Float Allocation Using the Total Risk Approach

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Abstract: Float ownership is one of the controversial issues in the litigation of delay claims. As float time does not always affect the overall project completion time, many believe that this time can be used by any of the project parties and that it does not belong to a particular party. This study introduces the "total risk approach" for float allocation, a new approach that integrates several current approaches to allocate float among project parties. The approach is based on the basic concept that the party who has the greatest risk in a project should be entitled to float ownership and deserves compensation from other project parties who increase the risk associated with the project by consuming the float. This new approach takes into consideration the changes in float that may occur as a result of actions that delay or accelerate the project's schedule.

DOI: 10.1061/(ASCE)0733-9364(2009)135:2(88)

CE Database subject headings: Construction industry; Contracts; Scheduling; Risk management; Construction management.

Introduction

Float ownership is one of the controversial issues in the litigation of delay claims. As float time does not always affect the overall project completion time, many believe that this time can be used by any of the parties in the project and that float time does not belong to a particular party. Hence, as the term "float" implies, this time serves as a safety net against project risks. The unplanned consumption of total float (TF) can, in fact, increase the cost of noncritical activities and raise the risk of project delays. The inappropriate consumption of float time early in a project can lead to difficult challenges in the management of the remaining float time at later stages of the project. As float time can be used to help all project parties manage their risks, float ownership and consumption should be addressed contractually within the overall project plan for risk management to help minimize potential project disputes.

This paper discusses six major issues/constraints that influence float allocation. These six issues were taken from previous studies (De La Garza et al. 1991; Householder and Rutland 1990; Pasiphol and Popescu 1995; Ponce de Leon 1986; Prateapusanond 2004). Current approaches for determining float ownership are discussed to show how responsive these approaches are to the different issues related to float ownership. Based on this discussion, an integrated approach, called the "total risk approach," is introduced.

Concept of Risk-Based Float Ownership

When the time uncertainties of noncritical activities are great, the use of float can result in increased project risk and schedule overruns (Gong and Hugsted 1993; Gong et al. 1995; Gong 1997; Lockhart and Roberds 1996; Zhong and Zhang 2003). The actual project risk is primarily a function of project conditions, project delivery systems, and contract terms. Ultimately, the terms of the contract allocate the risk between stakeholders. It is these allocated risks that should govern the allocation of float among the project parties and the exchange of float among them. As a result, the ownership of float should be decided in advance and allocated among the parties on the basis of their comparative risk levels. This approach will decrease the likelihood that there will be project disputes related to the use of float. Accordingly, the concept of risk-based float ownership is based on the principle that the party who carries the greatest project risk should be entitled to the greatest consumption of float and deserves compensation from other project parties who consume more than their proportionate share of the available float. For instance, in a lump-sum contract, the contractors should own float that is equivalent to their risk, and those who use float beyond their allocations should be liable. Just the opposite is true for a cost-plus-fixed-fee contract. In this case, the owner (rather than the contractor) should own float that is equivalent to her or his risk, and, as stated earlier, those who use float beyond their allocations should be liable.

Many constraints and issues related to the allocation of float have been considered/introduced in previous studies (Callahan et al. 1992; De La Garza et al. 1991; Householder and Rutland 1990; Pasiphol and Popescu 1995; Zack 1992, 2000). Six such issues, extracted from these previous studies, are introduced in this paper. The six issues relate to the rights to own and consume the float based on the type of contract and associated risks.

Contractor's Right for Resource Leveling

A contractor has the right to manage the project resources to help keep the project cost and schedule within estimates, which are made during the bidding stage. For example, in a lump-sum contract, the contractor estimates the project cost risk and contingencies in order to establish a resource profile. Once float has been determined, the contractor is entitled to use float to optimize resource usage and reduce the overall risk.

Therefore, the decision as to whether the contractor owns the float should be made before the contract is signed. Many construction contracts entitle contractors to manage available re-

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Note. Discussion open until July 1, 2009. Separate discussions must be submitted for individual papers. The manuscript for this paper was submitted for review and possible publication on April 2, 2007; approved on August 5, 2008. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 135, No. 2, February 1, 2009. ©ASCE, ISSN 0733-9364/2009/2-88–95/$25.00.

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sources in order to control project risk. "Means and methods" is a common contract term that entitles contractors to manage resources at their own discretion. For more discussion of "contractor's means and methods" as it relates to float ownership, the reader is referred to Shumway et al. (2004).

Owner's Right for Change Order

In some cases, the owner's right to change orders could conflict with the concept of risk-based float ownership discussed earlier. For example, in a lump-sum contract, most owner-issued change orders that add more work are, in effect, consuming the float that is owned by the risk-bearing party, i.e., the contractor in this case. Consequently, the contractor may incur additional risk when a change order that consumes float is implemented. Such a situation creates a conflict between the contractual right of issuing change orders and the contractor's right to own the float based on risk liability. Here, the contractor-owned float is consumed indirectly by the owner. This conflict can be resolved if the owner agrees to reimburse the contractor the costs of the change order in addition to any additional risk contingencies (De La Garza et al. 1991).

Disentitled Float Consumption

According to the risk-based float ownership concept, in a lump-sum contract, the contractor has the right to own the float. Moreover, the float approach should be flexible enough to grant the owner a contractual right to issue change orders when considering the additional risk that may be associated with them. The owner can also consume float by means other than change orders. For example, if the owner does not allow the contractor access to the site or if permit approvals are delayed, the owner is not entitled to consume such float. Such float consumption is tentatively named here "owner disentitlement-float consumption." Further, by allowing the disentitled consumption of float, the contractor (the risk-bearing party) incurs additional risk without additional compensation for that risk. In such a situation, the contractor may conceivably negotiate for compensation for losses that directly or indirectly result from the disentitled consumption of float by the owner. The contractor can also have disentitlement float consumption if the owner carries the project risk. The float ownership approach provides a reasonable way to deal with such disentitlement float consumption issues.

Distribution of TF among Contractors or Subcontractors

Float ownership is not limited to the owner–contractor relationship, and it can be extended to other parties in the project, such as the contractor–subcontractor relationship, depending on the delivery system that is used in the project. For the traditional delivery system, the general contractor typically hires subcontractors who are specialists in executing specific parts of the project. Employing subcontractors who are specialists is a frequently used technique that reduces the general contractor's risk by shifting it to the subcontractors. The "professional construction management" (PCM) delivery system has been used extensively in recent years. In this system, more than one contractor is usually engaged. Similar to the other delivery systems, float ownership should be expanded to include all project parties.

Because of the inclusion of several project parties, the risk profile changes, and the ownership of float becomes more complicated. Based on the contractual agreement among the project parties, each of them should carry its own risk. As a result, the TF should be distributed judiciously among the project parties. The complexity of distributing the float among these parties stems from the fact that the TF belongs to the path, not to the activity, and there can be many project parties on the same path. Therefore, in each activity, the TF should be distributed over all the project paths on a rational basis, such as contract risk.

"Schedule Games"

Contractors occasionally resort to "schedule games" in which they try to manipulate the schedule to reserve some float (Zack 1992). When contractors do not own the float but control the schedule, they can reserve some float by increasing activity durations or changing project sequences. This type of schedule manipulation is usually the result of pressures faced by the contractors to manage their risks. The float approach should therefore prevent such schedule manipulation.

Issues Associated with TF Changes

TF is a variable value that can be affected by project delay or acceleration. TF increases with critical path delays and decreases when the critical path is accelerated. The occurrence of float change raises the question of which project party should own the excess TF, or, conversely (in the case of decreases in TF), who should pay. Accordingly, there are three situations in which the proposed approach must address the question of ownership or responsibility, i.e., pacing delay, change orders, and schedule acceleration. In general, any party, such as an owner, a contractor, or a third party who causes a change in the TF of any of the project activities should receive a credit or a debit for that change (Al-Gahtani 2006).

Float Allocation Approaches

Several approaches dealing with float ownership were introduced in the last three decades. Each approach actually represents a viewpoint on how to best respond to each of the six issues, identified earlier, associated with float ownership. As the goal of this study is to use "risk" as the primary basis for determining float ownership, all six issues are discussed and the linkages between them are examined. In the following, nine approaches are explored. Table 1 shows the comparisons of the six issues with the nine approaches.

1. Owner ownership float approach. It has been argued that project floats belong to the owner (Pasiphol and Popescu 1995; Prateapusanond 2004). The basis for this position is that, as the owners pay the costs associated with the project, they have the right to own the project floats. Such a claim cannot be justified, because the more important consideration is the potential for increasing the overall risk in the project of which cost is only one of several factors. A more defensible argument is that the owners are entitled to manage the float to lower their project-associated risk as they have accepted responsibility for the risks associated with the project. This approach primarily fits the scenario in which the contract assigns the risk associated with the project to the owner.
2. Contractor ownership float approach. Many believe that the contractor has the right to own the float. The basis for this position is that the contractor has the contractual right to have the "means and methods" and that this right entitles the contractor to control the project schedule and the sequence of activities. Consequently, the contractor has the right to manage the workforce, equipment, and cash flow to achieve the project on time and within the planned budget. In order to achieve this goal in a lump-sum contract, the contractor can use the project float to control project risk in terms of time and cost. In addition, as the contractor owns the float, there is

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Table 1. Comparison of Nine Current Approaches and the Proposed Approach

Float ownership issues	Allow flexibility for resource leveling	Allow flexibility to include change order	Prevent disentitled float consumption	Prevent schedule games	Ability to distribute TF among project parties	Solve TF changing issues
Contractor	√	×	×	*	×	×
Owner	×	√	×	×	×	×
Project	*	*	*	*	*	*
Bar	×	×	√	×	×	×
50/50	*	*	*	*	×	×
Contract risk	√	×	√	*	×	×
Path distribution	√	×	√	*	√	×
Commodity	√	√	*	√	×	×
Day-by-day	×	×	×	×	×	√
Contract risk+path distribution+commodity+day-by-day	√	√	√	√	√	√

Note: *=minimized but not prevented.

no need to resort to schedule games to reserve some float to control risk.

3. Project float approach. Project float is the most frequently accepted approach of float ownership introduced in legal cases. It is the simplest method for solving the complications of float ownership issues. The approach makes float time available for all of the project parties. Whoever needs the float first can use it. This approach gives both the owner and the contractor the right to consume the float. It gives flexibility to contractors to manage their resources, and it gives flexibility to the owners to include change orders.

   The project approach for float ownership can lead to misleading results when schedule delays are analyzed. Arditi and Pattanakitchamroon (2006) explain how this approach affects the results of delay analysis. For example, in a case in which the owner consumes the contractor's entire float on a noncritical path, the contractor delays the newly developed critical path, thus increasing the contractor's project risk with no compensation. To make matters worse, in this case the contractor would be responsible for the liquidated damages as a result of delaying the project completion date.
4. Bar approach. Some argue that, when conducting delay analysis, it is unfair to only account for critical path delays and overlook noncritical path delays (Callahan et al. 1992). The bar approach, which was introduced by Ponce de Leon (1986), responds to this argument. Thus, the purpose of this approach is to use the results of delay analysis to minimize the effects of consuming float. The approach accounts for critical and noncritical path delays by considering every consumption of float as a critical delay. Subsequently, in this approach the TF activity of each activity is represented as a bar in the bar chart. Again, any delay in the project is critical, and the overall effect on the project can be determined. The bar approach deals with the float ownership issue in a totally different manner than does the project approach. The project approach poses no restrictions on float use by any of the project parties, whereas the bar approach greatly limits such use. Thus, the bar approach prevents disentitled float consumption by both the owner and the contractor.
5. 50/50 allocation approach. The 50/50 allocation approach was recently introduced to address the issue of float ownership (Prateapusanond 2004). The approach integrates the owner, contractor, and project float ownership approaches, and it attempts to overcome the drawbacks of previous approaches by establishing a common ground that can be accepted by both the owner and the contractor. It starts with a 50/50 split of the TF between the owner and the contractor. The next step is keeping track of the owner's and the contractor's float consumptions. If the owner or the contractor consumes more than the allocated float and the noncritical path becomes critical, any delay in that critical path is shared between the owner and the contractor based on the ratio of disentitled consumption by each party. For paths that are not critical, none of the contract parties will be entitled to float consumption, as it is governed by the project float approach. The approach tries to formulate a rule for consuming the float that affects the critical path delay. So, the owner or the contractor would be cautious when consuming the float.
6. Commodity approach. The commodity approach was introduced by De La Garza et al. (1991). The commodity approach deals with float as a commodity that is tradable between the contractor and the owner. This approach was inspired by the business motto, "time is money," and it is one of the approaches that considers the effects of float consumption on risks. The approach gives the contractors complete control over float, because they assume the project risk as is done in a lump-sum contract. The approach is flexible in that it allows the owner to consume the float if needed by purchasing float from the contractor based on a formula that had been agreed to earlier in the project contract. This formula guides the negotiation between the owner and the contractor during arrangements for change orders and during the pricing process. The formula considers the change of project risk as follows:

$$\text{Daily trade-in TF value for each activity} = \frac{\text{Late finish cost} - \text{Early finish cost}}{\text{TF}} \tag{1}$$

7. Contract risk approach. The contract risk approach was introduced by Householder and Rutland (1990) to establish a link between float consumption and contract risk. Based on this approach, contractors own the float if they assume full responsibility for the project risks, as is done in a lump-sum contract. On the other hand, owners own the float completely if they have full responsibility for the project risks, as is done in cost-plus-fixed-fee and cost-plus-percentage-fee contracts. In a project in which both the owner and the contractor share

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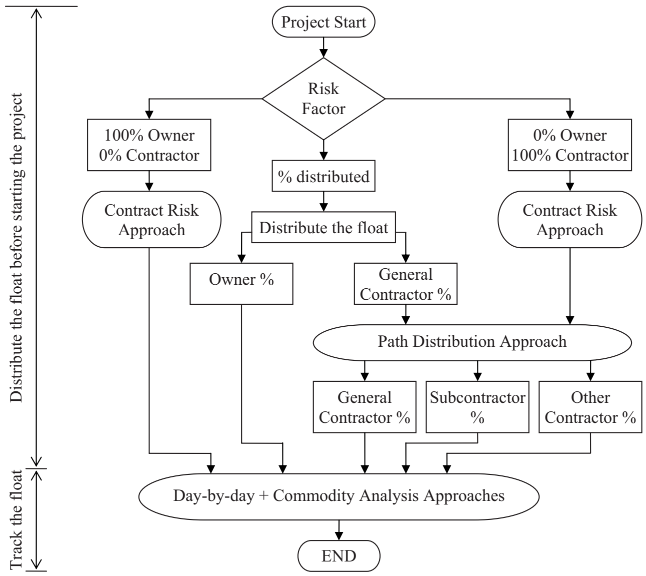

Fig. 1. Overall flowchart for the total risk approach

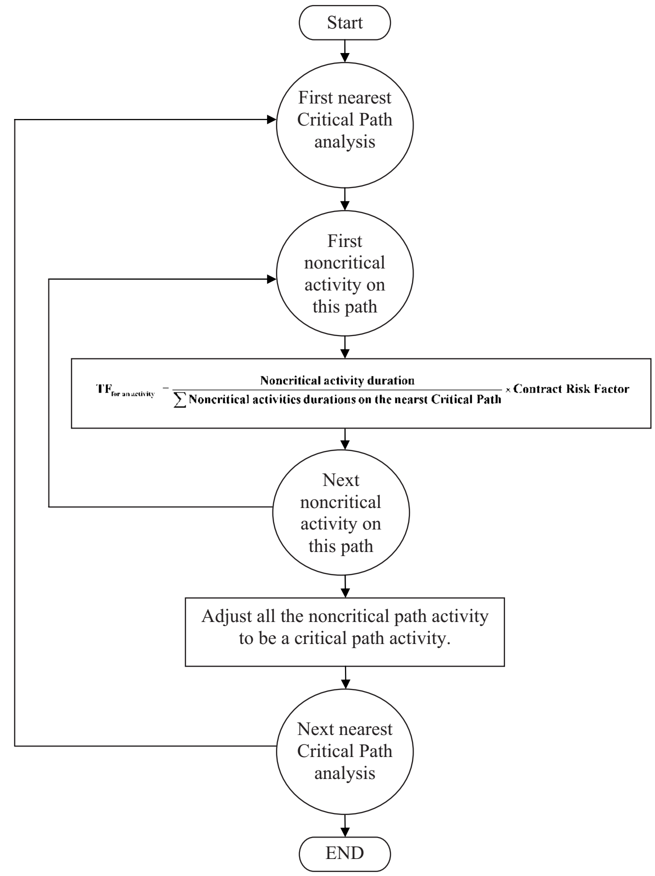

Fig. 2. Path distribution process

the project risks, such as cost-plus-fixed-fee contract with a maximum or percentage ceiling, the owner and the contractor should agree to a ratio to share the float that is proportional with their levels of risk. However, having the contractor assume full responsibility for all risks in a lump-sum contract does not always accurately depict the actual situation, because it might be possible to shift some contract terms to the owner, e.g., subsurface risk.

8. Path distribution approach. The path distribution float approach is an approach enhanced by a systematic approach that can distribute the TF for each noncritical path activity (Pasiphol and Popescu 1995). The approach is that the TF for each noncritical path can be distributed based on the duration of the activity. The method starts from the nearest critical path (second longest path after the critical path) and proceeds to the next-nearest critical path (third longest path after the critical path) until completion of all the noncritical paths. In each path calculation, the TF is distributed proportionately to the noncritical activities based on their durations. The distribution ratio can be extended to include other risk factors, such as labor hours or level of activity risks (Pasiphol and Popescu 1995). Before moving to the next-nearest critical path, the distributed TF of all noncritical activities on that analyzed path should be adjusted to its activities' durations to become critical path.
9. Day-by-day approach. The day-by-day approach is another formula implemented by a systematic approach named total float management (Al-Gahtani and Mohan 2007; Al-Gahtani 2006). The approach is focused on solving the associated issues of changing the TF as result of impacting the critical path. In addition, the approach tracks the float consumption for the owner and the contractor, which can be used to determine the disentitled consumption. The approach states that any of the contract parties who change the TF as a result of delaying the critical or noncritical paths will get credits or debits for impacting the critical and noncritical paths based on a day-by-day, systematic assessment. The approach tracks and records TF changes or consumption, and it is integrated with the delay/acceleration project analysis. As a result, all scheduling issues related to delaying, accelerating, or managing TF will be solved in an integrated manner, because all the issues affect each other. In addition, the concurrent delay and its effect on both project time and TF are addressed by this approach. At the end of the analysis, all contract parties have an account (credit/debit) for recording their entitlement TF consumption, their project delays, and their actions that accelerated the project schedule.

Total Risk Approach for Ownership of Float

The review of the current float ownership approaches showed that none of those approaches could respond effectively to all of the identified issues relating to float ownership from the risk point of view. By examining the approaches collectively as shown in Table 1, there is a possibility of synthesizing the strong points of the four approaches with the goal of developing a new, integrated approach that could respond to all identified issues according to a risk-based float ownership philosophy. Figs. 1 and 2 show how four of the existing approaches are integrated into the proposal based on project risk allocation. The following explanation shows how the four approaches can be integrated consistently with the philosophy.

The contract risk approach can form a suitable basis for establishing a risk-based float ownership philosophy. It can serve as the fundamental framework for such an approach, because the contract risk approach takes into account the link between contract risk and float ownership. According to the reasoning in the discussion of the contract risk approach, this link responds directly to the three identified issues related to a contractor's right for

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resource leveling, disentitled float consumption by any project party, and manipulations of work schedules. At the same time, based on the owner's share of risk, owners can consume the float to manage their risk, such as waiting to make decisions to change material types to lower the increased project cost. In addition, the approach prevents both disentitlement float consumption and schedule manipulation, as shown in Table 1.

The contract risk approach does not address float distribution among other project parties. This shortcoming can be remedied by integrating the path distribution approach into the framework of contract risk. The path distribution approach considers the duration of a given activity as a basis for distributing the float for that activity. As discussed earlier, the path distributing approach can be expanded to include other risk factors. In this study, the risk associated with the contract is the expanding risk factor that is embedded within the distribution path approach, which is in keeping with the risk-based-float-ownership philosophy. The contract risk between the contractor and subcontractor or between the owner and other contractors (in a PCM delivery system) can be integrated with the activity duration for sharing this contract risk according to the integrated formula

$$\mathrm{TF}_{\mathrm{distribution}} = \frac{\text{Noncritical activity duration}}{\Sigma \text{ Noncritical activities durations on the nearest critical path}} \times \text{Contract risk factor} \qquad (2)$$

The contract risk factor ranges between 0 and 1 and is assigned to a project party in proportion to that party's risk liability. This factor is related to risk distribution that is written into the contractual terms of the project and to the types of risks that are related to project conditions, project delivery systems, and kinds of activities. For example, if owners carry 25% of the project risk, they are assigned a contract risk factor value of 0.25, whereas the contractor risk factor value would be 0.75. By integrating the two approaches, the new combined approach can respond to the fourth issue of the six issues relating to float ownership, i.e., the possibility of distributing float ownership among all the project parties.

Another challenge in enabling the proposed integrated approach is to respond to changes in risk profiles resulting from owner-issued change orders. The question is how to grant owner's rights to issue change orders (beyond their share of float) and still protect the risk-bearing party (contractor/subcontractor). The commodity approach, as described earlier, responds to this issue. As such, this approach provides a suitable element for integration in the proposed integrated approach to address the issue, and abides by the boundaries of the risk-based framework of float ownership.

The commodity approach does not address the contractual risk boundary because it gives the contractor full authority to consume or sell the float. However, it is flexible enough to give the owner the ability to buy the float in case it is needed. By integrating the three approaches, the new approach solves the entitlement of float consumption for all the project parties within proportionate risks, and it also solves the contractual dilemma that can arise when the owner needs to consume the float without affecting the other project parties. Again, the synthesis from the three approaches answers the five proposed arguments without resulting in any conflict.

Although the new, combined approach can regulate both the float entitlements for all the project parties and the flexibility of these entitlements to consume the owner's or the contractor's float without affecting the other project parties, it does not answer the associated issues of changing the float as the "day-by-day" approach does. Because the day-by-day approach is designed to work with any other float approach to track the float changes on the critical and noncritical paths, the four approaches can be integrated smoothly and seamlessly to work together to respond to all the identified issues without affecting any of the project parties' rights to manage their own risks. Not only are the associated float issues solved, but all of the associated issues with delaying/accelerating the project are also solved. The new integrated approach is labeled the "total risk" approach.

Applicability and Limitations

Although the total risk approach responded to all the previously identified issues, there are still some difficulties with its implementation. The approach is difficult and time-consuming to implement directly by schedulers. Therefore, as it follows a systematic procedure, the approach can be programmed and included in the current Project Management Software. Another difficulty of using this approach has to do with defining the contract risk factor. It is possible to have two types of risk responsibilities (i.e., owner responsibility and contractor responsibility) in the contract for the same task or activity. In the total risk approach, the risk factor is assumed to have a constant value for all project activities in order to facilitate the calculations. For more accurate results in such a situation, the risk factor should be changed for each activity based on the contract terms. Therefore, the risk factors for these activities should be assigned before starting the analysis.

Illustrative Example

The following is an illustrative example of how the total risk approach will be applied in a small project. Fig. 3 shows the CPM network for a factual project. The project assumes to follow a traditional delivery system that has the following types of contracts:

- The contract between Owner and General Contractor is a guaranteed maximum cost contract, so both contract parties agree to share the project risk by 50%.
- The contract between General Contractor and Subcontractor A is a guaranteed maximum cost contract, so both contract parties agree to share the project risk by 50%.
- The contract between General Contractor and Subcontractor B is a lump sum.
- All the above-mentioned contracts assume not to have any protective terms that shift the risk to another party.

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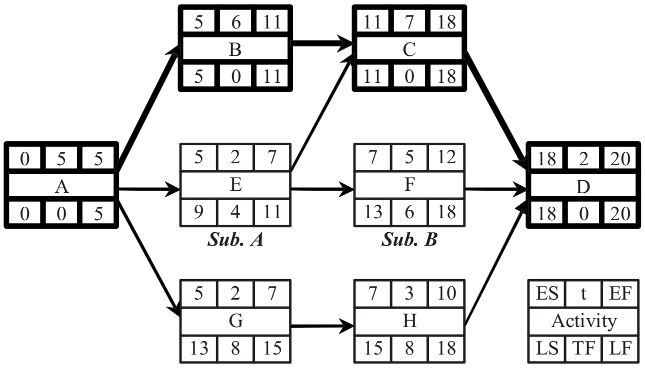

Fig. 3. CPM as-planned schedule for the applied example

- The project as-planned schedule.

The example has the following paths and associated float times:

$$CP = A - B - C - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$NCP1 = A - E - C - D = 5 + 2 + 7 + 2 = 16 \text{ days } (TF = 4)$$

$$NCP2 = A - E - F - D = 5 + 2 + 5 + 2 = 14 \text{ days } (TF = 6)$$

$$NCP3 = A - G - H - D = 5 + 2 + 3 + 2 = 12 \text{ days } (TF = 8)$$

The next step is distributing the float of the nearest first critical path, which yields the following calculations:

$$\Rightarrow TF_{(\text{Owner})} = \tfrac{2}{2} \times 4 \times 0.5 = 2 \text{ days}$$

$$\Rightarrow TF_{(\text{General Contractor})} = \tfrac{2}{2} \times 4 \times 0.5 \times 0.5 = 1 \text{ day}$$

$$\Rightarrow TF_{(\text{Subcontractor A})} = \tfrac{2}{2} \times 4 \times 0.5 \times 0.5 = [4 - 2 - 1] = 1 \text{ day}$$

After distributing the nearest first critical path, the CPM as-planned schedule is updated (Fig. 4) to distribute the float of second nearest critical path

After updating the CPM schedule, the project paths are updated as follows:

$$CP1 = A - B - C - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$CP2 = A - E - C - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$NCP1 = A - E - F - D = 5 + 6 + 5 + 2 = 18 \text{ days } (TF = 2)$$

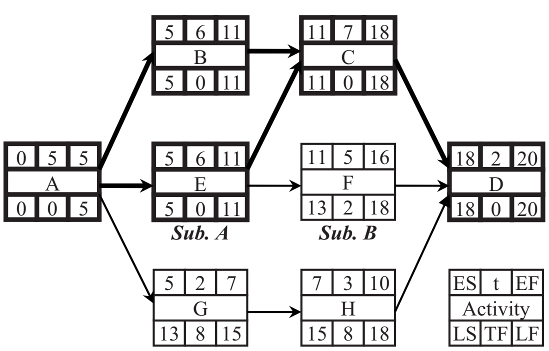

Fig. 4. Update the as-planned schedule to distribute the second nearest critical path

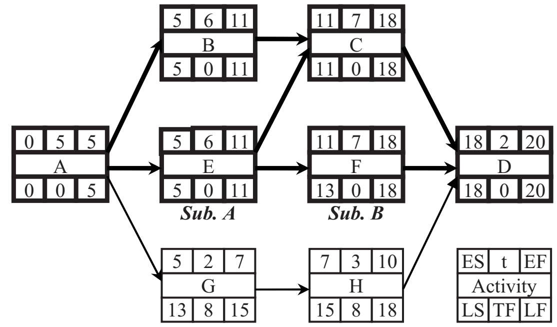

Fig. 5. Update the as-planned schedule to distribute the third nearest critical path

$$NCP2 = A - G - H - D = 5 + 2 + 3 + 2 = 12 \text{ days } (TF = 8)$$

Now the second update schedule of previous steps becomes the first nearest critical path. The following calculations are followed to get the float distribution of this path float:

$$\Rightarrow TF_{(\text{Owner})} = \tfrac{5}{5} \times 2 \times 0.5 = 1 \text{ days}$$

$$\Rightarrow TF_{(\text{General Contractor})} = \tfrac{5}{5} \times 2 \times 0.5 \times 0 = 0 \text{ day}$$

$$\Rightarrow TF_{(\text{Subcontractor B})} = \tfrac{5}{5} \times 2 \times 0.5 \times 1.0 = [2 - 1] = 1 \text{ day}$$

The last path of the example project can be distributed by updating the previous updated as-planned schedule as shown in Fig. 5.

Now the new updated schedule has the following paths:

$$CP1 = A - B - C - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$CP2 = A - E - C - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$CP3 = A - E - F - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$NCP1 = A - G - H - D = 5 + 2 + 3 + 2 = 12 \text{ days } (TF = 8)$$

As a result, the following calculation can be applied to distribute the float of the last path on the project:

$$\Rightarrow TF_{(\text{Owner})} = \left(\frac{2}{2+3} \times 8 \times 0.5\right)_{\text{activity G}} + \left(\frac{3}{2+3} \times 8 \times 0.5\right)_{\text{activity H}} = 4 \text{ days}$$

$$\Rightarrow TF_{(\text{General Contractor})} = \left(\frac{2}{2+3} \times 8 \times 0.5\right)_{\text{activity G}} + \left(\frac{3}{2+3} \times 8 \times 0.5\right)_{\text{activity H}} = 4 \text{ day}$$

Fig. 6 represents graphically the final TF distributions, using a bar chart technique. The example paths after distribution can be represented as follows:

$$CP = A - B - C - D = 5 + 6 + 7 + 2 = 20 \text{ days}$$

$$NCP1 = A - E - C - D = 5 + 2 + 7 + 2 = 16 \text{ days}$$
$$(TF = 4; OW = 2, GC = 1, SA = 1)$$

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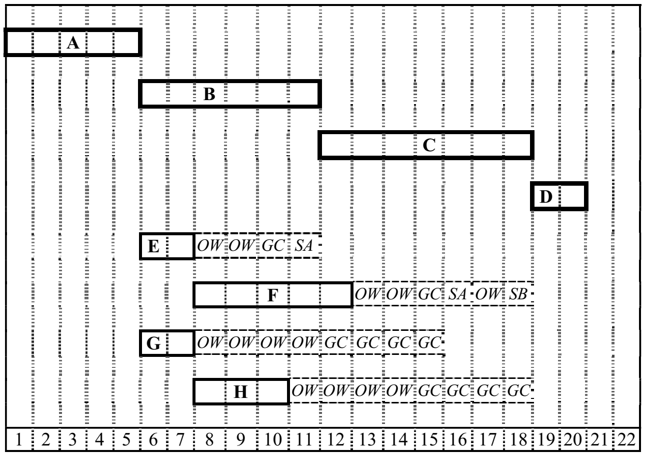


Legends: OW= Owner's Float, GC= General Contractor's float, SA=Subcontractor A's float, SB=Subcontractor B' float.

Fig. 6. As-planned bar chart for the example project

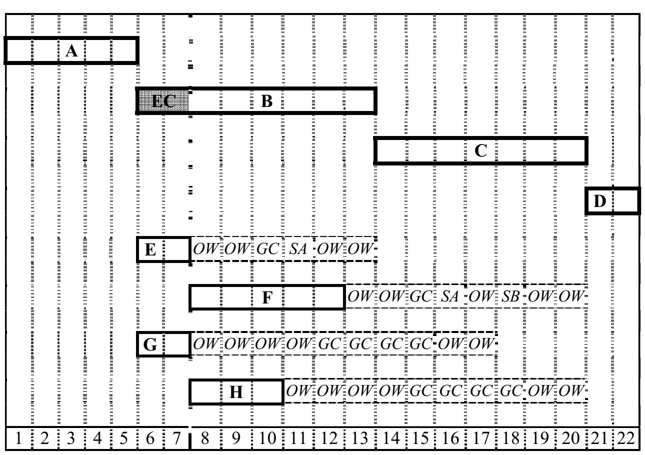
$$\text{NCP2} = \text{A} - \text{E} - \text{F} - \text{D} = 5 + 2 + 5 + 2 = 14 \text{ days}$$
$$(\text{TF} = 6; \text{OW} = 5, \text{GC} = 1, \text{SA} = 1, \text{SB} = 1)$$

$$\text{NCP3} = \text{A} - \text{G} - \text{H} - \text{D} = 5 + 2 + 3 + 2 = 12 \text{ days}$$
$$(\text{TF} = 8; \text{OW} = 4, \text{GC} = 4)$$

After the project started and the first updated schedule is developed, the first analysis schedule happened in day 7 of the analysis schedule (Fig. 7). The owner caused a 2 excusable compensable delay (EC) in the activity B start time. As a result, all the noncritical paths on this example have been increased by 2 days on their float as shown in the following calculations:

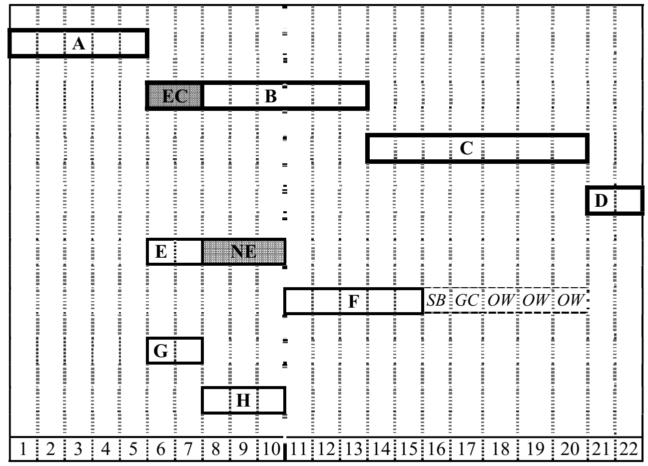
$$\text{CP} = \text{A} - \text{B} - \text{C} - \text{D} = 5 + (6 + 2) + 7 + 2 = 22 \text{ days}$$

$$\text{NCP1} = \text{A} - \text{E} - \text{C} - \text{D} = 5 + 2 + 7 + 2 = 16 \text{ days}$$
$$(\text{TF} = 6; \text{OW} = 4, \text{GC} = 1, \text{SA} = 1)$$



Legends: OW= Owner's Float, GC= General Contractor's float, SA=Subcontractor A's float, SB=Subcontractor B' float, NE=Nonexcusable Delay, EC=Excusable and Compensable Delay

Fig. 7. Day 7 analysis of the example project



Legends: OW= Owner's Float, GC= General Contractor's float, SA=Subcontractor A's float, SB=Subcontractor B' float. NE=Nonexcusable Delay, EC=Excusable and Compensable Delay

Fig. 8. Day 10 analysis of the example project

$$\text{NCP2} = \text{A} - \text{E} - \text{F} - \text{D} = 5 + 2 + 5 + 2 = 14 \text{ days}$$
$$(\text{TF} = 8; \text{OW} = 5, \text{GC} = 1, \text{SA} = 1, \text{SB} = 1)$$

$$\text{NCP3} = \text{A} - \text{G} - \text{H} - \text{D} = 5 + 2 + 3 + 2 = 12 \text{ days}$$
$$(\text{TF} = 10; \text{OW} = 6, \text{GC} = 4)$$

As noticed, the increased 2 day floats belong to the owners because they are compensated for occasioning a 2 day delay in the project.

The next updated schedule occurred on day 10 when the Subcontractor A consumed 3 float days on activity E (Fig. 8). As a result, the noncritical paths affected are as follows:

$$\text{CP} = \text{A} - \text{B} - \text{C} - \text{D} = 5 + (6 + 2) + 7 + 2 = 22 \text{ days}$$

$$\text{NCP1} = \text{A} - \text{E} - \text{C} - \text{D} = 5 + (2 + 3) + 7 + 2 = 19 \text{ days}$$
$$(\text{TF} = 3; \text{OW} = 4, \text{GC} = 1, \text{SA} = 1 - 3 = -2)$$

$$\text{NCP2} = \text{A} - \text{E} - \text{F} - \text{D} = 5 + (2 + 3) + 5 + 2 = 17 \text{ days}$$
$$(\text{TF} = 5; \text{OW} = 5, \text{GC} = 1, \text{SA} = 1 - 3 = -2, \text{SB} = 1)$$

$$\text{NCP3} = \text{A} - \text{G} - \text{H} - \text{D} = 5 + 2 + 3 + 2 = 12 \text{ days}$$
$$(\text{TF} = 10; \text{OW} = 6, \text{GC} = 4)$$

As shown in the calculations, Subcontractor A consumed 2 disentitled days. Consequently, this consumed float has been taken from other shared parties on this path (Owner, General Contractor, and Subcontractor B)

Conclusions

In this paper, six issues were identified to be the most relevant and common when dealing with the questions of float ownership and consumption and their effects on the party who bears the risk. The study indicates that float ownership should correspond to the risk assumption that the party who bears the most risk should own the most float. As a result, the total risk approach integrates several existing approaches to streamline the allocation of float

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among the project parties. The float is divided between parties based on the levels of risk they assume based on project conditions and contract terms. Next, float is treated as a commodity, so, if a nonowning party consumes float, that party must compensate the party who owns that part of float. The proposed approach then uses a day-to-day system to deal with the dynamics of float management that arises from schedule updates or as a result of delays/accelerations.

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