Indeed, a growing number of enterprises including SME are adopting ERP [branded integrated information systems] more as a strategic initiative, seeing long term benefits in adopting ERP. By virtue of definition and meanings as discussed, IIIS adds the 'knowledge' and 'intelligence' dimensions to ERP, and thus becomes a very important business enabler.

Intelligent enterprises build, add-on, and integrate information sub-systems that can make significant CTQ contributions in many ways. See for example such contributions in Indian cases of award-winning intelligent IT deployments (Network Magazine, 2005). These enterprises [names of companies/ organisations within square brackets] have achieved: risk reduction [credit card fraud preventive detection system at HDFC Bank], higher customer retention and loyalty [CRM at New Delhi Power Ltd], better citizen service and increased revenue generation [Citizen Facilitation Centers by Kalyan Dombivili Municipal Corporation], improved service delivery set up [fully-digital broadcasting at All India Radio], flexible ticketing [centralized purchase and management of unreserved tickets by Center for Railway Information Systems for Indian Railways]. It is thus clear that IIIS applies to all types of industry and service organisations and enterprises.

An appropriate IIIS can, and should, give leading 'knowledge' and 'intelligence' edge to an otherwise ordinary enterprise.

## 4.0 THE APPROACH & A FRAMEWORK

Having established the meaning of and need for IIIS, let us raise and answer some key questions like: Is there a standard IIIS? Is it possible to create and sustain enterprise-specific IIIS? How to approach the design, development, and deployment of such an IIIS?

Given our definition of IIIS, and as it is made up of several sub-systems and components, some of which may be available as ready-made package, no standard ready-made product available in the market would fit the requirements completely. Nor will extensive customisation and integration be easy. The question therefore of buying off-the-shelf IIIS, and customizing it, does not arise. A combination of some ready-made and some tailor-made parts is a much better and more viable option, and more about this will be discussed later.

Answer to the next question about enterprise-specific [appropriate] IIIS, is therefore, an emphatic yes. It is both desirable and necessary to design and deploy enterprise-specific IIIS, mainly because the goals [apart from profit maximization] and the means [processes] of accomplishing such goals could be different among enterprises. Even within industry, and lines of businesses, differences exist in terms of management style, philosophy, organisational ethos, and so on. Cultural and environmental factors also contribute to the differences in the ways enterprises are run and managed. While for common benchmarkable processes, standardized sub-systems and components can be brought and plugged in, for non-common and unique and differentiating processes and parts, the enterprise must still go for its own designing. So, how does one approach the question of designing, developing, and deploying enterprise-specific [parts or whole of] IIIS?

The various parts of our definition itself indicate a logical and systematic approach to the question. The following 7-step list takes us through the process:

4.1. Understand the business and strategy, in order to align IIIS. For this, the designer must understand the business and strategic orientation of the enterprise. Specifically, the understanding should cover: size, line of business, nature of products and services, market share, competition, financial strength, and strategic plans and initiatives. Alignment implies ensuring that complete IT processes are in tune with the strategic plans and initiatives, in terms of CTQ.

4.2. Identify, and decompose into, components and sub-systems that are unique to the enterprise, categorizing them into 'basic automation' and 'learning intelligent' systems. While the former deals with information processing, the latter deals with building and growing institutional knowledge bases. Prioritize these sub-systems and components for development and integration, considering OSS [Open Source Standards] and

OOAD [Object Oriented Analysis, Design, Development] methodologies.

4.3. Integrate legacy systems if any, including ERP if applicable, through EAI [enterprise applications integration] tools, ensuring interoperability, compatibility, scalability, and security.

4.4. Concentrate first on basic automation components, including OPS [operations system]; OA [office automation]; DMS [documents management system], and DSS [decision support system].

4.5. Add on intelligent components: ES [expert system]; WFO [workforce optimization]; BI [business intelligence].

4.6. Pay special attention to data issues: meta data integration; data quality automation; ownership; accountability, traceability, learning from history.

4.7. Monitor, review, and revise the IIIS, keeping TCO [total cost of ownership] and TCOP [total cost of operations] in check.

The reader will notice that the approach considers a number of points and perspectives for designing, developing, and deploying enterprise-specific IIIS, significant among them being: the enterprise-pervasiveness, business goal alignment and therefore appropriateness, nature and lines of business including size, intelligence and automation components, gradual progression through the DIKW spectrum, keeping an eye on the overall TCO and TCOP.

A multi-dimensional framework incorporating the foregoing perspectives, points, and approach is presented in Figure 2.
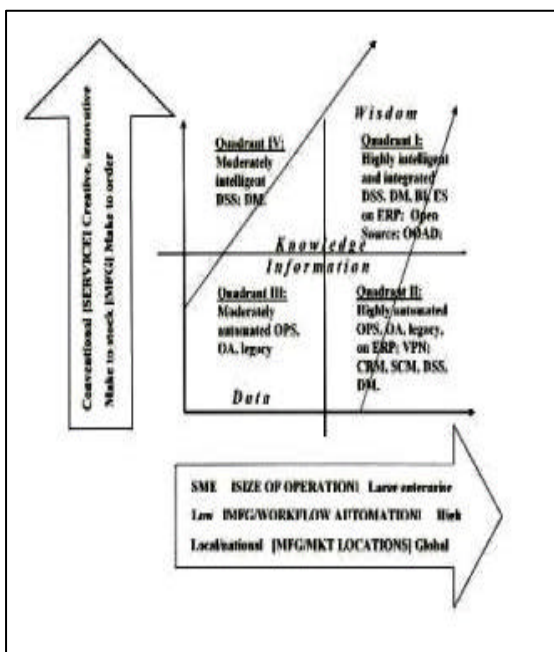


*Figure 2: IIIS - DIKW: A Multi-Dimensional Framework*
*[A4 size version at the end]*

## 5.0 THE RIGHT OPTIONS & JUSTIFICATION

As the reader will notice from Figure 2, an enterprise can have several options in the course of designing, developing, and deploying enterprise-specific IIIS. For instance, for an SME operating only in local markets with conventional manufacturing systems producing products on 'stock to sell' basis with some competition, a moderately automated OPS and OA would be good enough an IIIS to yield the intelligence, forecasting, and decision supporting components via applications [say legacy systems] and OA [Quadrant III]. For a large conglomerate operating globally with complex and geographically spread manufacturing and distribution processes, with big competing players around, an IIIS incorporating highly intelligent BI, ES, DSS, WFO sub-systems, running on highly automated ERP would be ideal [Quadrant I].

The figure also shows the DIKW dimensions as one traces the location of enterprise and therefore composition of IIIS.

Even within these options, sub-options exist like: buying vs. making of a sub-system; renting one; outsourcing one or more components. Even in home-growing option, OSS, OOAD, incremental and evolutionary developments merit serious consideration.

Ultimately, the choice would be ideally made when we consider two important factors: first is the strategic implication; and the second is TCO, TCOP, and benefits considerations. As noted earlier, many an enterprise consider adopting ERP, and now IIIS, more out of strategic compulsions than pure ROI considerations. There are a number of justification arguments for considering IT investments strategic. [See Padmanaban, 2005]. The second consideration is important because ultimately the overall effectiveness of IIIS can only be measured in terms of TCO, TCOP, and benefits [as many tangible as possible] both pre and on IIIS scenarios. Table 1 illustrates a tabular template listing some of these benefit factors at operations, tactical and strategic levels.

*Table 1: A Template for Benefit-Factors at three management levels: IIIS-Investment*
*[A4 size version at the end]*



Table 1:
A Template for Benefit-Factors at three management levels: IIIS-Investment
[Projected / Actual]

| S.No | Benefit Factors | Time 0 | Time 1.... |
|---|---|---|---|
| **OPERATIONS Level** | | | |
| | Time taken from Market Desire - Design - Production of new products/processes | | |
| | Number of Business Processes shrunk/with improved predictability and assurance of correctness/freedom from defects | | |
| | Number of Enquiries Generated | | |
| | Number of New Orders Generated | | |
| | Average Time Enquiry to Proposal | | |
| | Average Time Proposal to Order | | |
| | Average Time Order to Invoice | | |
| **TACTICAL Level** | | | |
| | Average Inventory Level | | |
| | Average Receivable Period | | |
| | Average Payable Period | | |
| | Number of Purchase Orders | | |
| | Average Value per PO | | |
| | Average Value per Order | | |
| | Decisions/Actions proven right and correct, by hindsight | | |
| **STRATEGIC Level** | | | |
| | New trends identified and strategies initiated | | |
| | Correctness in prediction of trends, competition initiatives | | |
| | Sale per person | | |
| | Number of Patents Generated and yield therefrom | | |
| | Number of IP Rights Generated and yield therefrom | | |
| | ... | | |

## 6.0 ISSUES BEYOND TECHNOLOGY

Regardless of the technology components chosen, the first and foremost area which requires attention is data itself. In the DIKW spectrum, the base is data and if that base is not clean, dependable, accurate, current, and complete, everything else that is built on it would be useless. A number of automation and intelligent tools are available to ensure good quality data. These tools should of course be supplemented by control procedures to ensure data ownership, traceability, and accountability.

While technology components are important, there are other issues beyond technology, for an effective deployment of IIIS, and making it work for the effectiveness of the whole enterprise. These include: employees; other stakeholders; management's commitment; cultural and environmental factors. Both in designing and in deploying IIIS, the expectations and willingness/preparedness of employees, impacts from organisational ethos, and environmental factors should be factored in. Empowerment, training, skill upgradation, and above all an atmosphere that transparently encourages and rewards intelligence, teamwork, and knowledge sharing with result orientation, are all equally important.

## 7.0 CONCLUSION

IIIS has become an important and powerful business enabler today. In the context of Internet, ICT, globalisation and liberalisation [in countries like India], post-WTO trends and pressures, only tech-savvy enterprises with appropriate IIIS can survive and grow. Intelligent enterprises aim and secure cost, time, and quality advantages by employing and exploiting IIIS. Given the options [both technology and non-technology] available, it is essential that one approaches the issue of designing, developing, and adopting enterprise-specific IIIS. This paper has attempted to provide a systematic step-by-step approach with a multi-dimensional framework and template, not only to adopt but also to justify IIIS on an on-going basis.

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**Conventional [SERVICE] Creative, innovative**
**Make to stock [MFG] Make to order**

*W i s d o m*

**Quadrant IV:**
**Moderately**
**intelligent**
**DSS; DM.**

**Quadrant I:**
**Highly intelligent**
**and integrated**
**DSS, DM, BI, ES**
**on ERP;  Open**
**Source; OOAD;**

*K n o w l e d g e*
*I n f o r m a t i o n*

**Quadrant III:**
**Moderately**
**automated OPS,**
**OA, legacy**

**Quadrant II:**
**Highly automated**
**OPS, OA, legacy,**
**on ERP; VPN;**
**CRM, SCM, DSS,**
**DM.**

*D a t a*

SME     [SIZE OF OPERATION]   Large enterprise

Low   [MFG/WORKFLOW AUTOMATION]     High
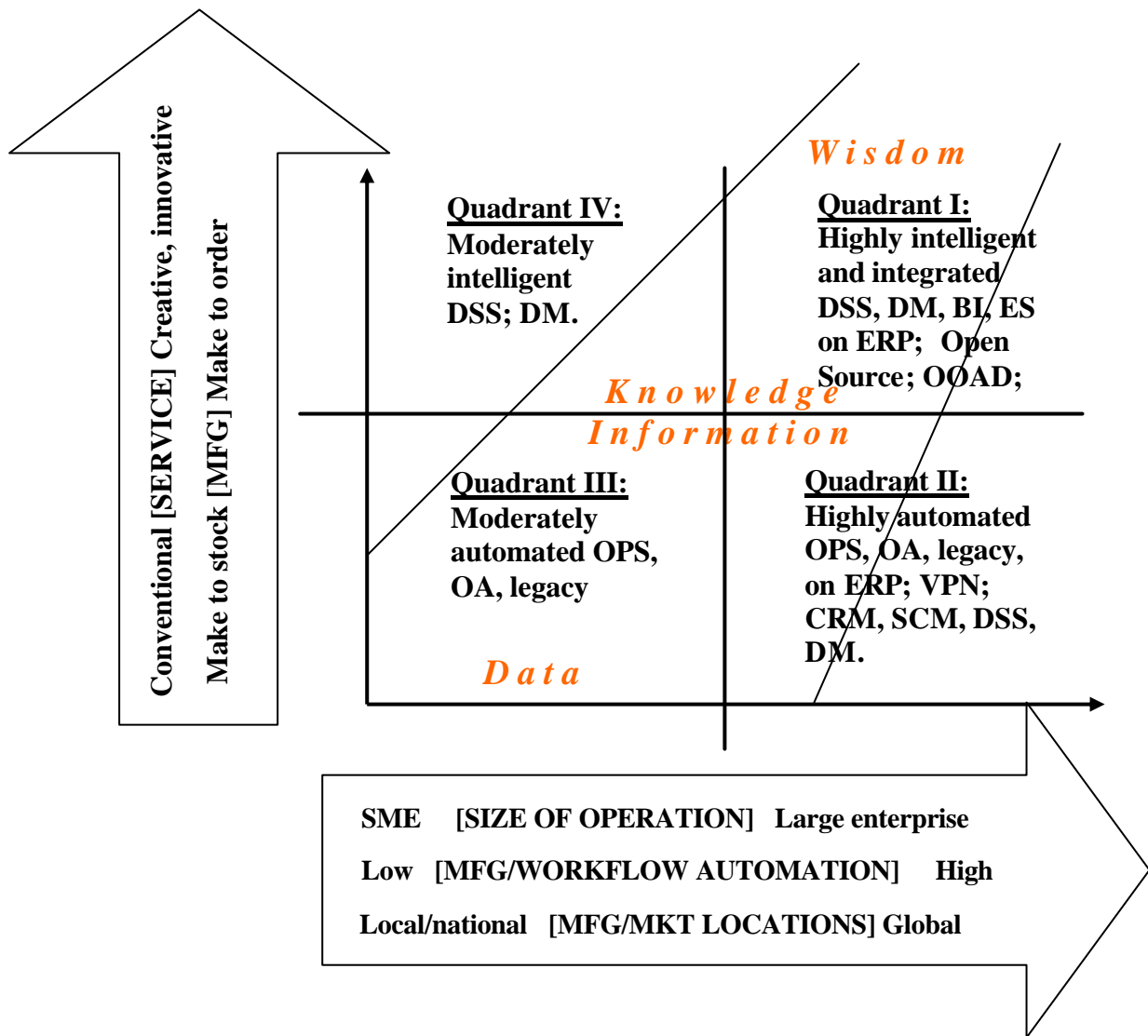
Local/national   [MFG/MKT LOCATIONS] Global

*Figure 2: IIIS - DIKW Options: A Multi-Dimensional Framework*

*Table 1: A Template for Benefit-Factors at three management levels: IIIS-Investment*
*[Projected / Actual]*

| S.No | Benefit Factors | Time 0 | *Time 1….* |
|------|----------------|--------|-----------|
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| | …. | | |
| TACTICAL Level: | | | |
| | Average Inventory Level | | |
| | Average Receivable Period | | |
| | Average Payable Period | | |
| | Number of Purchase Orders | | |
| | Average Value per PO | | |
| | Average Value per Order | | |
| | Decisions/Actions proven right and correct, by hindsight | | |
| STRATEGIC Level: | | | |
| | New trends identified and strategies initiated | | |
| | Correctness in prediction of trends, competition initiatives | | |
| | Sale per person | | |
| | Number of Patents Generated and yield therefrom | | |
| | Number of IP Rights Generated and yield therefrom | | |
| | … | | |