CRITICAL SUCCESS FACTORS FOR MANAGING SYSTEMS INTEGRATION

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System integration is a complex technological task, and an infrastructure decision that seems right today might well be obsolete tomorrow. This article proposes a framework of critical success factors (CSFs) that can be used to manage IS integration projects, according to a firm's current stage of IT integration maturity and other IS infrastructure characteristics. To demonstrate the potential utility of this CSF framework, the authors analyze case studies at two firms using 86 metrics for 20 CSFs developed by the authors.

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SYSTEMS INTEGRATION IMPROVES THE coordination of work undertaken by different parts of a company. The creation of a fully integrated corporation with application links to associates (employees), salespeople, and suppliers has become a means of responding to pressures of global competitiveness. However, despite the advantages a systems integration project potentially offers a company, these projects tend to have a high failure rate (Tuft, 2001).

The goal of this article is to propose a framework of critical success factors (CSFs) to manage information system (IS) integration projects that take into account the current level of integration of the organization's business and its systems. As part of this study, we also formulated a set of metrics to measure the CSFs for systems integration projects at different maturity levels. First we provide some definitions and introduce four levels of integration proposed by Schmidt (2000) that were used for this study.

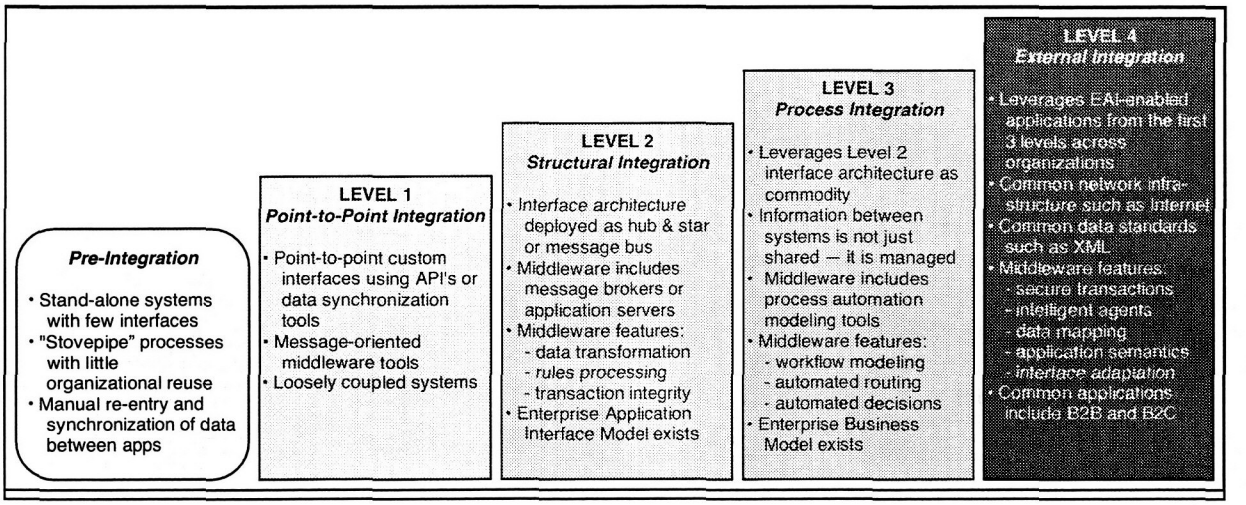
DEFINITIONS

According to Markus (2000a), Seeley (2000), and MacLaghant (1998), systems integration can be defined as the unification of a company's information systems and databases to improve the process flow and focus on customer services. Basically, systems are integrated to make existing systems consistent so that business processes flow more smoothly and information can be displayed in a unified way to support administrative and management decision making.

Phillip (2000) defines the integration of business applications as a corporate-level problem that requires a corporate-level strategy. According to Markus (2000b), in the best of cases, integrated business systems meet only about 70 percent of an average organization's needs. For example, data warehouses, enterprise resource planning (ERP) systems, intranets, and extranets are technologies that use different approaches to integrate processes with their corresponding IS. Further, many IS leaders are rewarded for finishing IS projects on time and on budget, but not for making those systems capable of integration with existing applications — hence, the necessity of fostering enterprise application integration (EAI).

EAI refers to the use of plans, methods, and tools designed to modernize, consolidate, integrate, and coordinate computer applications with the organization (McKeen and Smith, 2002). EAI acts as a high-performance

FIGURE 1 Integration of Applications — Maturity Model (Schmidt, 2000)



mechanism capable of achieving enterprise-level integration as well as improved relationships with customers. Corporate application integration can involve considerable time and effort, so corporations implement EAI only if they can envisage a good return on their investment.

It is thus quite acceptable for many companies to evolve gradually toward complete integration (Schmidt, 2000), with the goal of creating a fully integrated corporation, with application links to associates, salespeople, and suppliers, over time. According to Schmidt (2000), the integration of new applications with existing packages provides the functionalities needed to support a corporation's business process. However, the EAI challenge is to link different systems and applications efficiently throughout the corporation, thereby enabling the organization to not only survive but also rapidly respond to market changes.

To date, the EAI industry has focused on application-to-application integration (Davis, 2001). The considerations for automating the business processes, the process flow, and the people involved in the process itself were initially not a part of EAI. The inclusion of workflow integration in EAI makes it possible to integrate business processes, people, and different systems throughout the corporation, thus enabling companies to adopt a business process model how and when needed. But that is not all: it is also essential to choose the right integration tools for the targeted integration level, as described below.

INTEGRATION LEVELS

According to Schmidt (2000), integration can be attained at four different maturity levels (see Figure 1). These levels are essentially based on a company's current IT. It is necessary to first assess what information systems the organization has and what the scope of those systems are — such as access to data analysis tools, whether the flow of current business processes is optimal, what the interrelationship with the environment is, what E-business technologies it has, etc. Figure 1 summarizes the four integration levels proposed by Schmidt, which are introduced below:

- *Level 1: Point-to-point integration.* This level involves establishing a basic infrastructure for exchanging information between applications, although without any real business intelligence being linked to the infrastructure.
- *Level 2: Structural integration.* At this level companies use more advanced middleware tools to standardize and control the information exchange between applications.
- *Level 3: Process integration.* At this level organizations have made the transition from sharing information between applications to managing the information flow between applications.
- *Level 4: External integration.* At this level companies achieve external integration by real-time business applications, the transformation of business processes, and new customer-focused structures for redefining the organization.

The future is somewhat unpredictable as to the new tools that will be used for systems integration, because innovative technologies are constantly appearing. But one thing is perfectly clear: the organizational structure of companies has to be adapted for successful integration solutions and global business processes. Therefore, CSFs that can guide the systems integration process could be useful for achieving all four of these integration levels.

RESEARCH METHODOLOGY

The research methodology we followed to identify and develop the CSFs and their metrics is based on the Systemic Methodological Framework for IS Research developed by the Information Systems Research Laboratory (LI-SI, as named in Spanish), which was inspired by the Action Research (AR) method (Baskerville, 1999). This research methodology integrates DESMET methodology (Kitchenham et al., 1996) because it provides the most appropriate method for the evaluation phase in this kind of investigation (see Appendix A).

Specifically, a set of 20 CSFs and 86 metrics were developed based on an extensive review of material related to systems integration, EAI, integration levels, technology management literature, and referential documentation about CSF formulation (Rockart, 1979; Esteves & Pastor, 2001). Additionally, we reviewed input from experts in the field ("best practices") because the CSFs found in the literature were not operationalized and did not specifically address EAI deployment. We then developed a questionnaire to measure the extent to which relevant CSFs had been implemented at two selected case sites. Additional details are provided in Appendix A.

CRITICAL SUCCESS FACTORS

According to Esteves and Pastor (2001), a set of CSFs is the limited number of areas in which the results, if satisfactory, will guarantee successful competitive behavior for an organization and are based on common organizational objectives. Rockart (1979) was the first researcher to apply the CSF approach in the field of IS. His aim was to provide chief information officers with the necessary information about the CSFs of their organizations from a business manager perspective to help them develop IS solutions to meet the organization's most critical needs. Because achieving integration in an organization is an evolutionary process, the intent here is to develop a framework of general CSFs as well as CSFs specific to one or more levels of integration.

Table 1 shows the specific CSFs at each of the four maturity levels and the number of metrics developed for each factor. The ID numbers in the second column will be used later in the analysis of the two case studies.

Table 2 provides a list of CSFs, called general CSFs, that have been associated with multiple maturity levels. That is, some of the CSFs of one level may also be present in other levels, but with different relevance (Pinto & Slevin, 1987; Sumner, 1999; Esteves & Pastor, 2001). This is because they do not belong to a single integration level but to the integration process itself. Table 2 also provides their conceptual definitions, the levels to which they apply, and the number of metrics associated with each one.

As described previously, we also developed a set of 86 metrics for evaluating the presence of the CSFs. Table 3 shows an example of the seven metrics used for CSF G1: "Significant administrative support for the project." The other 79 metrics can be found in Appendix B.

Table 4 provides the decision rules for determining the level of acceptability for each metric and how the conformity level for the CSF was formulated. The conformity level for each CSF (Kitchenham et al., 1996) was determined based on interviews with IT consultants, surveys, and a literature review of experiences of companies around the world. The experts that participated in the validation of the content and the suitability of the CSFs also validated the acceptability measures.

Table 5 provides an example of how the conformity (i.e., existence) of CSF G1 was determined, based on calculations using the given case example.

APPLYING THE CSF FRAMEWORK: TWO CASE STUDIES

Two organizations renowned for the quality of their products/services and their long-term standing in the national market were selected for demonstrating the utility of the CSF framework and the associated metrics. Both companies were developing applications to integrate their information systems and business. For reasons of confidentiality, the names of these companies are treated as anonymous. We developed a survey instrument to determine the conformity level for each CSF, as appropriate for their desired integration level.

TABLE 1 Specific CSFs for Four Maturity Levels

Level	ID	CSF	Conceptual Definition	Metrics
Level 1: Point-to-point integration	1.1	Appropriate configuration of the communication software	Communication software installation and configuration to achieve point-to-point integration; useful for developing an interface to serve as a bridge between the different applications of the organization	3
Level 2: Structural integration	2.1	Standard data model documentation, unification and updating	Existence of a common, documented up-to-date data model; at this level the organization must have a business data model to guarantee, for example, consistent data and secure transactions	5
	2.2	Appropriate outsourcing management	Adequate project implementation; existence of management processes developed to ensure its success	4
Level 3: Process integration	3.1	Known organizational structure	Study of the structure within the organization and determination of its support for the integration process to be implemented	3
Level 4: External integration	4.1	Change determined and justified at a productivity level	Cost/benefic justification of the investment required in integration projects at this level, because they call for a high investment in terms of hardware, software, and experts, which requires a quantitative justification for the change	2
	4.2	Valuable support by senior management	Degree of commitment to the project by members of senior management; their vision and support is key to its development because applications at this level provide many tools for decision making on management issues	3
	4.3	Adequate management of project scope	Determine the existence of the objectives to be reached with the project; the project's scope, the characteristics to be covered, and the need to develop a new version must be defined from the outset	4
	4.4	Appropriate strategy of security	Existence of security strategies to safeguard the information and guarantee the reliability of the applications, because many of the applications between suppliers, the organization, and consumers are implemented through the Internet	4
	4.5	Effective outgoing and incoming communication	Exchange of effective communication within the organization, and also between the organization and the entire chain (suppliers, distributors, customers), to determine requirements and needs	3

Company A has been involved in the pharmaceutical industry for more than 100 years. Following Tapscott's (1999) classification, this company is *aggregated*, because it is structured hierarchically and acts as an intermediary between producers and consumers, having several distribution companies nationwide. At the time of the data collection, it was aspiring to develop business-to-business (B2B) applications with its suppliers and affiliates, business-to-consumer (B2C) applications with clients, and an intranet/extranet for internal communication. It currently has an ERP (modules of the same package) at each distribution company and a call center that deals with affiliates' requests. Using the above-mentioned applications, Company A's goal is to integrate the main members of its business chain (suppliers, affiliates, clients) — which are the goals of a level 4 company (see Figure 1). At the time of data collection, it was implementing B2B transactions with affiliates and had obtained B2B information from suppliers.

Company B is a services company with a nationwide presence and a head office in Caracas, Venezuela. Following Tapscott's (1999) classification, this company is a *value chain* firm. Its focal point is process optimization to

TABLE 2 General CSFs for Multiple Levels

Levels	ID	CSF	Conceptual Definition	Metrics
All	G1	Significant administrative support for the project	Support given by the company to consultants during the integration project, for better compilation of information and project follow-up.	7
All	G2	Complete technological infrastructure	Existence of a complete technological base comprising, for example, an internal network, operating systems, and adequate software releases, high-performance and highly scalable tools, and project development.	12
All	G3	Effective project leadership	Project leader's capacity and vision to attain the objectives set on time.	5
All	G4	Valuable project management	Appropriate project management; existence of management processes developed to guarantee its success.	3
2, 3, 4	G5	Relevant user involvement	Degree of commitment and cooperation of the users involved in the project within the organization, in order to define and share the business rules.	6
2, 3, 4	G6	Effective internal and external training plan	Existence of a training plan for users and the staff for assigning (in the case of high integration level applications) the components of the chain (distributors, suppliers, customers).	2
3, 4	G7	Effective organizational change management	Definition, control, progress, and prioritization of organizational and project changes, because high integration levels entail many processes and structural changes.	5
3, 4	G8	Low impact of information systems on the organization	Definition and compliance of the transition measures to be followed for reducing the impact when new application(s) are implemented.	4
3, 4	G9	Careful strategy of implementation	Definition of a strategy and its performance indicators, to be followed when the project is implemented. It is important to define how it must be done: by stages or all at once. Regardless of the strategy to be followed, a careful process is necessary to ensure "business as usual."	4
3, 4	G10	High-expertise project team	Having a project team capable of identifying information and supporting business decision-making processes to avoid these applications being rejected.	4
3, 4	G11	Helpful technical support	Having the cooperation of specialists in new tools. Tools must be obtained from manufacturers who offer additional support services.	3

achieve greater operational effectiveness to serve its clients and thus meet the growing demand in the national market. At the time of the data collection it was implementing an ERP and aimed to move up to a higher level of integration (level 4) in the future, based on this new system. This ERP project involves a change in technological platform for the company, because it will totally replace its present software; it has already trained its project team in anticipation. This application was at the design stage.

Together, these two case studies enable us to evaluate the CSFs in applications at different integration levels as well as at different stages of the systems' life cycles. Each CSF was measured with the authors' questionnaire. All members of each group participating in the projects at Companies A and B were the survey respondents, resulting in a total of 16 responses:

- 2 top-level managers (such as VP of MIS, CEO, CIO, and Human Resource directors)
- 4 middle-level managers (such as MIS managers, project managers, financial and administrative managers)
- 10 professionals (such as systems analysts, programmers, software engineers, administrators, office workers)

Of all respondents, 2 (12.50 percent) had a postgraduate degree, 5 (31.25 percent) had a graduate degree, and 9 (56.25 percent) had an undergraduate degree. Most degrees were in computer science, followed by engineering and business. The age of the participants

TABLE 3 Seven Metrics of CSF G1 (Significant Administrative Support for the Project)

Metric Name	Formulation	Lower Value	Higher Value
Definition of the mission and vision of the project	5 = totally defined 4 = almost totally defined 3 = fairly defined 2 = hardly defined 1 = not defined	1	5
Definition of the project plan	5 = totally defined 4 = almost totally defined 3 = fairly defined 2 = hardly defined 1 = not defined	1	5
Definition of the budget of the project/investment plan	5 = totally defined 4 = almost totally defined 3 = fairly defined 2 = hardly defined 1 = not defined	1	5
Allocation of the budget for the project $\left(\text{where } X = \frac{\text{Economic resources allocated}}{\text{Economic resources budgeted}}\right)$	5 = {0.8 < X1} 4 = {0.6 < X 0.8} 3 = {0.4 < X 0.6} 2 = {0.2 < X 0.4} 1 = {0 X 0.2}	1	5
Personnel's availability assigned for the project monitoring $\left(\text{where } X = \frac{\text{Times available}}{\text{Times required}}\right)$	5 = {0.8 < X 1} 4 = {0.6 < X 0.8} 3 = {0.4 < X 0.6} 2 = {0.2 < X 0.4} 1 = {0 X 0.2}	1	5
Conditioning of the offices for the work of the *project team* $\left(\text{where } X = \frac{\text{Offices conditioned}}{\text{Offices assigned}}\right)$	5 = {0.8 < X 1} 4 = {0.6 < X 0.8} 3 = {0.4 < X 0.6} 2 = {0.2 < X 0.4} 1 = {0 X 0.2}	1	5
Definition of strategies to inform the personnel about the project organization	5 = totally defined 4 = almost totally defined 3 = fairly defined 2 = hardly defined 1 = not defined	1	5

TABLE 4 Decision Rules for Determining the Level of Acceptability for Each Metric

Decision Rule	Level of Acceptability
If the response to the metric is closed (i.e., values of only 1 and 5):	5
If the response to the metric is 1, 2, 3, 4, or 5:	Values above 3 are taken, which is more than 50 percent.
If the response to the metric depends on another question:	The acceptability of the independent response is taken.

ranged from 25 to 59, with an average of 35.52 years. Their average length of service in their current job was 4.5 years. The project managers and systems analysts had been working an average of 12.3 years in software development.

CASE STUDY RESULTS

Our findings are presented in two parts. First we analyze the CSF results for each company. Then we compare those results to our four-level CSF framework.

TABLE 5 Calculating the Conformity Level for a Given CSF (G1)

Metric	Level of Acceptability and Conformity	Total Value Obtained	Total Difference
Defining the project's mission and vision	3	4.83	1.83
Establishing the project plan	3	5	2
Determining the budget for the project/investment plan	3	4.75	1.75
Allocating the budget for the project	3	5	2
Availability of staff assigned to prepare and follow up on the project	4	3.75	–0.25
Preparing the physical space for the work of the project team	3	4.625	1.625
Establishing strategies to inform the staff about the project organization	4	4.325	0.325
If % of difference ≥ 85% → 6 of the 7 variables must be present		(+6, –1)	85.41%

Note: The result for each factor is obtained according to DESMET (Kitchenham et al., 1996): once an acceptability value has been assigned to each metric, they are evaluated and the values obtained for each of them are averaged. Then, a column called "Difference" is created, where the value obtained, less the acceptability level, is calculated. If a negative result is obtained, that variable does not fulfill the acceptability level required. Then the positive and negative results are totaled and compared to the percentage of acceptability. This determines whether the factor is present (if it conforms or not) in the integration project.

Company A

As can be seen in Figure 2, Company A's integration project was deficient in only one general CSF (for levels 3 and 4) and one level-4 CSF:

CSF G9:"Careful strategy of implementation"
CSF 4.5:"Effective outgoing and incoming communication" (suppliers and distributors). This may result in the estimated budget for implementation being exceeded and also communication problems that in turn could translate into significant changes to be solved. The reason for this is that the later the project errors are discovered, the greater is their impact.

Company B

As can be seen in Figure 3, Company B's integration project did not satisfy one level-2 CSF:

CSF 2.1:"Standard data model documentation, unification and updating"

It also was deficient in two level-4 CSFs and the same general CSF as Company A:

CSF 4.3: "Adequate management of project scope"
CSF 4.4:"Appropriate strategy of security"
CSF G9:"Careful strategy of implementation"

Company B therefore needed to define more clearly certain aspects related to the project's scope. Because the implementation strategy was still at the design stage, the impact of the implementation strategy aspect (CSF G9) was less significant.

It is noteworthy that the company currently developing level 4 applications (Company A) has very high values for several of these factors, many of which were classified as general CSFs because they have a significant effect on multiple levels (see Figure 2). Company B's project, on the other hand, fulfills only the minimum level of acceptability for two general CSFs required for even a level 1 maturity:

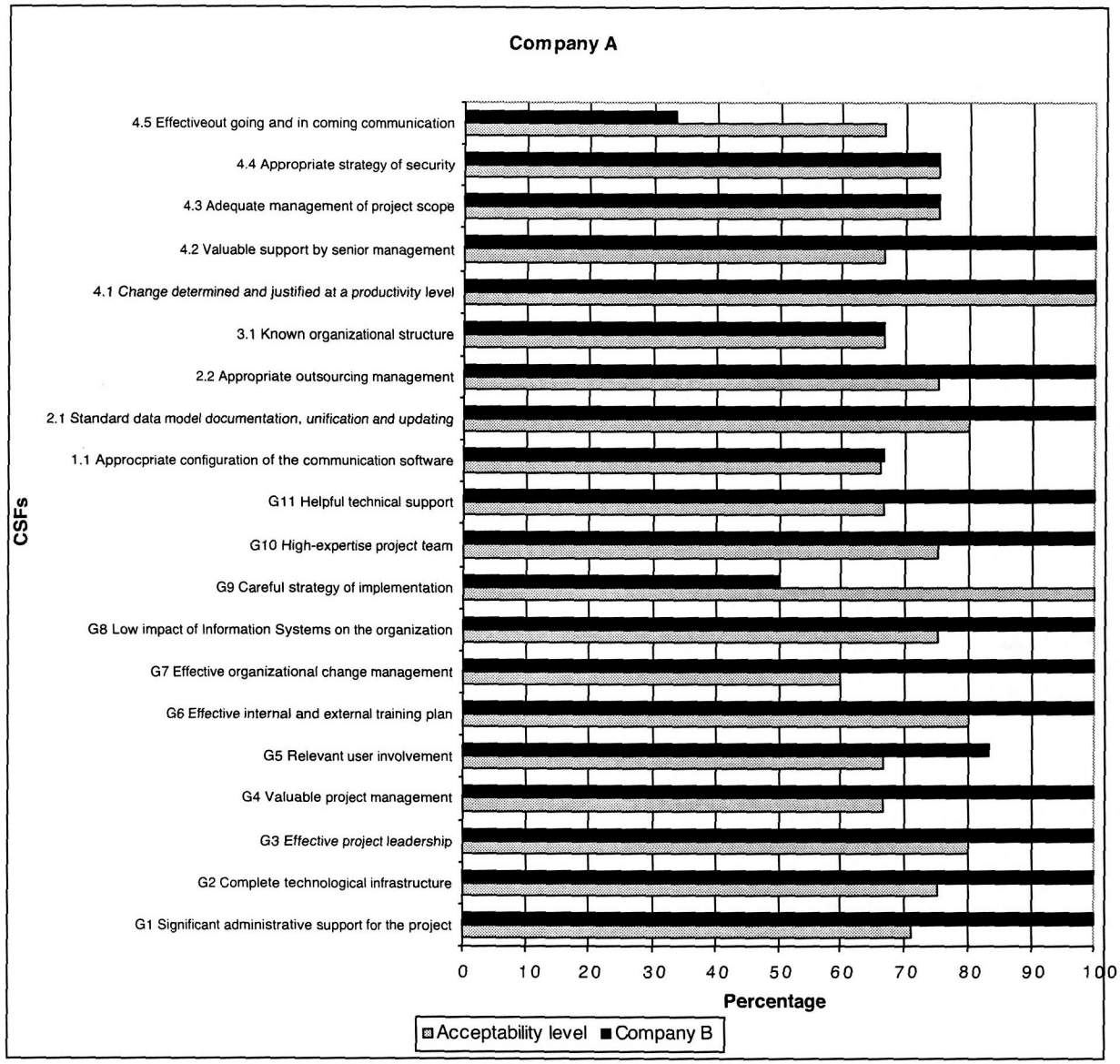
CSF G3:"Effective project leadership"
CSF G4:"Valuable project management"

Both CSFs, according to their conceptual definitions in Table 2, relate to the role of project managers, so the company needs to pay attention to these factors (see Figure 3).

Analysis of CSFs by Integration Levels

Level 1: Point-to-Point Integration. As can be seen in Figures 2 and 3, both companies' projects satisfied the level of acceptability for the CSFs for level 1. However, Company A's project scarcely satisfies CSF 1.1 ("Appropriate configuration of the communication software"), which is important for achieving point-to-point integration. Although this CSF includes

FIGURE 2 Company A: Percentage Obtained for Each CSF

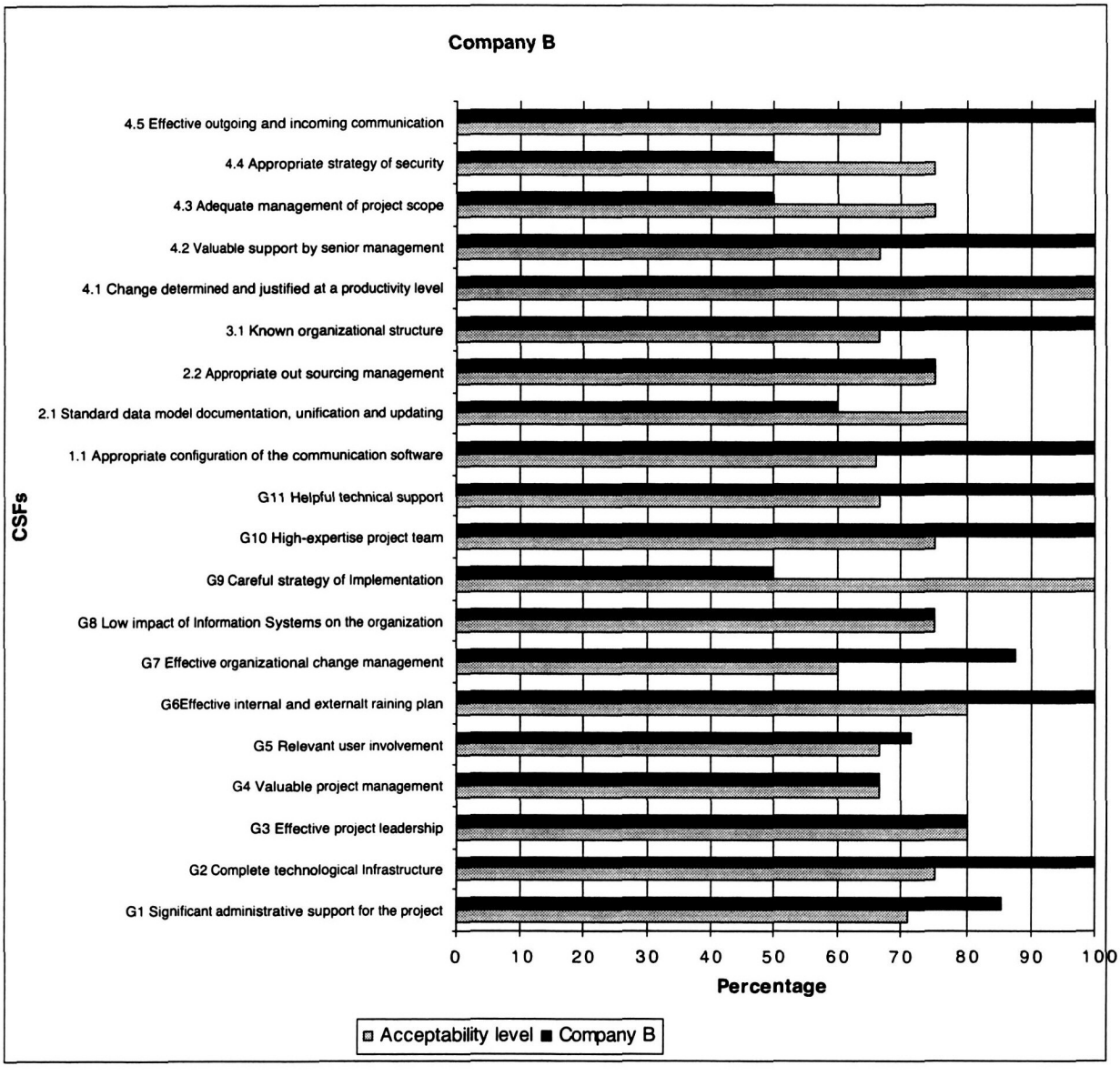


only internal communication software, it can negatively affect CSF 4.5 for external communications ("Effective outgoing and incoming communication").

Level 2: Structural Integration. In general, Company A has already attained level 2 of integration maturity. However, Company B's project does not satisfy CSF 2.1 ("Standard data model documentation, unification and updating"); as shown in Figure 3, value obtained was 60 percent, but the acceptability value was 80 percent. This CSF is important for preparing a successful integration project, because it is essential to start with a unified data model and keep all the information on the existing systems documented and up to date.

Level 3: Process Integration. As Figures 2 and 3 show, for both companies, the minimum acceptability level for CSF G9 ("Careful strategy of implementation") is not satisfied. This could be attributed to one of the following: (1) applications at this level are more complex and involve many changes in business processes, which increases the complexity of the implementation; or (2) the project team has not fully estimated implementation needs

FIGURE 3 Company B: Percentage Obtained for Each CSF



and may lack expertise in this type of implementation. However, for other CSFs at level 3, both companies fulfill the acceptability level. Certainly, these two companies have strong possibilities of reaching this integration maturity level.

Level 4: External Integration. Neither of the companies meets all the critical factors of level 4. Company A, which is currently developing an integration project with this level's characteristics, still must satisfy the factor not fulfilled at the previous level and must make follow-up efforts for the factors not satisfied at this level. Another vitally important CSF at level 4, which has not been satisfied by Company B, is CSF 4.4 ("Appropriate strategy of security"); the companies' information must be safeguarded, and therefore this factor must be considered from the start of the project.

Although if strictly analyzing the results of satisfied CSFs by level, Company A is at level 2 (structural integration) and Company B is at level 1 (point-to-point integration), in general the two companies' results are similar to our initial estimates prior to the calculation of the survey responses. As can be seen in the case study descriptions, Company A was aiming

toward applications with level 4 integration (B2B applications), whereas Company B was aiming to reach level 3 integration (implementing an ERP). However, based on our experience as researchers, the initial estimation for the two companies was that they had achieved level 2, and that levels 3 and 4 would be very difficult to reach. The analysis of the results confirmed our initial thoughts.

It is important to point out that the two companies, after reviewing the results, stated that the CSF framework applied in this study pointed out the organizations' strengths and weaknesses. It also provided a snapshot of these companies that they could use as a reference framework for making decisions about what must be improved, reinforced, and/or modified to achieve a desired level of integration.

CONCLUSIONS AND RECOMMENDATIONS

Business integration and IS integration can be competitive advantages for organizations. However, the complex and difficult nature of the integration projects facing companies is no secret, and some researchers are beginning to conduct studies and develop recommendations. Schmidt (2000) has proposed four integration levels with certain characteristics that must be reached for each level, thereby enabling an organization to be classified according to its IT integration attained.

We have proposed a set of 20 CSFs, and their 86 metrics, which can serve as a guide to be used by organizations when carrying out IT integration projects. These CSFs can be measured from the outset to determine which factors are lacking or fail to meet the proposed acceptability level. The framework also can be used to determine which factors, according to their integration levels, have a low acceptance value or still fail to meet the acceptability level and are likely to affect the achievement of higher integration levels. Last, companies can determine their current integration level(s). The proposed CSF metrics also can be used by future researchers to estimate a company's compliance level for each factor in a given integration project, because they are objective and repeatable.

Measurement of the proposed CSFs at different stages of the integration project is also recommended for two basic reasons:

- By being aware of CSFs, those interviewed undergo a process of change, which may be beneficial for the project, because some factors that were not considered at the outset begin to be taken into account in response to concern over whether or not they are being considered.
- It enables CSFs that fulfill only the previous aspect with the minimum level of acceptability, and are essential for the successful development of an integration project, to be reinspected.

The 20 CSFs proposed were applied through two cases studies of companies undertaking application projects to integrate their business and their systems. Both companies reported that the proposed CSFs for each level met their expectations and were considered part of the integration process, even though their companies failed to meet all of the acceptability levels.

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APPENDIX A: ADDITIONAL DETAILS OF THE RESEARCH METHODOLOGY

The research methodology we followed to identify the critical success factors (CFSs) and their metrics is based on the Systemic Methodological Framework for IS Research developed by the Information Systems Research Laboratory (LISI, as named in Spanish), which was inspired by the Action Research (AR) method (Baskerville, 1999) and integrates the DESMET methodology (Kitchenham et al., 1996) to choose an evaluation method. The instantiation of the methodological framework for this research is provided here (Figure A1).

1. *Documentary and bibliographical research to make up the theoretical referential framework.* This activity corresponds to the revision of the bibliographical material related to systems integration, enterprise application integration (EAI), integration levels, and prior research about CSF formulation — for example, Rockart (1979) and Esteves and Pastor (2001). It is extracted from different available sources (electronic included) to build a conceptual base that would serve as a reference to support the CSF formulation. The products obtained include a set of social, technological, and organizational aspects to be considered for identifying the CSFs and their metrics.
2. *Analysis of the background.* Based on the experiences of companies around the world on systems integration, interviews with consultants in IS and IT areas, and surveys and literature review made in the prior activity, we identified possible reasons for failure, best practices, and performance measures that may be useful in the research to be conducted.
3. *Formulation of the objectives and scope of the research.* During this activity, the scope of the research was formulated. Its inputs are the results of the two previous activities. The main result of this activity was establishing the following objective: to propose a set of CSFs that can be used to manage IS integration projects according to the integration level of the organization and its IS and IT infrastructure.
4. *Design of the set of CSF and metrics.* This was the first activity in the "taking action" phase. From the previous activities, 20 CSFs were proposed in a beta version, as well as the considerations of the context and cases in which they must be applied. To formulate the metrics of each CSF, we followed Basili's goal question metric (GQM) paradigm (Basili et al., 1994).

The GQM paradigm (see Figure A1-2) allowed us to formulate the CSF and its metrics following a top-down refinement of CFSs into questions and then into metrics, as well as a bottom-up analysis and interpretation of the data that would be obtained when applying them. From this step it was clear how the data obtained for the measurement would be analyzed, the presentation formats for this data, and the description of how to compare the measured data with the defined hypotheses when organizing the CSF for integration levels. This was considered as a basic guide to support the IS integration project manager with the "feedback" obtained from the measurement.

Finally, 86 metrics were defined. These metrics were inspired by an extensive review of material related to systems integration, EAI, integration levels, referential documentation about CFS formulation (Rockart, 1979; Esteves

FIGURE A1-1 Methodological Framework Used

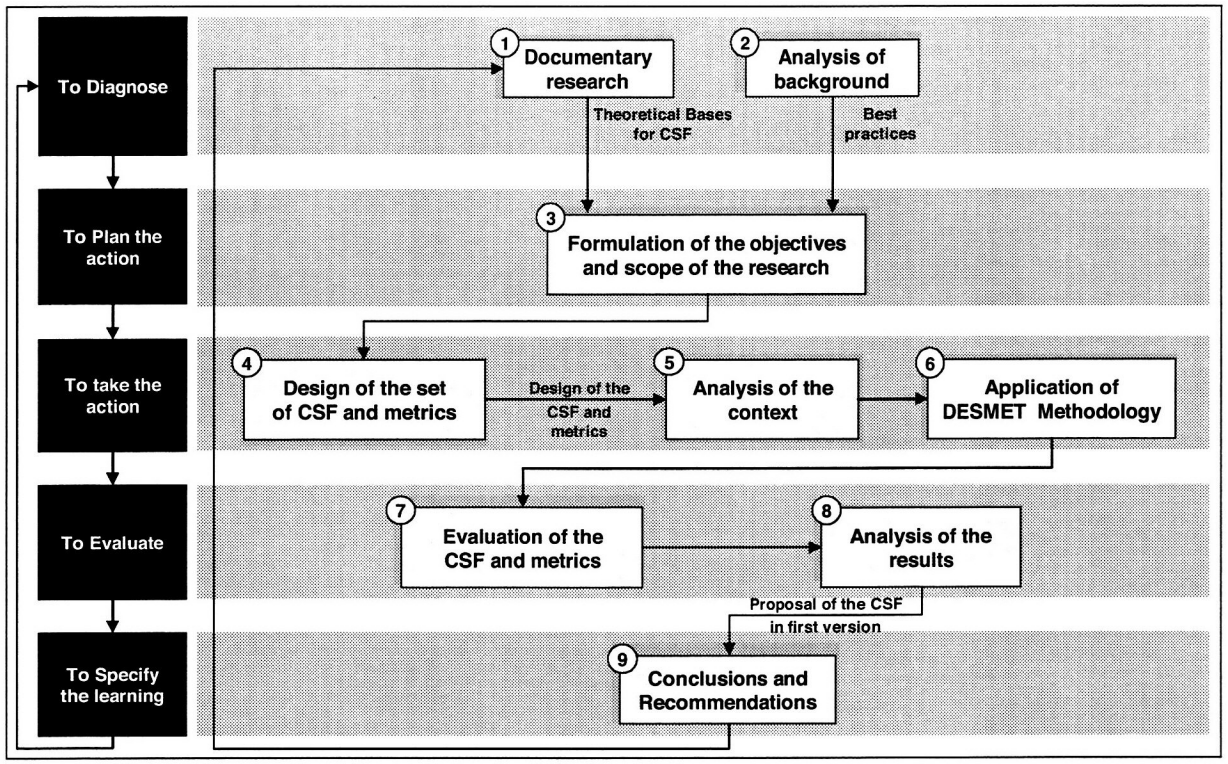
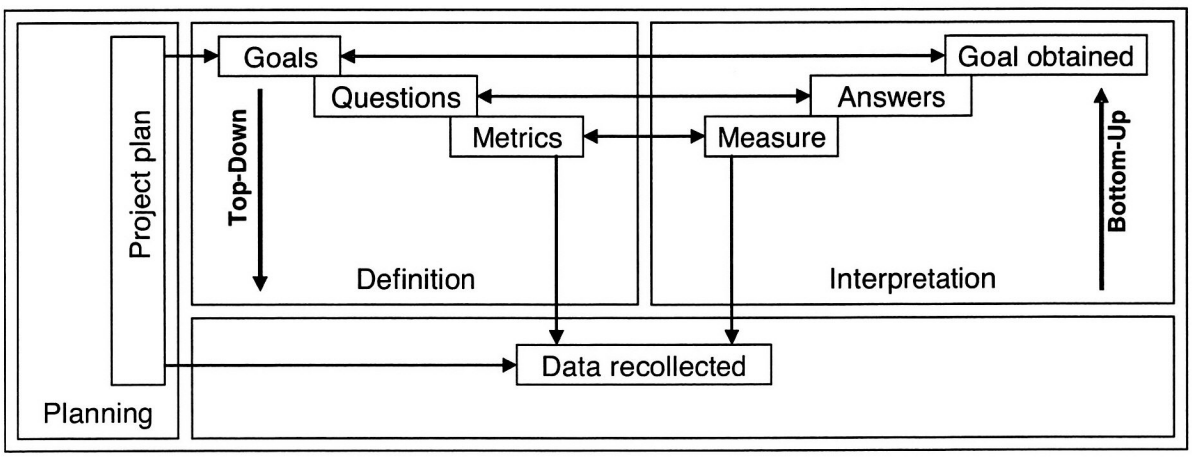


FIGURE A1-2 GQM Paradigm Phases (Basili et al., 1994)



& Pastor, 2001), and technology management literature.

5. *Analysis of the context.* This is the second activity of the taking action phase. The technical criteria proposed by DESMET were analyzed so that we could decide on the right evaluation method to be applied to the CFS produced in the previous activity.
6. *Application of the DESMET methodology.* This is the last stage of the taking action

phase. During this activity the DESMET evaluation was more widely adapted to the CFS selected. Because the CSFs would be applied to a real case study, the questionnaire was elaborated to include the 86 metrics.

Content validity, which assesses the completeness and reliability of the measurement, was established through the careful selection of items that had been validated in prior studies (Rockart, 1979; Pinto & Slevin, 1987; Sumner, 1999; Esteves & Pastor, 2001). To further reduce the possibility of any non-random error, three academic experts from different universities and two IS senior executives in the software development units were asked to review the questionnaire with respect to its validity, completeness, and readability. Their suggestions were carefully reviewed and the questionnaire was adapted accordingly so that it would better reflect industry practices and naming conventions.

Cronbach's alpha coefficient was calculated to assess measurement reliability.The results of Cronbach's alpha to the questionnaire was .9123, and the analysis showed that the reliability of metrics was higher than the value of .86 suggested by Hernández et al. (2002) for the early stages of basic research; principal component factor analysis was used to test this validity property.

7. *Evaluation of the CSF and metrics.* This is the first activity of the evaluating phase. The CFS proposal was evaluated using the method selected according to DESMET in the previous activity.
8. *Analysis of the results.* This is the second activity in the evaluating phase. It consisted of studying the results based on the objective in the research, in terms of the application of the evaluation method proposed by DESMET, the tangible products achieved, and the changes in the environment. By incorporating the changes needed, we obtained a second formal version of the CSF proposal for future iterations.
9. *Conclusions and recommendations.* In this activity within the specifying the learning phase, the conclusions on the CSF proposal already applied must yield satisfactory results; otherwise the scope of the next interaction of the AR cycle is reinforced.

APPENDIX B: CSF METRICS

In this appendix, all metrics used to quantify the value of each of the 20 CSFs are defined, with the exception of CSF G1 ("Significant administrative support for the project"), which appeared in Table 3 of the article. ▲

GENERAL CSFS

G2: Complete Technological Infrastructure

Metric Name	Formulation	Lower Value	Higher Value
Internal network installed $\left(\text{where } X = \frac{\text{Installed points}}{\text{Projected points}}\right)$	5 = {0.8 < X 1} 4 = {0.6 < X 0.8} 3 = {0.4 < X 0.6} 2 = {0.2 < X 0.4} 1 = {0 X 0.2}	1	5
Software existence to measure network yielding	5 = exist 4 = do not exist	1	5
Allocation of budget for the creation, update, or technological infrastructure acquisition that is needed for the project $\left(\text{where } X = \frac{\text{Economic resources allocated}}{\text{Economic resources budgeted}}\right)$	5 = {0.8 < X 1} 4 = {0.6 < X 0.8} 3 = {0.4 < X 0.6} 2 = {0.2 < X 0.4} 1 = {0 X 0.2}	1	5
Existence of a technical group with high knowledge of the present infrastructure	5 = exist 1 = do not exist	1	5
Existence of a technical group with high knowledge of the infrastructure that is needed for the project	5 = exist 1 = do not exist	1	5
Existence of plans for technology infrastructure training	5 = exist 1 = do not exist	1	5
Fulfillment of plans of training in technological infrastructure	5 = fulfilled 1 = not fulfilled	1	5
Existence of plans of update or technological acquisition	5 = exist 1 = do not exist	1	5
Fulfillment of plans of update or technological acquisition	5 = fulfilled 1 = not fulfilled	1	5
Existence of plan of early tests of technology and communicational infrastructure by project	5 = exist 1 = do not exist	1	5
Fulfillment of plan of early tests of technology and communicational infrastructure by project	5 = fulfilled 1 = not fulfilled	1	5
Existence of internal roles or "outsourcing" dedicated to the technical support and maintenance of the infrastructure	5 = exist 1 = do not exist	1	5

G3: Effective Project Leadership

Metric Name	Formulation	Lower Value	Higher Value
Keeping follow-up of project plan	5 = always 4 = almost always 3 = sometimes 2 = hardly ever 1 = never	1	5
Knowledge of business rules	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5
Capability of conduction of development groups or equipment	5 = excellent 4 = good 3 = medium 2 = low 1 = none	1	5
Ability for the decision making	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5
Use of some methodology of development	5 = is used 1 = is not used	1	5

G4: Valuable Project Management

Metric Name	Formulation	Lower Value	Higher Value
Existence of a clearly well-known methodology of development by all the equipment of the project	5 = exist 1 = do not exist	1	5
Objectivity of the feasibility study of the scope of the project	5 = objective 1 = not objective	1	5
Fulfillment of plans to comprise the managers of the organization with the objectives of the project	5 = fulfilled 1 = not fulfilled	1	5

G5: Relevant User Involvement

Metric Name	Formulation	Lower Value	Higher Value
Existence of a chronogram for interviews and meetings	5 = exist 1 = do not exist	1	5
Validation of information/making up the draft plans	5 = always 4 = almost always 3 = sometimes 2 = hardly ever 1 = never	1	5
Availability at the time of interviews and meetings	5 = totally available (80–100%) 4 = almost totally available (60–80%) 3 = fairly available (40–60%) 2 = hardly available (20–40%) 1 = not available (less than 20%)	1	5
Existence of an estimated test plan	5 = exist 1 = do not exist	1	5
Fulfillment of an estimated test plan	5 = fulfilled 1 = not fulfilled	1	5
Accomplishment of meetings for agreements	5 = always made 4 = almost always made 3 = sometimes made 2 = hardly ever made 1 = never made	1	5

G6: Effective Internal and External Training Plan

Metric Name	Formulation	Lower Value	Higher Value
Establishment of a plan for internal and external training	5 = completely established 4 = almost always established 3 = moderately established 2 = hardly ever established 1 = not established	1	5
Time destined for the training	5 = adequate 4 = sufficient 3 = medium 2 = low 1 = very low	1	5

G7: Effective Organizational Change Management

Metric Name	Formulation	Lower Value	Higher Value
Existence of a list of changes with priority	5 = exist 1 = do not exist	1	5
Fulfillment of the list of changes	5 = always 4 = almost always 3 = sometimes 2 = few times 1 = never	1	5
Existence of a reengineering process plan	5 = exists/it does not apply 1 = does not exist	1	5
Existence of people in charge of the changes	5 = exist 1 = do not exist	1	5
Communication of the benefits of the changes to the organization	5 = always 4 = almost always 3 = sometimes 2 = few times 1 = never	1	5

G8: Low Impact of Information Systems on the Organization

Metric Name	Formulation	Lower Value	Higher Value
Percentage of processes that have to be changed in order to implant the new information systems	5 = less than 5% 4 = between 10 and 5% 3 = between 10 and 30% 2 = between 30 and 50% 1 = more than 50%	1	5
Degree of dependency of the company with the information systems	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5
Dependency on the technical support and "outsourcing" during the implantation and stabilization of the new information systems	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5
Importance of the information systems in the decision making	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5

G9: Careful Strategy of Implementation

Metric Name	Formulation	Lower Value	Higher Value
Definition of a deployment strategy that has to be followed	5 = totally defined 4 = almost totally defined 3 = moderately defined 2 = hardly ever defined 1 = not defined	1	5
Existence of a user manual, aids, and technical support	5 = exist 1 = do not exist	1	5
Existence of a test plan for exchange of information that involves the chain (distributing, suppliers, etc.)	5 = exists 1 = does not exist	1	5
Measurement of the indicators for strategy performance	5 = always 4 = almost always 3 = sometimes 2 = few times 1 = never	1	5

G10: High-Expertise Project Team

Metric Name	Formulation	Lower Value	Higher Value
Business rules knowledge at the time of elaborating the applications	5 = completely 4 = almost completely 3 = moderately 2 = few 1 = not known	1	5
Control and validation of the information with users	5 = always 4 = almost always 3 = sometimes 2 = few times 1 = never	1	5
Group work experience on the tools to be used in the construction of applications for high levels of integration	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5
Group work experience in the construction of applications for high levels of integration	5 = very high 4 = high 3 = medium 2 = low 1 = none	1	5

G11: Helpful Technical Support

Metric Name	Formulation	Lower Value	Higher Value
Existence of plans for acquisition of support contracts	5 = exist 1 = do not exist	1	5
Preview experience with other clients with respect to the external support	5 = known 1 = not known	1	5
Dependency on the technical support team and external technicians	5 = very low 4 = low 3 = medium 2 = high 1 = very high	1	5

CSF OF LEVEL 1: POINT-TO-POINT INTEGRATION

1.1 Appropriate Configuration of the Communication Software

Metric Name	Formulation	Lower Value	Higher Value
Documentation of existing errors between the communication interface and the documented applications	5 = completely documented 4 = almost totally documented 3 = moderately documented 2 = hardly ever documented 1 = not documented	1	5
Rate of requests that have been interchanged successfully in a certain time $\left(\text{where } X = \frac{\text{Total of successful requests}}{\text{Total requests}}\right)$	5 = {0.8 < X 1} 4 = {0.6 < X 0.8} 3 = {0.4 < X 0.6} 2 = {0.2 < X 0.4} 1 = {0 X 0.2}	1	5
Fulfillment of test plans for the communication interface	5 = completely fulfilled 4 = almost completely fulfilled 3 = moderately fulfilled 2 = very few fulfilled 1 = not fulfilled	1	5

CSFS OF LEVEL 2: STRUCTURAL INTEGRATION

2.1 Standard Data Model Documentation, Unification and Updating

Metric Name	Formulation	Lower Value	Higher Value
Existence of personnel in the suppliers group with knowledge related to the applications installed in the organization and the business rules	5 = exist 1 = do not exist	1	5
Existence of maintenance and support contracts with the suppliers of the existing applications in the organization	5 = exist 1 = do not exist	1	5
Existence of documentation on the existing applications in the organization for each supplier	5 = exist 1 = do not exist	1	5
Documentation is updated on the existing applications in the organization for each supplier	5 = completely updated 4 = almost completely updated 3 = moderately updated 2 = very few updated 1 = not updated	1	5

2.2 Appropriate Outsourcing Management

Metric Name	Formulation	Lower Value	Higher Value
Existence of a database administrator	5 = exists 1 = does not exist	1	5
Existence of a database administrator contract for technical support	5 = exists 1 = does not exist	1	5
Documentation of the supported data models	5 = completed 4 = almost completed 3 = moderately completed 2 = very few completed 1 = not documented	1	5
Update of the documentation of the supported data models	5= updated 1= not updated	1	5
Existence of safety measures for the data access	5 = exist 1 = do not exist	1	5

CSF OF LEVEL 3: PROCESS INTEGRATION

3.1 *Known Organizational Structure*

Metric Name	Formulation	Lower Value	Higher Value
Amount of existing levels for decision making	5 = between 1 and 2 levels 4 = between 2 and 4 levels 3 = between 4 and 6 levels 2 = between 6 and 8 levels 1 = more than 8 levels	1	5
Importance of the department of systems within the organizational structure	5 = very high 4 = high 3 = medium 2 = low 1 = very low	1	5
Areas involved in changes of processes work jointly	5 = always 4 = almost always 3 = sometimes 2 = few times 1 = never	1	5

CSFS OF LEVEL 4: EXTERNAL INTEGRATION

4.1 Change Determined and Justified at a Productivity Level

Metric Name	Formulation	Lower Value	Higher Value
To consider cost/benefits of the project	5 = completely estimated 4 = almost completely estimated 3 = moderately estimated 2 = very few estimated 1 = not estimated	1	5
Existence of time estimation for the return of investment	5 = completely estimated 4 = almost completely estimated 3 = moderately estimated 2 = very few estimated 1 = not estimated	1	5

4.2 Valuable Support by Senior Management

Metric Name	Formulation	Lower Value	Higher Value
Approval of the budget for the integration projects	5 = completely approved 4 = almost completely approved 3 = moderately approved 2 = very few approved 1 = not approved	1	5
Existence of technological projection plans for the organization in the short, medium, and long term	5 = exist 1 = do not exist	1	5
Existence of plans for process updating	5 = exist 1 = do not exist	1	5

4.3 Adequate Management of Project Scope

Metric Name	Formulation	Lower Value	Higher Value
Existence of different versions of the project according to the characteristics that are needed to be covered by each version	5 = exist 1 = do not exist	1	5
Definition of the risks involved in the project	5 = totally defined 4 = almost totally defined 3 = fairly defined 2 = hardly ever defined 1 = not defined	1	5
Existence of plans of risk contingency and mitigation involved in the project	5 = exist 1 = do not exist	1	5
Communication to the equipment of the project scope	5 = completely communicated 4 = almost completely communicated 3 = moderately communicated 2 = very few communicated 1 = not communicated	1	5

4.4 Appropriate Strategy of Security

Metric Name	Formulation	Lower Value	Higher Value
Clear definition of the profiles for users and its permissions considering the surroundings of the applications	5 = totally defined 4 = almost totally defined 3 = fairly defined 2 = hardly ever defined 1 = not defined	1	5
Acquisition of the necessary security software and hardware	5 = acquired 1 = have not been acquired	1	5
Conforming of a technical support team in charge of the security	5 = conformed 1 = not conformed	1	5
Diffusion of the security norms	5 = always 4 = almost always 3 = sometimes 2 = few times 1 = never	1	5

4.5 Effective Outgoing and Incoming Communication

Metric Name	Formulation	Lower Value	Higher Value
Planning of the project considering all the chain (distributing, suppliers, etc.)	5 = yes 1 = no	1	5
Early tests of electronic communication between the organization and its chain (distributing, suppliers, etc.)	5 = completed 4 = almost completed 3 = moderately completed 2 = very few completed 1 = do not exist	1	5
Reliability of the security from inside toward outside and from outside inward	5 = very high 4 = high 3 = medium 2 = low 1 = very low	1	5