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A CONCEPTUAL FRAMEWORK FOR INTEGRATED PROGRAM AND PROJECT MANAGEMENT

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ABSTRACT
Conventional thought dictates that what cannot be measured, can not be improved. In a quest for improved operational and financial performance, Architecture, Engineering, and Construction (A/E/C) industry participants have developed numerous systems and measures to benchmark and categorize project execution. Unfortunately, their efforts have fallen short in two critical areas: applicability beyond the project boundary and ability to enable proactive decision-making. To remedy this situation, a conceptual framework was developed to create a comprehensive indicator for integrated program and project management performance. Known as ARIES (Agile Resource Information and Execution System), this framework balances the resource utilization requirements of projects and programs with the cumulative amount of time available to an owner for facility occupation. Additionally, the framework incorporates contract value to produce consistent measures that provide multiple comparisons independent of project scope or delivery system choice. Such analysis allows A/E/C enterprises to align their organizational visions and plans with their project portfolio, permitting proactive decision-making regarding future work, growth, and competency development. Eventually this framework will allow today's disconnected delivery process to become one integral to predictable A/E/C enterprise success.

KEYWORDS
Program Management, Strategic Thinking, Performance Measurement, Resource Management

1. THE MANAGEMENT CHALLENGE

Engineering and construction companies must make radical changes to their project management techniques if they are to be successful in the global marketplace in the 21st century. Customers will continue to expect lower costs, shorter engineering and construction periods, and prompt attention to their needs. These expectations mean that dramatically new approaches will be required not only in the organizational structure of such companies, but also in their way of thinking (Kini, 2000). Companies in the Architecture, Engineering, and Construction (A/E/C) services marketplace must be able to reconcile internal corporate objectives with their customers' project demands. They must do so mindful of both their long-range plans and the near-term realities of their existing competencies. Most importantly, A/E/C firms must realize that the management challenge of the future requires a consistent, systematic, and singular focus able to encompass all aspects of employee development, business process redefinition, and the ability to cope with an increasingly uncertain business environment.

1.1 Fostering Employee Development

Today's A/E/C professionals are entering into, and working within, the industry with only a narrow, project-level knowledge base that is insufficient for activities required of senior and executive-level positions (Chinowsky, 2000). It is improbable to think that most A/E/C company executives would be able to adequately address corporate-level management issues from a project-level perspective, yet this is exactly the situation that exists in many firms. In fact, in the early 1990's, many construction industry analysts began to call for a new kind of construction executive who understands not only project-level engineering and management, but also comprehensive construction company management as well (Krippaehne et al, 1992). This dichotomy can be rectified in two ways: either by educating A/E/C professionals in traditional business and management topics, or by enhancing their existing project-level knowledge with program management concepts consistent with their firm's framework, goals, and structure.

1.2 Redefining Business Processes

Business processes in the A/E/C industry have either a company or project-level focus. Company-level business processes support ongoing organizational operations to sustain business, while project-level business processes support the administrative aspects of project operations (Soares and Anderson, 1997). Although both business processes share many common themes, few methodologies exist, if any, that formalize concurrent product, process, and organizational design. This situation is compounded by the fact that there are no generally-accepted procedures that support single-project, multi-project, or industry-wide integration (Fischer et al, 1998). If such procedures did exist, A/E/C companies would be able to assimilate all their project-level activities within an overall organizational context. Fortunately, this type of assimilation can be created within an intermediary framework of integrated project and program management concepts.

1.3 Coping in an Uncertain Business Environment

It has been said that the only constant in business is change. Companies in the A/E/C industry can certainly attest to the volatility and cyclic nature that typifies their business environment. In order to cope with an ever-changing business landscape, A/E/C industry firms must begin to organize and operate differently than they have in the past. Primarily, this means thinking strategically about their business processes and corporate structure. In contrast with strategic planning, which attempts to forecast the future business climate and position the firm to meet anticipated market needs, strategic thinking requires that companies adopt agile organizational structures and business processes able to adapt to market demands. While this distinction may seem small, the results are not—often representing the difference between success and failure. Going forward, A/E/C companies who use strategic thinking to their advantage will be able to face an uncertain business environment with confidence. Their business processes and project portfolios will form an integrated framework that promotes performance regardless of market conditions.

So, the question remains; what do the above, seemingly divergent topics have to do with each other? On the surface, the topics appear to be unrelated. Conventional construction management research advocates numerous and different solutions for each topic. However, the proliferation of solutions for every topic in construction management is not the answer. Rather, it is the problem. A/E/C industry companies cannot continue to wade through a dizzying array of solutions for every problem they encounter. These companies need a straightforward and comprehensive solution that incorporates different topics into an integrated whole. In construction management practice, the whole is certainly more than the sum of its parts. 21st century research in construction management must focus on the whole by enhancing A/E/C enterprise capabilities as opposed to seeking topical efficiencies. Viewed from this perspective, the three topics described here are not individual problems, but outcomes that stem from the lack of a consistent and systematic approach toward A/E/C enterprise management. This is the management challenge. A framework for integrated program and project management is the appropriate response.

2. PROGRAM MANAGEMENT DEFINED

Program management is typically defined as "The coordinated management of a portfolio of projects to achieve a set of business objectives (CCTA, 1993)." While this definition does relay the importance of tying execution effectiveness to organizational and enterprise goals, it does not explain the different variations and organizational expressions of program management that result from different portfolios of projects. Generally, it is accepted that four types of program management exist, each differing in their approach toward the portfolio (Reiss, 1996):

- *The Multi-Project Organization*—management of a portfolio of projects that benefit from a consolidated approach and integrated within an organization that undertakes project work exclusively.
- *The Mega Project*—management of a portfolio of projects towards one specific objective. The US Apollo Space Program is a good example of numerous different projects culminating in a successful lunar landing.
- *Numerous Projects for One Client*—management of a series of projects within an organization and for the same client. Projects may differ, yet share similar organizational and technical standards.
- *The Program Management Organization*—management of a portfolio of projects all of which aim towards corporate objectives. Several institutional investors use this approach for their operations.

While programs differ in their treatment of project portfolios, all four program types share several common factors. Regardless of type, all programs involve many simultaneous projects, all concentrate on resources, and all need a multi-project view of scheduling (Reiss, 1996). In the A/E/C industry, not only can programs of each type be found, but many organizations also implement various iterations and hybrid arrangements of these program types. For example, large industrial-sector engineering, procurement, and construction (EPC) contractors organize client-specific task forces and alliances for a particular client within their Multi-Project Organization. In theory, this type of arrangement enables the EPC contractor to capture economies of scale while allowing task force designers to become intimately familiar with client engineering standards. However, these benefits can not be fully realized without a concerted focus on benefits and an understanding of program management issues.

Very few A/E/C enterprises formally define their work within a program management context. This is due to both a lack of knowledge regarding program management concepts and the overriding and incorrect belief amongst project management professionals that a program is merely a complex project. In practice, project managers try to address multi-project environments by using traditional project management tools and techniques (Kara et al, 2001). This promotes sub-optimal program results as individual project managers independently carry out actions to attract resources and attention for their own projects (Eskerod, 1996). Eventually, these conditions combine to create possibly dire economic consequences for any A/E/C firm that incorrectly or unknowingly performs program work.

Justification and viability are needed to ensure that sub-optimal enterprise results are not obtained. Being able to measure and compare the value of projects and programs leads to coordinated and consistent realization of benefits. In order to compare any project or program, three factors are normally used: (1) the value of the project to the organization, (2) the resources it will absorb, and (3) the risk of the project not reaching its objectives with those resources (Reiss, 1996). A/E/C firms that are able to justify and manage their projects and programs on the basis of resource utilization, benefit realization, and realistic risk mitigation hold the best promise for long-term success and viability. Fortunately, pioneering firms do exist. These firms have been able to view projects as materially different from, yet directly related to, their constituent programs. Within the A/E/C industry, such companies can be found amongst architecture and engineering design firms that focus on centralized prototype and site-adaptive design for program owners. In these firms, design activities typically encompass the "rollout" of similar facilities such as "big box" retail stores, service stations, and restaurant and hotel "chain" buildings. Not surprisingly, some of these A/E firms have a comprehensive plan for monitoring resource utilization, capturing benefits, and mitigating risk.

The performance of an A/E/C company extends beyond the boundary of the projects it performs. Overall operational and financial enterprise results are not simply the result of aggregate project outcomes, but rather an indicator of the firm's ability to manage projects and programs in a coordinated way. While the composition of program type and project mix varies from company to company, the need for integrated project and program management does not. This type of integration starts with a planning effort that understands the interrelations among the allocation of *resources*, the *timing* of activities, and *cash flow* (Speranza and Vercellis, 1993).

2.1 Resources

Basic project management functions such as resource allocation and resource leveling are amongst those that have been the least improved (Hegazy, 1999). Issues of resource utilization (i.e. allocation and leveling) are normally only considered by project management near the completion of project planning and after a networked activity schedule has been constructed. Following the calculation of the network's critical path, resource demand is considered. Resource leveling attempts to reduce sharp variations among the peaks and valleys in the resource demand histogram while maintaining the original project duration. Using leveling, project managers try to meet external resource demands, such as limiting project needs to the maximum number of specialized resources available to the project. This management technique is primarily premised on the belief amongst project

management professionals that a schedule efficiently employing limited resources, avoiding daily fluctuation, and reducing project duration is eventually less costly (Hegazy, 1999). Certainly, within the scope of project management, leveling has done an acceptably good job of accomplishing these objectives. In fact, numerous scheduling software programs implicitly incorporate resource leveling functionality. However, additional focus and techniques are required for appropriate resource management when program management is involved.

Program management requires that resource levels be much more fixed and static when compared to project management's treatment of resource issues. Simply stated, project managers tend to want to keep resource numbers down, whereas program managers want to keep utilization up (Reiss, 1996). In order to maintain steady resource numbers and comprehensive utilization, analysis of resource allocation is needed. Unlike leveling, resource allocation attempts to reschedule the project tasks so that a limited number of resources can be efficiently utilized while keeping the unavoidable extension of the project to a minimum. The technique tries to reduce the overall assignment duration of any individual resource on a given project. This is critically important when the resources are either available for only a short or specified duration, or when payment for the resource is duration-dependent (as is the case for rented construction equipment). Regardless, in a program environment, both resource allocation and resource leveling must work hand-in-hand to maximize utilization and overall benefits.

In both program and project environments, comprehensive evaluation of resource utilization is possible. Using a well-known heuristic algorithm known as the minimum moment algorithm (Harris, 1978), evaluation of both resource leveling and allocation can be accomplished. Basically, the minimum moment algorithm calculates the moment crated by a program or project's cumulative resource loading curve. Taking the curve's moment around the x-axis (M_x) yields a perspective of resource leveling in accordance with Equation 1.

$$M_x = \sum_{j=1}^{n} (\text{Resource Demand}_j)^2 \qquad \textbf{(Eq. 1)}$$

$$M_y = \sum_{j=1}^{n} [(1 \times \text{Resource Demand}_j) \times j] \qquad \textbf{(Eq. 2)}$$

Similarly, Equation 2 is used to calculate the moment about the y-axis (M_y) to permit a view of resource allocation. Summing these moments creates a double moment ($M_x + M_y$) that is useful in determining a project or program's overall resource utilization. Notice that the double moments are almost the same (189 vs. 190) for each different resource loading curve shown in Figure 1.

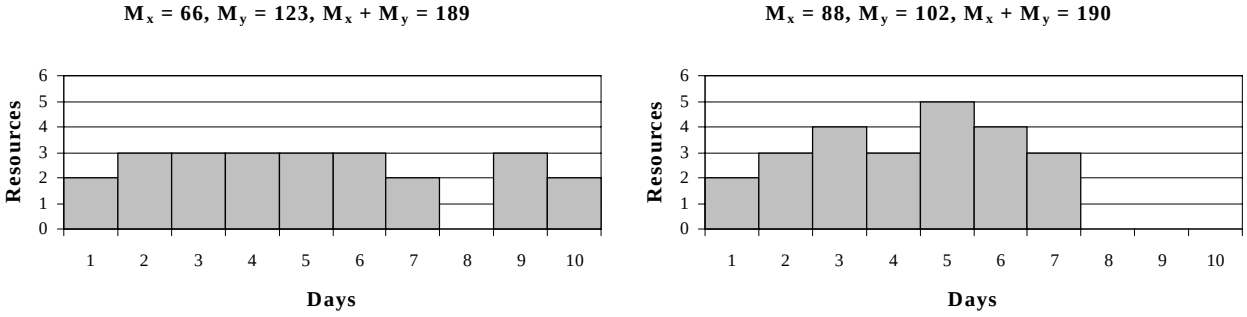

Figure 1: Resource Utilization Calculation Examples

Having the moment calculations defined, a manager may use them as modified heuristics according to the program or project's resource utilization objectives. Minimization of the double moments ($M_x + M_y$) is appropriate when a manager's objective is to reduce both daily resource fluctuation *and* the resource assignment period. This objective has a direct relationship to the minimization of time and cost, neither of which can be adequately achieved using mathematical optimization techniques (Hegazy, 1999).

2.2 Timing

Program managers have to worry about benefits. Program managers have to watch the environment closely to make sure that each project's objectives make sense and help the organization achieve its overall strategy. Within a program, managers have to be ready to drop a project altogether, modify others, and introduce new projects if the benefits of a program look like they're being whittled away (Reiss, 1996). Above all, program managers must carefully balance the benefits that accrue to both the program's owner and its A/E/C services provider in a consistent

and methodical way. Effectively, this means that program management is a responsibility that must be shared amongst all program stakeholders, even if their individual goals differ. For an A/E/C enterprise, remuneration for services performed is often a primary motivator. However, for a program owner, timing is a main concern. They depend on a program for its ability to quickly deliver a number of facilities which, when opened, typically add sizeable amounts of revenue to their operations.

Retail facility program owners use "revenue weeks" to track the progress of a project or program. Revenue weeks measure the cumulative amount of time available to an owner for facility occupation in any given year (or relevant planning period). This measure is very important because predictable delivery of facilities is required by owners in order to meet financial and operational projections that they have established for themselves. In many cases, these projections have already been communicated to investment analysts. Some sophisticated program owners are even beginning to tie the delivery of new facilities and the renovation and closure of existing facilities to their corporate management information systems for these same financial and operational reasons. Figure 2 shows a typical schedule profile for a retail program ("big box" stores, hotel and restaurant "chain" facilities) consisting of 15 planned projects and 350 revenue weeks.

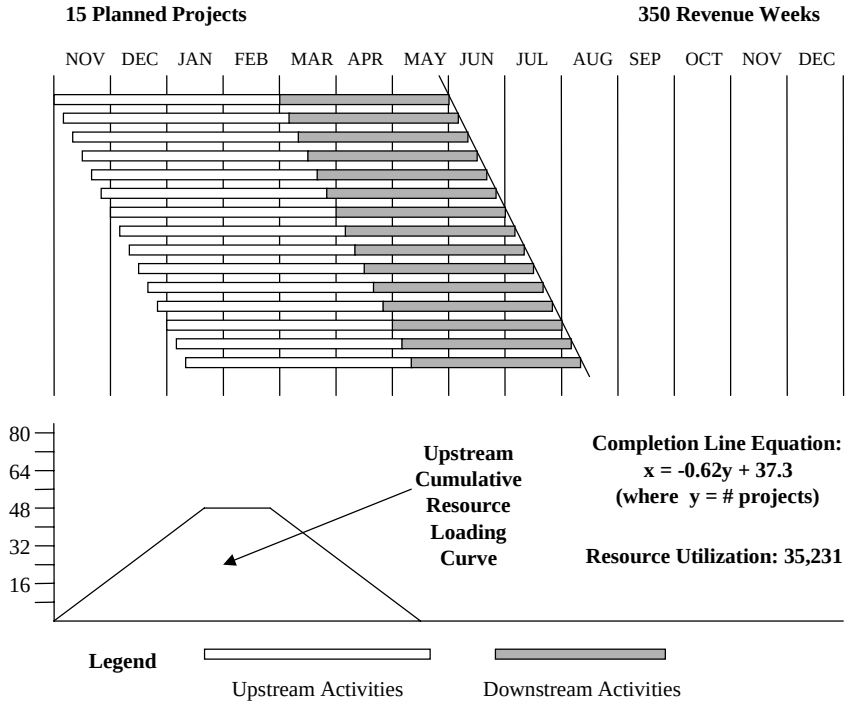

Figure 2: Typical Program Schedule Profile

In Figure 2, revenue weeks are calculated as the average area remaining between the program's "completion line" and the end of the program year multiplied by the number of planned projects. A sample calculation is shown in Equation 3 where the first project contributes 28.00 revenue weeks and the fifteenth adds 18.67 revenue weeks.

$$\textit{Revenue Weeks} = \frac{(\underline{28.00 \text{ weeks} + 18.67 \text{ weeks}})}{2} \times 15 \text{ slots} = 350 \qquad \textbf{(Eq. 3)}$$

Figure 2 also shows the resource utilization value for this program's "upstream" cumulative resource loading curve. "Upstream" activities refer to all activities that lead to the completion of project contract documents (C/D's) such as real estate, site development, design, and specification activities. In contrast, "downstream" activities are related to construction and start-up. The distinction between upstream and downstream is also used to distinguish between the "open" and "closed" portions of each project in the program. By definition, a project is "open" when a range of possibilities are available to influence its eventual configuration, such as in design. However, a project becomes "closed" once the scope is fully determined, such as in construction. This is why primary focus is given to the upstream activities in a program. After all, the ability to influence the generation of revenue weeks is greatest during the involvement of upstream providers when the project is open.

2.3 Cash Flow

A contractor's resource management objective should be consistent with their maximum profit or rate of return objective (Adrian, 1976). It should also be consistent with timing objectives set by the project or program owner. Fortunately, the interrelation amongst the three objectives is easily understood. Achievement of a greater number of revenue weeks impacts an A/E/C company's resource utilization. Increases in resource utilization are normally associated with increases project or program cost that often squeeze profit and rate of return margins. For these reasons, cash flow (i.e. contract value) from a project or program is critically important to the viability of any A/E/C firm. The most desirable scenario exists when an improvement in cash flow is accompanied by decreased resource utilization. If these goals are achieved without sacrificing project or program revenue weeks, benefits accrue to both the owner and their affiliated A/E/C companies.

Cash flow also has the ability to normalize the value of projects and programs, thereby promoting managerial integration between the two. Incorporation of cash flow with appropriate resource utilization and timing measures allows effective comparisons between different projects and programs. For example, two different programs could exist where each includes 15 planned projects and 350 revenue weeks. If one of these programs were undertaken to deliver small ice cream stores and the other to deliver large "big box" department stores, a discrepancy would exist between the resource utilization profiles of the two programs. Comparison between the two programs would not be possible without a normalizing factor such as cash flow. Obviously, the "big box" department store program would require a greater cash flow than the ice cream store program. However, by limiting the analysis of integration to resources, timing, and cash flow, comparative analysis and integration between projects and programs within any A/E/C enterprise is possible. Beyond the benefits of comparable progress reporting and consistent calculation of resource requirements (Payne and Turner, 1998), integration offers the potential to add new value and to create competitive advantage for all types of individual firms (Fischer et al, 1998).

3. INTEGRATED PERFORMANCE MEASUREMENT

By coupling the planning and control cycles for single projects and the portfolio of projects, an overall framework can be created to meet the multi-project challenge (Platje et al, 1994). A conceptual framework known as ARIES (Agile Resource Information and Execution System) was developed over the past two years by the authors to meet this challenge. The framework balances the revenue weeks and cash flow (i.e. contract value) generated by a project or program with the resources required to bring it to completion. ARIES uses the resource, timing, and cash flow analysis methods described in this paper to provide individual A/E/C firms with multiple comparisons between their various projects and programs that are independent of scope or delivery system choice. In many ways, ARIES is a not only a conceptual framework, but also a management system capable of integrated performance measurement.

However, no management system should be installed unless it (1) increases profits, (2) reduces risk, and (3) improves management control (Coulter, 1990). It might also be nice if the system simplified overall project and program management into an integrated process that advocates effective A/E/C enterprise management. ARIES facilitates the achievement of these objectives via a simple measurement shown in Equation 4.

$$\text{Efficiency Rating} = \frac{\text{Revenue Weeks } x \text{ Contract Value}}{\text{Resource Utilization}} = \frac{350 \; x \; \$450{,}000}{35{,}231} = 4{,}470 \qquad \textit{(Eq. 4)}$$

Using the calculated values shown in Figure 2 and a hypothetical contract value of $450,000, Equation 4 shows that a measurement can be created to quantify the conversion of A/E/C work into the delivery of benefits. While seemingly simple, an efficiency rating such as the one shown in Equation 4 can be a powerful means of promoting goal-congruent management at all levels within an A/E/C firm. Indeed, a measurement can be developed that is based on objective project performance and it can be successfully used to compare projects of different types and sizes (Griffith et al, 1999).

Although ARIES efficiency ratings are only relative to each other with a higher rating being preferable, they can illustrate performance gains achieved by reconfiguration of a project or program schedule profile. One way such reconfiguration could occur if an A/E/C enterprise was to change a project or program's resource utilization level. The utilization level on any single project or program would change given the completion or addition of any other ongoing work in the firm. It might also change given new technology, the outsourcing of work to other firms, or

redefined enterprise policies and business processes. Regardless of what causes underlie the changes, ARIES and its integrated performance measures provide a singular and comprehensive focus that is needed for effective A/E/C management. Figure 3 shows the effect that reconfiguration of a program's schedule profile can have.

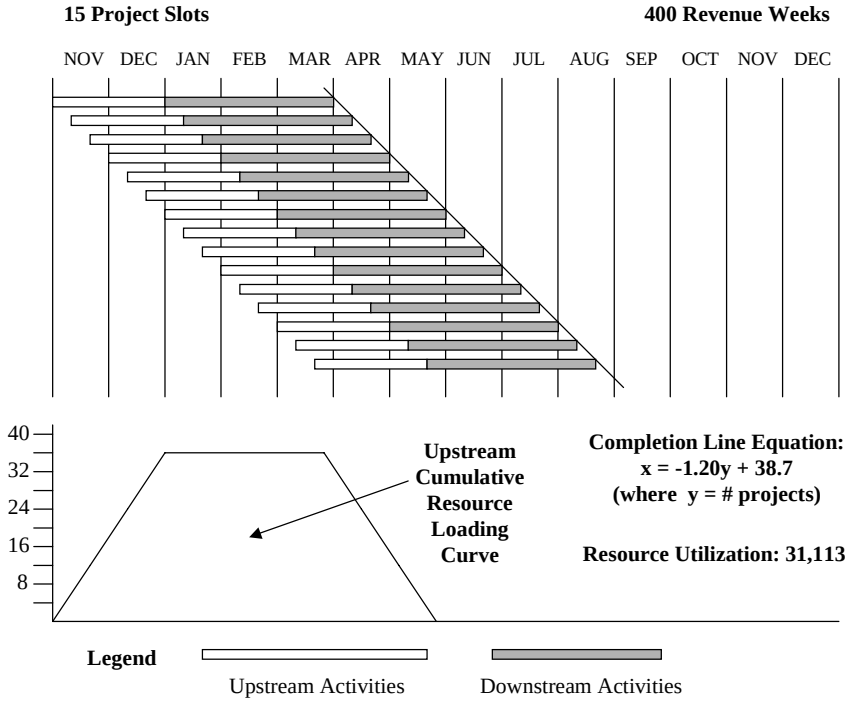

Figure 3: Improved Program Schedule Profile

In this case, a 29% improvement in efficiency rating (4,470 to 5,785) was accomplished by adjusting the duration of each project and the overlap between them. These two interrelated changes are reflected in the equation of the program's completion line. Although the peak resource value dropped from 48 to 36, both program schedule profiles incorporate the same number of resource hours. Decreasing the completion line's slope (from –0.62 to –1.20) and increasing its x-axis intercept (from 37.3 to 38.7 weeks) made the only improvements. The logic by which these improvements were obtained is in opposition to popular project management thought and program management practice. Improvement would normally be expected by increasing the completion line's slope and decreasing its x-axis intercept. In practice, there is a limit to the amount of project schedule compression that can be incorporated into a program. Still, an optimal efficiency rating should exist for every project or program that any A/E/C enterprise is willing to undertake, although the determination of this optimal rating is left to future extensions of this research. For now, the ARIES conceptual framework is enough to fully and adequately address the seven categories of performance measures: effectiveness, efficiency, quality, productivity, quality of work life, profitability, and innovation (Armentrout, 1986).

3.1 Owner and A/E/C Company Benefits

Beyond an improved efficiency rating, several intangible benefits can accrue to both owners and A/E/C firms within the ARIES framework. Operationally, changes to the program's completion line normally result in a reduction of the number of ongoing projects at any one time. Comparing the "upstream" activities in Figures 2 and 3, a reduction of 7 (15 to 8) simultaneous projects at any given time can be seen. This simplifies the process through which an owner's staff delivers project definition information (e.g. real estate sites) to its affiliated A/E/C firms. It also simplifies start-up staffing and training requirements necessary for operations at each facility. Simplified managerial benefits also accrue to the A/E/C company performing the work. Financially, the program owner can begin to receive revenues earlier in the program due to the schedule compression of each project. This may potentially help to offset future program expense. Most importantly, the ARIES conceptual framework provides a comprehensive indicator of performance that can be used by all stakeholders in a particular program or project.

4. THE FUTURE OPPORTUNITIES

Going forward, the ARIES framework enables proactive decision-making by virtue of its structure. Given a historical perspective of individual A/E/C enterprise performance, knowing any two parts of the framework will yield what the third should be. This form of integrated project and program performance measurement will undoubtedly become increasingly valuable for determination of contract value in new delivery systems or when incentives are provided for faster completion. This is important since it forms the basis to realign incentives for project participants and to re-engineer current fragmented project delivery processes (Fischer et al, 1998). ARIES can also serve as the basis for a new form of A/E/C enterprise management system. Such a system would extend the functionality of project management systems to include higher-level managerial requirements for managing all the activities of the enterprise including strategies, products, value chains, and people (Heindel and Kasten, 1997). This would enable A/E/C companies to think strategically about future plans for growth and competency development. In short, a conceptual framework such as ARIES could serve as the foundation for all managerial activities at all levels within an A/E/C company. With this type of foundation, A/E/C firms can meet the management challenge of tomorrow by fostering employee development, redefining business processes, and coping in an uncertain and ever changing business environment.

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