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Techniques and Tools for Project Cash Flow Prediction in the Australian Construction Industry

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In July 1995, the North American journal **PM Network** published its source guide to project management-related software, which listed more than 350 software packages that are used as tools for the time and cost management of projects [13]. Although primarily used for the key functions of estimating, scheduling, and project control, the applications can be multifeatured and have accounting, information management, simulation, or other miscellaneous functions.

In this paper, the authors will discuss different approaches to cash flow forecasting in the Australian construction industry and introduce a unique software package developed by the CSIRO (Australia), Division of Building, Construction, and Engineering, called FINCASH, which is specifically designed for project cash-flow management and is widely used by quantity surveyors, cost engineers, developers, and contractors. The authors will describe a technique in the use of time and cost data, which produces accurate cash flow forecasts using project profiles that fit the project or individual project stages, and which incorporates the major determinants of a construction project cash flow.

The prediction and monitoring of expenditures during the life of a project are important aspects of Total Cost Management. This paper examines modern techniques using computer software that enable us to accurately predict, monitor, and report on project costs. Cost to one party is income to another; yet more importantly for each party, the costs incurred have an associated income stream to be received. This is the cash flow approach that our cost models must address whether we act as cost managers to the client or as managers controlling project costs within a contracting organization.

IMPORTANCE OF CASH FLOWS DURING CONSTRUCTION

Cash flow forecasting during construction is a significant and often underestimated part of the planning of a large capital works project. Equally important is the need to manage the finances of a project so that the forecast cash flow is met during construction. While it is not necessary to predict when every single dollar will be spent, it is necessary to understand and predict the monthly variations in cash flow demands in order to plan and later monitor and manage the finances of a large project as it progresses.

There are three main requirements of a construction project where knowledge of cash flows is the underlying key element. The first requirement is that the client estimate as accurately as possible, with limited information, the final cost of the project. The second requirement is to forecast the fluctuations in the monthly cash flow in order to arrange for funds to be available when needed. The third requirement is to manage the schedule so that the planned cash flow schedule is met and the final cost continuously updated.

A considerable amount of research has been conducted into the techniques of forecasting and monitoring construction project cash flows. This is now undertaken in an environment of increased project complexity and an increase in the use of nontraditional contractual and financial arrangements. Some research mentions the high rate of bankruptcy in the construction industry as signifying the importance of cash flow forecasting and monitoring. Cash flow forecasting and control are seen as essential for the survival of any contractor.

For project developers, the cash flow issue is just as important. A project is feasible within a given budget only when the timing of payments is determined. Often major facilities and infrastructure works that take many years to complete are undertaken by large corporate clients and government organizations within a diverse range of procurement and corporate operations. Here an accurate cash flow forecasting and monitoring process is required to match and update the project financing requirements against annual or semiannual capital budgets.

PROBLEMS WITH TRADITIONAL APPROACHES

The total contract price of a project is commonly estimated with great accuracy, at least as far as the known construction activities are concerned. Yet, the impact of financing charges and cash flow management are often much larger than inaccuracies in the costing. The ideal approach is to link project activities, time, and cost and by aggregating the myriad of individual costs contained in a project schedule, produce a cash flow profile for the whole project.

For a large project, this is a complex task requiring voluminous data, much of which is not available until the project begins. Changes to the schedule and the costs take considerable time and effort and in practice are not done systematically until some significant rescheduling is necessary. Then, modifications are made for only the one schedule that has been decided upon, i.e., they are not done for decision-making purposes but as an afterthought to show the consequences of a decision previously taken. In addition, use of such detailed data implies integration with an accounting system if the information is to be accurate, efficiently incorporated, and as up-to-date as possible. While all the data collection and transfer can be done and is done on occasions, the lack of timeliness reduces the impact of financial control to be little more than an historical necessity.

Table 1—Standard P3 Resource/Cost Curve Values

Curve Name	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Linear	0	10	10	10	10	10	10	10	10	10	10
Triangular	0	2	6	10	14	18	18	14	10	6	2
Triangular Increasing	0	2	3	6	7	9	11	13	14	17	18
Triangular Decreasing	0	18	17	14	13	11	9	7	6	3	2
Back Loaded	0	7	7	7	7	7	13	13	13	13	13
Front Loaded	0	13	13	13	13	13	7	7	7	7	7
Trapezoidal	0	2	7	11	15	15	15	15	11	7	2
Bell Shape	0	1	3	8	15	23	23	15	8	3	1

Australian Contractors' Approach

Before the FINCASH approach is explained, an overview of cash flow forecasting and monitoring techniques as discussed in recent interviews with Australian contractors is examined below. Interviews were conducted with construction planners and schedulers on the methods they employ to forecast and monitor cash flow using cost data from the bid team. The software tools that are most commonly used are project management packages such as those from Primavera Systems, P3 and Suretrak™, and Microsoft Project™. Most contractors will have access to a Windows™-based spreadsheet program into which data can be exported for further analysis, for creating databases and reports, or for creating charts and graphs. This forecasting and monitoring of the cash flow position is done once the bid has been successful, and this provides the basis on which claims for progress payments are made at monthly intervals. The bid-estimating team hands over the bid breakdown data to the contract administrator, but it is generally the scheduler/planner's program upon which the cash flow forecast is based.

To produce an accurate cash flow requires a major expenditure in time in allocating costs to resources and resources to activities. Typically, the bid cost breakdown contains subcontract quotes, labor and material supply prices, and both fixed and time-related project overheads, plus a component for the contractor's head office overheads and profit margin. Where an estimate has been used as the basis of bidding, a great deal of detailed cost information is available, reflecting the price of the individual components of the project; however, the activities and resources associated with these components have to be extracted from the specified trade sections of the bill.

Apart from the time needed to match bid costing with programmed activities and resource use, for most project management software the ability to spread the activity cost over the duration of the activity is limited to either a fixed payment at the beginning or end of the activity or dividing the sum equally into pro-rata payments. P3 for Windows™ has a feature to apply one of nine different resource curves (see table 1 and figure 1) or construct a customized resource curve by simple algorithm, which maps percentage expenditure/income at intervals of 10% activity duration, as shown in figure 2.

A cash flow analysis can be produced using any of these profiles for a particular activity or group of activities. In interviews with schedulers/planners it was revealed that the most useful profiles are:

- linear—for activities with a fixed payment stream, e.g., time-related items;
- front loaded—activities where a large portion of payment is up front, e.g., an air-conditioning plant installation where the air-handling units are expensive and paid for and brought onsite before fixing; and
- triangular—approximates the cost/resource distribution of a number of activities that have a peak in the middle of the activity duration.

Reporting features in project management applications allow for the total resource/cost to be modeled as a bar chart or histogram over the project period when all the resources and costs have been entered for each activity. As previously mentioned, with detailed construction programs this is likely to be a time-consuming exercise, and the format of the cost data from the bid is component/trade based rather than activity based. An option used by project schedulers is to "hammock" a series or group of activities for which the total cost is shown from the estimate data. The hammock feature allows the application of an appropriate resource/cost profile curve to the total value of the trade or defined group of activities.

The contractor's approach will be influenced by other factors related to the bidding process so that for the same project value and the same schedule of work, two contractors are likely to produce two different cash flow curves. This may be due to estimating errors or the different loadings that contractors can use.

The requirement for a bidding contractor to produce a project cash flow analysis for the client varies with bidding and contractual arrangements. On fixed-price contracts, project cost engineers who are engaged in selecting contractors and reporting on bids will request one, although in many cases the project includes separate contracts, charges, and contingencies that the cost engineer must then incorporate into a global cash flow analysis of the clients financial commitment.

FORECASTING MODELS

Simplifying the Approach

Instead of defining each activity and its cost in great detail, an alternative, quick, easy, and effective cash flow forecast can be achieved by modeling the underlying cash flow profiles that are characteristic of the project type and adding on the required features to produce the familiar variations over time, e.g. ,different number of working days per month, indexed cost increases, and retentions. This approach is particularly applicable to construction projects that have a consistent set of construction activities, such as the repetitive nature of activities entailed in constructing high-rise buildings.

The expected cash flows can be forecast from minimal data once the type of project and its characteristic cash flow profile are determined. The advantages of this simplified approach are many, but they include a considerable savings in management time and data collection effort, an ability to make decisions based on possible cash flow information instead of accepting cash flows resulting from decisions made on other criteria, removal of dependence of the forecasts from data acquired from other systems and participants in the construction process, and quick forecasts of alternative scenarios using minimal data and the judgment of the decision-maker.

Such a model still requires professional assessment of the realism of the forecasts. The construction professional must remain responsible for the decisions made, but the timely availability of realistic future performance enables more well-informed decisions to be made.

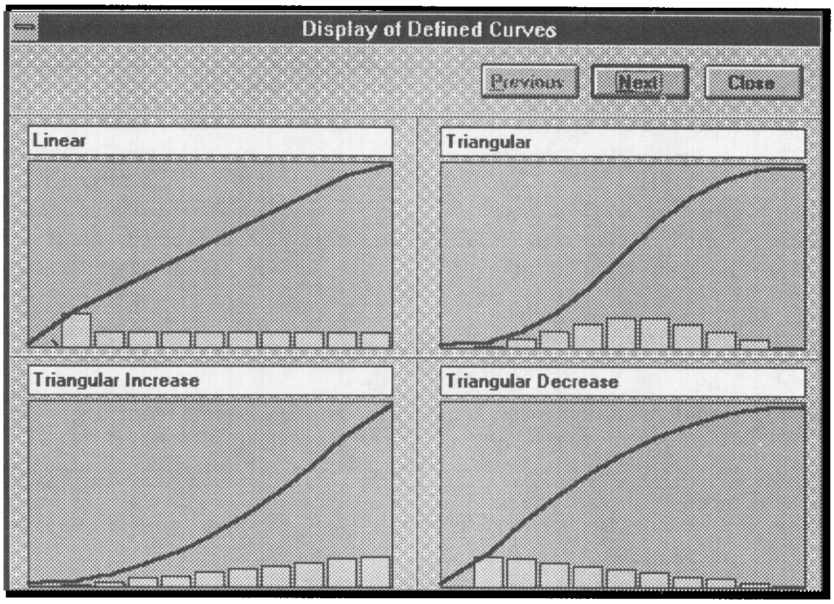

Figure 1—Standard Resource/Cost Profiles From P3™ (Primavera Systems)

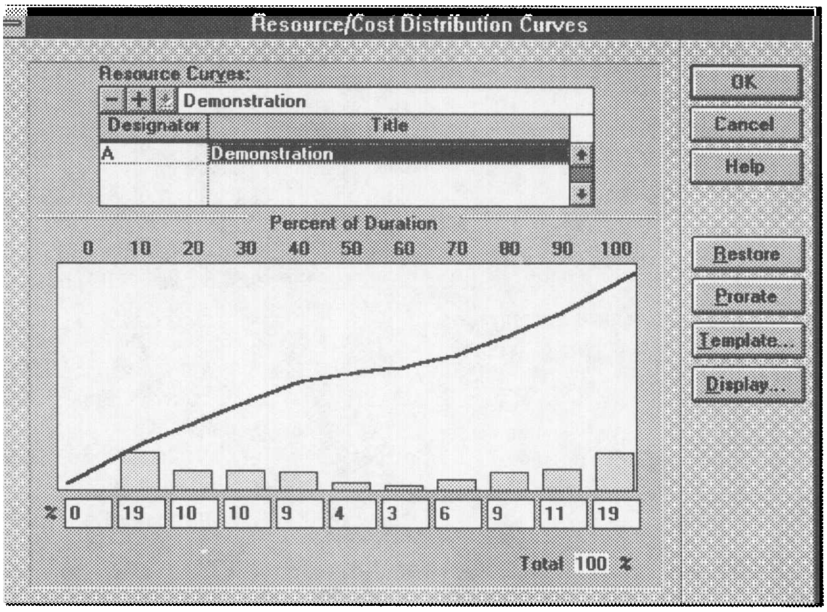

Figure 2—Customized Cash Flow Curve Using P3's Curve Template

Characteristic Cash Flow Profiles

Different types and sizes of buildings have their own characteristic cash flow profiles, each of which is a variation on a basic model. A cash flow profile is the distinctive shape of the graph of periodic cash flows plotted against time over the course of the project. These cash flow profiles during construction of large projects have been studied in several countries over many years, and research has shown that the cumulative cash flow for a building project follows what is commonly called an S-curve (after its graphical representation). The specific shape varies between types of project. The S-curve is the accumulation of a large number of small payments, the details of which are not required to produce an overall view. Principally, the studies have concentrated on large commercial office buildings [1, 4, 9, 8], but a similar approach has also been applied to civil engineering works [11], hospitals [6], housing [12], and schools [15].

The key to successful profile development has been to use the working days, not calendar days, as the time base. The apparent complexity is reduced, and the nonintuitive nature of the cash flows as normally observed is partly explained. However, many functions produce an S-curve when plotted cumulatively, and small changes in shape are not easily or necessarily detected. Project cash flows may start after the actual project start and finish well after the nominated project finish date because of delays in assessing work performed or payments received. The S-curve applies equally well to cost commitment and value of work done, and because of the relative timing and shape, the net cash flow profile found by the difference between the two types of cash flow can be an endless variety of shapes [9, 7].

The characteristic shapes from which these S-curves are derived are clearly visible when the progressive cash flows per time interval are graphed against the elapsed working days. The progressive cash flow can be regarded as the rate of change of the cumulative S-curve or the rate at which payments are made (and of course, the rate at which construction work is completed). The rate can be expressed as dollars per month. Even at what at first appears to be a long time interval of a month, the characteristic shapes are distinct, and deviations from the smooth curve are easily seen.

By manipulation of a simple set of parameters, quite different cash flow profiles can be generated without the need to describe or determine each and every construction activity in detail. Over the years, a variety of attempts have been made to find a simple formula for typical curves from cubic polynomials [4], with time as a function of cost to cost as a function of time when the function is a polynomial [4, 6, 2, 7, 10] or sine curve [11]. Until recently, all investigations of S-curves have been based on arbitrary functions devised to obtain a mathematical relationship between the cumulative cost to date and the elapsed time of a project.

The proliferation of possible curves has demonstrated a need for a general approach that can be adopted to suit the known characteristics of a particular construction cash flow profile. The only theoretical analysis drew an analogy between the probability of failure in reliability theory and the probability of payment during construction to develop a general approach to possible mathematical forms of the cash flow during construction [18, 19].

Not only does the approach consider the shape of the progressive cash flow curve, but it generalizes even further to a characteristic function equal to the progressive cash flow curve at any time during construction, divided by the remaining cumulative S-curve at that time. The characteristic curve is then the rate of payment of the remaining unspent cash flow sum. From the required properties of this function, a number of possible forms of the S-curve can be determined. One of the simplest forms is a Weibull function plus a linear function (which represents the constant cash flow over the construction time) i.e.,

$$P(t) = k\,[1-\exp(-((t-d)/c)^{b})] + (1-k)\,a\,(t-d). \qquad \text{(equation 1)}$$

where,

- $P(t)$ = proportion of contact cost expended at time t,
- t = fraction of construction time elapsed,
- a = linear gradient (when viewed in S-curve form),
- b = shape factor,
- c = peak factor (when viewed in progressive form),
- d = starting offset, and
- k = proportion of function in Weibull form.

A significant benefit to a user is that these parameters are meaningful when trying to adjust the shape to suit a new type of project that is to be modeled. Experience with this particular model has shown that it can be tuned to almost any project type in the construction industry. Projects for which excellent results have been obtained include low-rise (up to five stories) buildings, high-rise (up to 60 stories) buildings, power stations, site works, regional shopping centers (new and extensions), and hospitals.

FINCASH APPROACH

When implemented as a computer model, the S-curve cash flow profile method can be extended to a monitoring role as well as being simply a forecasting model for the whole construction period. As a project progresses, the cumulative cash flows to date are identified, and forecasts for the remaining construction period can be made by rescaling the time base so that the S-curve will continue to link the total cash flow to date and the final cost at the end of the project. The time base is converted from working days to calendar days, cost indices and retention are applied, and financing costs are calculated to forecast the remaining future cash flows. Thus, forecasts of cash flows for a construction project can not only be undertaken at the feasibility and pre-construction stages but also at each step in the actual construction.

A project may be split up into its several components, each with its own characteristic S-curve and the total cash flow aggregated from these components to obtain the total cash flow from the project, the principle being that each component can be clearly identified as its own construction stage. This assumption of a characteristic S-curve for construction projects or parts of projects has been supported by the results of studies in Great Britain [7], Singapore [16, 15], and Australia [9] for construction cash flows, and by Tueno [21] for contract overheads.

Thus, aggregation of two cash flow profiles also produces net cash flow curves when the difference between two profiles representing income and expenditure (or cost commitment and value of work done) is calculated [10, 8]. These net cash flow profiles can identify the working capital required and net margins (profit) on the project.

Because the cash flows can be quantified in absolute numeric terms, there is a tendency to forget that the forecasts are only good estimates and that every project has features that make it unique. In addition, some variation from the trends in the cash flow profiles is to be expected because of such factors as inclement weather, industrial disputes, construction techniques, and management practices. The approach is designed to be flexible enough to accept modifications to the cash flows as the special features of a project unfold.

Principles

FINCASH for Windows deals with one project at a time. A project may consist of a number of activities, each of which can be an independent construction activity, which itself is often called a project. FINCASH operates by defining a hierarchical structure of activities or stages to provide relationships between these components and to provide a quick method to select the required cash flow calculations. However, all the specifications of stages and other items, such as calendars, needed to estimate cash flows are kept in a database as a collection of independent entities and drawn upon as required in the calculation of cash flows. FINCASH for Windows refers to these entities as objects, of which there are six types: stage, calendar, profile, escalation, retention, and interest. These objects are treated as reference books by the project to look up how their specification is to affect the cash flows.

Cash flows are calculated on demand; results are stored temporarily. Thus, when a particular table or graph is selected, FINCASH for Windows looks up the stages involved, and, using the specifications of the stages and other objects referred to in those stages, proceeds to calculate the cash flows and then display them in the requested form in a window.

FINCASH uses the values entered in the objects in open windows before looking up the database. Once displayed, the results remain available until the window is closed; maximizing or minimizing the window, or viewing other windows or results, retains the results. However, if there have been changes to the specifications of an object needed for the cash flow calculations, the results can be set to be recalculated automatically or manually.

Project

The project window appears within the main window and defines the stages of a construction project in a hierarchical structure similar to that of file directories. The structure is based only on the requirements for aggregating cash flows, independent of project size, starting, and finishing dates.

The hierarchy (see figure 3) also includes folders that serve as points of aggregation of stages, e.g., folder 2 aggregates, stage 5, and stage 6. The top-most folder is the project folder and it, like all other folders, contains only identification data, such as its name and description, and unique to a project folder, a client name.

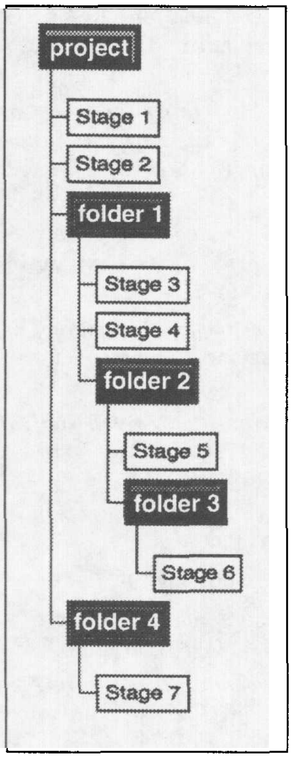

Figure 3—Construction Project Structure Presented as a Hierarchy

The project window also coordinates the components from which the stages are built up. Stages and folders may be added, edited, deleted, or moved, as required. Only the project folder cannot be deleted.

Objects

Objects are stages (or components of a project), working day calendars, profile models, escalation patterns, retention patterns, and interest patterns. Stages provide the basis for defining the cash flows of a project. The other objects define various subsidiary data to be used during the cash flow computations. All input data are entered via the definition of objects.

All objects are independently defined, and they can be referred to by any number of other objects.

The stage is a particularly special object that requires considerable data retrieved from other objects. The objects other than stages are independent of other objects with the exceptions of retention, which accesses interest, and combined escalation and aggregated stages, both of which merge data from escalation and stages, respectively, to create a new one similar to the originals. Objects of the same type must have unique names. Names may be changed by the user, but all previously assigned references will be lost and must be reestablished individually by the user.

Cash Flow Output

Cash flows are calculated when the results are requested by viewing a table or graph. Tables and graphs of cash flows can be displayed for any stage object or specified combinations thereof. Tables and graphs displaying entered data are also available for other objects, such as profiles, escalation indices, and calendars as shown in table 2.

Table 2—Cash Flow Data in Tables and Graphs Using FINCASH

Tables	Graphs
cash flow forecast	progressive forecast
cash flow budget	progressive budget
in/out forecast cash flow	cumulative cash flows
in/out budget cash flow	in/out forecast
multistage forecast	in/out budget
multistage budget	multistage forecast
forecast summary	multistage budget
budget summary	progressive profile
selected cash flow	cumulative profile
cash flow variance	escalation rates
summary variance	escalation index
escalation index	escalation indices
calendar	retention
	interest

Calculations

Cash flows are based on a profile model for each stage. The profile determines the variation in cash flow payments over the duration of a stage. Briefly, the cash flows are calculated as follows.

- The number of working days from the start date to the finish date is found from the calendar.
- Each cash flow is the difference between the cumulative cash flow of the nominated profile at the required date (whether end of month or nominated date) and the cumulative cash flow at the previous calculated date, multiplied by the stage value including margin. The profile is affected by the overrun limit (which restricts how long the cash flow profile continues past the finish date, if at all); the actual payments to date; and, if actuals (either actual estimated or future payments) exist, by the finish target.
- Escalation is applied to the resulting payments as set out in a construction industry cost adjustment standard using the table of values and the starting date for escalation adjustment to create an internal index.
- Retention monies are then calculated using the specified pattern and the payment type requested.
- All payments are then moved by the number of calendar days specified in payment delay.
- Interest is then calculated using the effective daily rate determined by the interest rates applicable during the time interval from the previous payment.
- Budget cash flows are calculated in a similar manner except that the payments are not affected by actuals but are adjusted by the historical value and finish date prevailing during the period for which the budget cash flows are being estimated.
- Cash flows of aggregate cash flows are the merging of the payments of all the individual cash flows, with payments summed if more than one payment occurs on the same date.
- Cumulative cash flows are simply the running totals to date of the payments on particular dates.
- All other values such as percentages and variations are calculated as required.

Since the widespread introduction of the PC and the development of spreadsheet software, what was once done manually with paper and calculator is accomplished in far less time with greater accuracy. A modern spreadsheet package will hold a model of our project cost by the categories and along a time scale we choose and input. Represented by tables and graphs, we can model the project cost in detail. More sophistication is required when we want to build models that can aggregate across physical stages or activities the costs and income from one or more sources.

Models that combine theoretical relationships based on research with industry-determined needs can result in tools that improve the efficiency and accuracy of the analysis of the financial requirements of a project before and during construction. One such implementation of this approach is the FINCASH model.

FINCASH confers a variety of benefits depending on the objectives of the user. While cash flow forecasting is the prime use, the ability to have a cash flow plan may result in beneficial deals with lenders who are guaranteed predictable financial demands from a project, or improvement in knowledge of how well a project is proceeding. In all cases, it is time saving and sufficiently accurate for decision-making purposes. The apparent simplicity belies its realistic simulation of complex cash flows during the construction phase of a project.

The versatility of this approach means that FINCASH can be used to estimate cash flows from the point of view of any contract party for one or more contracts. The contractor can estimate costs and add on profit for bidding and then compare the expected income stream with the outgoing stream to determine cash low viability. The client may be interested in the payments to the contractor with interest charges added to obtain total cost and cash flow demands. The financial consultant may forecast and monitor any or all of the cash flows for client or contractor as a means of assessing the progress on the project. Even the total financial standing of a construction contractor or investor can be forecast and monitored.

While a cash flow can be obtained from a detailed time schedule of individual activities, the effort to complete such a schedule and then continually update it as the dynamics of the project unfold are tedious, time consuming, and not easily changed to test the effects of different scenarios. A more macro-scaled cash flow model that can expand to the required detail can be simple, quick, and realistic. FINCASH provides this.

At the planning stage, such a model can be used to investigate the sensitivity of a particular project cost to changes in the various factors such as inflation indices, interest rates, etc., and to compare different construction schedules in consultation with clients in the office. Comparing the effects of changes may enable trade-offs for optimization purposes to be made and certainly provide a more sound basis for evaluating a project without undertaking excessively detailed data collection.

In the construction stage, the progress of a project can be measured by comparison with a forecast based on an expected cash flow profile. Monitoring cash flows requires much less information than traditional critical path methods yet provides sufficient information to the construction managers and client to indicate the state of the project, to forecast cash flow requirements, and to update final costs.

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