Schedule Acceleration Using Free Float and Multi-Path Analysis
(Applied Discrete Activity Float)
Schedule Acceleration
Using Free Float and
Multi-Path Analysis
(Applying Discrete Activity Float)

by Murray B. Woolf
Note: This White Paper was designed to function as a stand-alone reference document. It presumes a minimum understanding of the basics of the Critical Path Method. If you do not feel that you have this level of understanding, or if you find the content of this White Paper a little “over your head,” you would quite likely receive great benefit from reading CPM MECHANICS.

CPM MECHANICS is Volume 1 of the ICS-Compendium* and forms the basis for both the DOMINANT PROJECT MANAGEMENT SERIES and the COGNITIVE PROJECT MANAGEMENT SERIES. This White Paper is heavily referenced in CPM MECHANICS, and was written to serve as a supplement to that book.

To learn more about CPM Mechanics, we encourage you to investigate it at www.CpmMechanics.com.

* The ICS-Compendium is a five-year project that began in January 2011. The primary eight volumes are scheduled for issuance in six-month increments, starting with CPM Mechanics, which is already on bookshelves. Release Dates for the other volumes are posted at the ICS-Placement website. Simply go to www.ics-placement.com.

Note: Words appearing in bold font are defined in the glossary at the end of the White Paper. You may wish to consult the ICS-Dictionary for additional terms not defined in the glossary.
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Schedule Acceleration Using Free Float and Multi-Path Analysis

(Applying Discrete Activity Float)

As part of his or her routine duties, a Project Facilitator[1] may be asked to recommend ways to accelerate a Schedule. The objective would be to discover how to differently utilize Project resources such that one or more Project Execution Commitments are achieved earlier than they would have been without the different course of action.

I: Context of White Paper

At first, this White Paper was intended to offer an in-depth treatment of the concept of Free Float, which Cognitive Project Management contends is poorly understood (and, thus, under-utilized) throughout Dominant Project Management.

I.A: Initially, An Expose on Free Float

While thinking about a clever way to present a coherent and useful discussion on Free Float, it was quickly realized that a real-life example might be quite effective. However, not too long into the writing exercise it became apparent that we had developed a sound foundation for a paper on schedule acceleration. And so, this paper has these two distinct themes: a better understanding of Free Float, and a better understanding of the dynamics behind Schedule Acceleration.

[1] Project Facilitation is Cognitive Project Management's rough equivalent to Dominant Project Management's Project Controls and thus encompasses, at a minimum, Project Cost Management and Project Schedule Management. A Project Facilitator is someone who works in the Project Facilitation arena.
I.B: A Real Life Question: Additional Labor for Earlier Completion

The specific question behind this White Paper emanates from an imaginary discussion between a Project Manager and a Project Facilitator:

- **Manager:** We have four men who have been made available to us for six workdays. Where is the best place for us to use them?
  - **Facilitator:** Define “best.”
- **Manager:** I want to accelerate the schedule, to better our chances of meeting all deadlines in the schedule. This is not about maximizing profits; this is a scheduling exercise. We need to meet our deadlines. Beat them, if we can.
  - **Facilitator:** So, you're looking for me to suggest where we can get the biggest bang for the buck, but with respect schedule, not budget. And I have 24 Worker-Days to play with! **Four men for six workdays = 24 Worker-Days.**
- **Manager:** You got it. Now, get on it!

So, to be perfectly clear, this White Paper considers how the deployment of additional labor forces might be used to improve the likelihood that temporal commitments will be met. That is, we are primarily concerned with temporal outcomes, as opposed to consequences related to cost, risk, safety, or other important considerations.

I.C: Several Popular Approaches to Answering the Question

If you posed this question to a dozen seasoned Project Schedulers, the responses would be both quick and confident. Of course, they would also be different, as well. Here are some of the more common recommendations we might expect to hear:

- **Least Float Path:** An obvious answer, and the one most often chosen, is to assign the additional labor resources to whatever Activities have the **Least Total Float** in the Schedule. But, as we shall soon discover, that just might not be the best choice.
- **Longest Path:** Another equally-popular recommendation would be to apply the additional resources to any of the Activities residing along the **longest path** in the Schedule. This, too, might not be the best choice.
- **Largest Duration:** Or, we might be told to apply the resources to Activities that have very large Activity Durations. The presumption here is that if we double the labor, we cut the duration in half.
- **Most Successors:** A smaller percent of responses zero in on Activities that have the largest number of immediately-succeeding (downstream) Activities tied to them. The theory here is that if we can complete the predecessor sooner, then all of
those immediately-dependent Activities will be able to start that much sooner!

- **Nearest a Deadline:** Finally there is an argument for applying those additional resources to Activities that are closest to an impending Milestone. The closer to the Milestone an Activity it is, the more critical is its timely completion (for there is less time to "make up" for any slippage that such an Activity might incur).

### I.D: Necessary to Understand Two New Concepts

This White Paper will suggest that none of the above “obvious” approaches will necessarily yield the best answer to the question. Instead, we will recommend that the Project Facilitator use an **Activity Multi-Path Analysis**. Since this is a concept born in Cognitive Project Management and thus likely unfamiliar to the reader, this White Paper will also include a brief explanation of the Activity Multi-Path Residency concept. \(^2\)

The other concept that may appear foreign to the reader is **Discrete Activity Float**. This White Paper will provide a brief coverage of DAF, before applying it to a Multi-Path Analysis exercise. \(^3\)

### II: Comparison on Acceleration Options

We begin this White Paper by creating a simple ten-Activity “schedule,” which we will then try to accelerate, first by applying each of the five traditional approaches listed above. Then, we will perform an **Activity Multi-Path Analysis** and see if it yields a better solution.

### II.A: Establishing the Original Schedule

Let us begin with [Figure F002](#), which presents a ten-Activity Schedule. In the interest of simplicity, we have limited the network to **Default Restrictions**. However, **Multi-Path Analysis** is equally effective and valid in CPM networks that include **Start Restrictions** and **Finish Restrictions**.

#### II.A.1: How to Interpret the Logic Diagram’s Symbolism

Note that all **Forward Pass** and **Backward Pass** calculations are based on an End-of-Day

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2 For a thorough treatment of Activity Multi-Path Residency, see “CPM Mechanics.”

3 For a thorough treatment of Discrete Activity Float, see “Faster Construction Projects with CPM Scheduling.”
Perspective.  All CPM Network diagrams in this White Paper use the same Activity Box format and notations, as explained below.

- **Earliest Start:** The earliest that an Activity can start, as calculated using a traditional Forward Pass calculation process. Earliest Start is expressed as the last moment of the prior workday, consistent with the End-of-Day Perspective. Earliest Start appears at the top-left corner of the Activity Box.

- **Earliest Finish:** The earliest that an Activity can finish, as calculated using a traditional Forward Pass calculation process. Earliest Finish is expressed as the last moment of the last workday, consistent with the End-of-Day Perspective. Earliest Finish appears at the top-right corner of the Activity Box.

- **Latest Start:** The latest that an Activity can start, as calculated using a traditional Backward Pass calculation process. Latest Start is expressed as the last moment of the prior workday, consistent with the End-of-Day Perspective. Latest Start

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4 For more on Point-of-Day Perspectives, see ICS-White Paper WPB-KJ-28
6 For more on the Backward Pass Process, see ICS-White Paper WPB-KI-13
appears at the bottom-left corner of the Activity Box.

- **Latest Finish:** The latest that an Activity can finish, as calculated using a traditional Backward Pass calculation process. **Latest Finish** is expressed as the last moment of the last workday, as consistent with the End-of-Day Perspective. Latest Finish appears at the bottom-right corner of the Activity Box.

- **Activity Description:** In this sample CPM Network logic, we are using generic descriptions, such as Activity A or Activity J. Activity Descriptions appear in the center of the Activity Box.

- **Activity Duration:** The **Activity Duration**, which appears at the bottom-center of the Activity Box, represents Continuous Crew Days. As noted in the next subsection, the Original Schedule (before acceleration adjustments) assumes that every Activity is being worked by a crew of four workers.

- **Total Float:** **Total Float** is presented as both Start Total Float and Finish Total Float. However, because the sample CPM Network only utilizes Default Restrictions, in all cases the Start Total Float and Finish Total Float values will be the same for any given Activity. We are using the dual reporting system in order for this White Paper to be consistent, in format, with all other White Papers contained within the ICS-COMPENDIUM. Total Float values appear in left and right appendages to the Activity Box, which we have nicknamed Total Float “ears.”

### II.A.2: Specifics Concerning the CPM Network Content

For purposes of this White Paper, we will assume that every Activity is being worked by a crew comprised of four workers. Thus, an Activity with a **six-day** duration requires **24 Worker-Days**. Activity A requires **16 Worker-Days**. Activity G requires **48 Worker-Days**.

Also please note the imposition of three **Date Constraints**. The Schedule begins with a Start-No-Earlier-Than (SNET 0) Date Constraint of Day 0. The Schedule ends with a Finish-No-Later-Than (FNLT 50) Date Constraint of Day 50, pinned to the end of Activity J. Finally, Activity I is required to complete no later than Day 20 (FNLT 20).

We included the Date Constraints in order to create a CPM Network sample that simulates some of the more complex interdependencies typically found in larger CPM Networks. In particular, the FNLT 20, found at the end of Activity I, was purposely injected so as to create a Least Total Float **Critical Path** that does not terminate at the end of the Schedule. As a result, the Longest Path through the Schedule is not also the Least Total Float Path. It will be interesting to see how this complexity factors into the various

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7 For more on Continuous Crew Days, see “CPM Mechanics.”
8 To learn more about Start Total Float and Finish Total Float, see “CPM Mechanics.”
ways of applying additional labor resources.

II.A.3: Defining Critical Statistics Used in this Study

Now it is time to start using the sample CPM Network logic, which we will refer to as the “Original Schedule” from this point forward. Before we present the critical statistics for the Original Schedule Logic, let us provide some explanation of those values:

- **Activity Count**: The number of Activities in the Network Logic. The number of Activities does not change from one acceleration application to the next, but it will be repeated under each application for ease of review of other Critical Statistics, some of which are based on the number of Activities in the Network Logic.

- **Aggregate Duration**: This is the sum of all Activity Durations in the Network Logic.

- **Maximum Project Length**: This represents the maximum amount of time allowed to complete the work represented in this Network Logic. It is calculated as 50 workdays and is derived by subtracting the SNLT 0 from the FNLT 50.

- **Project Earliest Finish**: This is the calculated earliest date that the Network Logic can be completed, and is derived by performing a traditional Forward Pass on the Network Logic. We will use comparisons of various Project Earliest Finish calculations, under difference scenarios, to determine which acceleration approach achieved the greatest improvement in Final Completion.

- **Aggregate Total Float**: Aggregate Total Float is the sum of the Total Float values calculated for each individual Activity. This value is not commonly computed in Dominant Project Management circles. In fairness to its lack of popularity, we note that this value is a theoretic value of no real-world significance. We say this because Total Float belongs to an Activity Path, yet is reported (redundantly) to all Activities residing on that Path, thus making it a fairly bogus value. For example, if five Activities reside on Path A, which has Total Float of 4 workdays, then the Aggregate Total Float for Path A would be 16. Yet, if we were to decompose the logic of Path A, such that each Activity were split into two Activities, while the length of the Path would not change, and the Path's Total Float would not change ... the Aggregate Total Float across all four Activities would double.

Still, Aggregate Total Float is a down-and-dirty way to quickly compare the results of different schedule acceleration approaches, as to whether they tighten or loosen the Schedule. For a more precise (and more meaningful) measure of Schedule Resiliency, see Aggregate DAF, below.

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9 For more on Schedule Resiliency, including Activity Vulnerability and Activity Resiliency, see “Faster
Aggregate Free Float: Much like Aggregate Total Float, Aggregate Free Float is the sum of the Free Float values calculated for each individual Activity. It, too, is not a value with any practical, real-world significance. But it is of minor use in comparing the affect of different Schedule acceleration approaches.

TF/Length Ratio: This value is derived by dividing the Aggregate Total Float by the Maximum Project Length. What this value tells us is roughly how much Total Float is available, on average, for any given day in the Project Length. Keeping in mind that Aggregate Total Float is a bogus value, this ratio is of no real-world significance. However, it does allow us to get a sense of just how much sponginess there may be in the Schedule.

FF/Length Ratio: What was just said about the Length/TF Ratio is true of this ratio.

Critical Activities: This is an admittedly subjective value. One could choose any parameters for what is considered “critical.” For purposes of this exercise, we have decided to give a critical rating to any Activity with Total Float of zero or less (negative Total Float).

Near-Critical Activities: Even more subjective, we have chosen to appoint Near-Critical status to Activities with Total Float greater than 0, but less than 15% of Project Length. Since Project Length is 50, then Near-Critical Activities would have Total Float between 1 and 7.5.

Percent Critical/Near-Critical: This is just a generalized way to indicate the collective criticality of the overall Network Logic. It is derived by dividing the Activity Count into the sum of the Critical and Near-Critical Activities.

Aggregate DAF: Momentum Management employs a technique whereby Total Float, which belongs to an Activity Path, is proportionately allocated to each Activity resident on that Path. We call the assigned value Discrete Activity Float, and it is allocated in proportion to the Activity Duration’s percent of Aggregate Duration for the overall Path.

Aggregate DAF/Aggregate Duration Ratio: This is a far more precise and meaningful measure of Total Float than the TF/Length Ratio. If we accept that an Activity Duration reflects the amount of work as described by the Activity Description, then the summation of all Activity Durations represents the amount of work to be performed throughout the “project,” as depicted by the overall Network Logic. By dividing the Aggregate DAF by the Aggregate Duration, we get a much more realistic sense of just how much sponginess there really is in the Network Logic.
II.A.4: **Original Schedule Critical Statistics**

Now it is time to present and evaluate the Critical Statistics for the Original Schedule. It is this set of data that will be used as the basis of comparison for the results of the various Schedule acceleration approaches.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Value</th>
<th>Activity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity J Total Float</td>
<td>6</td>
<td>Activity I Total Float</td>
<td>0</td>
</tr>
<tr>
<td>Activity Count</td>
<td>10</td>
<td>Aggregate Duration</td>
<td>98</td>
</tr>
<tr>
<td>Maximum Project Length</td>
<td>50</td>
<td>Project Earliest Finish</td>
<td>44</td>
</tr>
<tr>
<td>Aggregate Total Float</td>
<td>86</td>
<td>Aggregate Free Float</td>
<td>62</td>
</tr>
</tbody>
</table>

We see that, before we attempt any Schedule acceleration approach, the Network Logic is destined to take **44 days**. We see that the Final Completion of the Schedule, at **Activity J**, has Total Float of **+6**. This makes sense since the Maximum Project Length is **50 days** and the Project Earliest Finish is **Day 44**.

The Aggregate Total Float and Aggregate Free Float values are benchmarks that we will use in our comparison of the various Schedule acceleration approaches to the starting conditions depicted by the Original Schedule.

In the Original Schedule, there are **1.72 days** of Total Float for each of the **50 days** in the Project Length. Likewise, there are **1.24 days** of Free Float for the Project Length. We will refer back to these values in the following pages.

Three Activities are critical and four are near-critical. Since there are ten Activities in the Network Logic, **70%** of them are either critical or near-critical.

The Aggregate DAF for the Original Schedule is **29.36**. This is the true amount of Total Float in the Schedule, when we remove redundant reporting of Total Float. When compared to the Aggregate Duration for the Schedule, each individual Duration-Day in the Schedule enjoys a **30%** Total Float cushion. In other words, on average, each Activity has a padding of **30%** up and above the duration itself.
When we compare Aggregate DAF to the Project Length, we find that for each day in the Schedule Length, there is 59% cushion. Again, we will use these benchmark values as points of comparison when we apply the various Schedule acceleration approaches.

II.A.5: Activities Targeted in Different Schedule Acceleration Options

Before we launch into our analysis of the different Schedule acceleration approaches, we need to identify the Activities that would be targeted by each acceleration option. For the following discussion, please refer back to Figure F002.

- **Least Total Float Path**: The Activity Path with the Least Total Float spans from **SNET 0** to **FNLT 20** and bears Total Float of **+0**. The Activities involved include **ACTIVITY A**, **ACTIVITY H**, and **ACTIVITY I**.
- **Longest Path**: The Longest Path through the Network Logic spans from **SNET 0** through **FNLT 50** and bears Total Float of **+6**. The Activities involved include **ACTIVITY A**, **ACTIVITY D**, **ACTIVITY E**, **ACTIVITY F**, and **ACTIVITY J**.
- **Largest Duration**: The Activity with the largest Activity Duration is **ACTIVITY G**, with a Duration of **20**.
- **Most Immediate Successors**: The Activity with the most immediate successors is **ACTIVITY D** with **five** successors. The Activities with the next most immediate successors are **ACTIVITY A** and **ACTIVITY H**, each with **two** successors.
- **Nearest to a Deadline**: **ACTIVITY I** and **ACTIVITY J** are each the last Activities in Paths leading to **FNLT Date Constraints**.

II.B: Schedule Acceleration Approach: Least Total Float

The first Schedule acceleration approach we will examine is the Least Total Float option. The rationale here is that if we apply the additional labor resources to Activities on the Activity Path with the Least Total Float, we will surely be advancing the likely completion of the Project Execution Milestone into which the Path terminates.

And that is precisely what we see from the results of the approach's application. But let us not get ahead of ourselves. We must first perform the approach application, and then we can analyze its results.

II.B.1: Applying the Acceleration Approach

For the following discussion, refer to Figure F004, which shows the deployment of additional labor forces to Activities along the Least Total Float Path.
F004: Least Total Float Schedule Acceleration Option

We logically start at the beginning of the Path, with Activity A. As we shall see in the next paragraph, not all of the available additional labor is consumed by this first Activity. So, we proceed to the next Activity in the Path. Activity H consumes the remainder of the available additional labor. Here are the labor allocation details:

<table>
<thead>
<tr>
<th>Activity A needs 16 workdays</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>9</td>
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<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
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<tr>
<td>After Deployment</td>
<td>8</td>
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<td>8</td>
</tr>
<tr>
<td>Additional Labor Used:</td>
<td>8 Worker-Days = 16 Worker-Days</td>
<td></td>
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<table>
<thead>
<tr>
<th>Activity H needs 32 workdays</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8</td>
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<td>8</td>
</tr>
<tr>
<td>Additional Labor Used:</td>
<td>16 Worker-Days = 32 Worker-Days</td>
<td></td>
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</table>

II.B.2: Analysis of Schedule Acceleration Approach

So what does this first acceleration approach accomplish? Let's look at the statistics.
At first blush, it would appear that this acceleration approach accomplished what the Project Manager had wanted; the Project Earliest Finish pulled back two days, from Day 44 to Day 42. This gain corresponds to the increased Total Float for the final Activity, Activity J, which went from +6 to +8.

But temporal gains were even more dramatic at Activity I, where Total Float went from +0 to +6! Of course this makes sense since we applied the additional labor to Activities along the Least Total Float Path, which terminates at Activity I.

While these temporal gains are impressive, we shall soon see that the results of this acceleration approach are not the best that we can achieve with those additional labor forces. Let's look at the next acceleration approach.

II.C: Schedule Acceleration Approach: Longest Path

The next Schedule acceleration approach we will examine is the Longest Path option. Accordingly, we will apply the additional labor resources to Activities on the Longest Path. We can expect this approach to improve the completion of the Project Execution Milestone at the end of the Schedule, since that is where the Longest Path terminates. And the results of the approach's application do confirm our suspicions. But before we get into an analysis of the results, let us first perform the approach application.

II.C.1: Applying the Acceleration Approach

For the following discussion, refer to Figure F006, which shows the deployment of additional labor forces to Activities along the Longest Path.

We logically start at the beginning of the Path, with Activity A. Not all of the available additional labor is consumed by this first Activity, so we proceed to the next two Activities in the Path, Activity D and Activity E.
Here are the labor allocation details:

### Activity A needs 16 workdays

<table>
<thead>
<tr>
<th>Activity A needs 16 workdays</th>
<th>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4 4 4 4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8 8</td>
</tr>
<tr>
<td>Additional Labor Used:</td>
<td>8 Worker-Days</td>
</tr>
<tr>
<td>Duration Reduction:</td>
<td>2 days</td>
</tr>
<tr>
<td>Duration goes from:</td>
<td>4 to 2</td>
</tr>
</tbody>
</table>

### Activity D needs 24 workdays

<table>
<thead>
<tr>
<th>Activity D needs 24 workdays</th>
<th>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8 8</td>
</tr>
<tr>
<td>Additional Labor Used:</td>
<td>12 Worker-Days</td>
</tr>
<tr>
<td>Duration Reduction:</td>
<td>3 days</td>
</tr>
<tr>
<td>Duration goes from:</td>
<td>6 to 3</td>
</tr>
</tbody>
</table>

### Activity E needs 40 workdays

<table>
<thead>
<tr>
<th>Activity E needs 40 workdays</th>
<th>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>Additional Labor Used:</td>
<td>4 Worker-Days</td>
</tr>
<tr>
<td>Duration Reduction:</td>
<td>1 day</td>
</tr>
<tr>
<td>Duration goes from:</td>
<td>10 to 9</td>
</tr>
</tbody>
</table>

**II.C.2: Analysis of Schedule Acceleration Approach**

Here is what this second acceleration approach accomplished:
Seasoned schedulers will not be surprised at these results. After all, we applied the additional labor to the Path that drives the Final Completion. Accordingly, the Project Earliest Finish pulled back six days, from Day 44 to Day 38.

This temporal gain is reflected in the increased Total Float for the final Activity, Activity J, which went from +6 to +12. Because only one of the three Activities (Activity A) receiving additional labor had anything to do with the Path leading to FNLT 20, the gains at the Intermediate Milestone were not as dramatic. Total Float went from +0 to +2!

So is this acceleration approach a better one than the Least Total Float option? Well, it depends on which deadline is more important to the Project Team.

II.D: Schedule Acceleration Approach: Largest Duration

The next Schedule acceleration approach we will examine is the Largest Duration option. The thinking here is rather intuitive: cutting a large-duration Activity in half eliminates more time than cutting a smaller-duration Activity in half. But, as we shall see, there are two fallacies with this thinking:

- **Distributive Law of Multiplication:** The Distributive Law of Multiplication tells us that $12 \times 0.50$ yields the same result as $[(4 \times 0.50) + (4 \times 0.50) + (4 \times 0.50)]$. This means that we could reduce a number of smaller Activities and gain the same reduction in time as we would by reducing one larger Activity.

- **Critical Path:** This should be immediately obvious to anyone who understands the basics of the Critical Path Method. If the largest-duration Activity has an abundance of Total Float, then its reduction in duration is unlikely to improve the completion time for any downstream Milestones it precedes.
II.D.1: Applying the Acceleration Approach

For the following discussion, refer to Figure F008, which shows the deployment of additional labor forces to the Activity with the largest duration, Activity G.

Activity G had an Original Duration of 20 workdays. By assigning all of the additional labor resources to this single Activity, its adjusted duration reduces from 20 workdays to 14 workdays, a gain of six workdays.

Here are the labor allocation details:

| Activity G needs 80 workdays | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-----------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|
| Before Deployment           | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| After Deployment            | 8 | 8 | 8 | 8 | 8 | 8 | 4 | 4 | 4 | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |

Additional Labor Used: 24 Worker-Days. Duration Reduction, six days. Duration goes from 20 to 14.

Notice what the Largest Duration acceleration approach accomplished. As we expected, neither of the two Project Execution Milestones realized any temporal improvement. Activity J still has Total Float of +6, and Activity I still has Total Float of +0. The overall Project Earliest Finish is still Day 44.

So, did this approach have any positive effect whatsoever? Well, the Aggregate Duration
reduce

d by 6 days and, correspondingly, both the Aggregate Total Float and the Aggregate Free Float increased by 6 days. Accordingly, both Length/TP Ratio and Length/FF Ratio improved.

But none of the reported gains of the previous paragraph mean anything in the real world, because they are all reflecting redundant Total Float reporting. Remember what we said earlier about the same (Path) Total Float values being reported against all Activities along that Path. To prove that the statistics of the previous paragraph are bogus, consider the DAF statistics in the next paragraph.

The Aggregate DAF also improved, but less dramatically. Whereas the Aggregate Total Float improved by roughly 7%. Aggregate DAF only increased by 5%.

\[
\frac{92}{86} = 1.069 \%
\]
\[
\frac{30.92}{29.36} = 1.053 \%
\]

I hope you don't miss a side lesson about Total Float. Cumulative Total Float can increase or decrease irrespective of any changes in Project Execution Milestones. So do not fall into the trap of thinking that just because some effort reduces Total Float it necessarily translates into gains on downstream Deadlines.

What such changes do reflect is what Cognitive Project Management calls Schedule Buoyancy, which is the ability of the Schedule to absorb schedule delays and somehow bounce back from them.\[11\]

### II.E: Schedule Acceleration Approach: Most Immediate Successors

The next Schedule acceleration approach to emphasize Activity having the greatest

\[11\] For more on Schedule Buoyancy, see “Faster Construction Projects with CPM Scheduling.”
number of Immediate Successors. This option argues that the more a given Activity
withholds the start or finish of immediately-succeeding Activities, the more significant
it is to overall Schedule performance.

II.E.1: Applying the Acceleration Approach

Look at Figure F010. Which Activity has the most Activities immediately following it?
Why, that is Activity D, which has four Activities immediately following it (Activity B,
Activity C, Activity E, Activity G).

However, even after applying additional labor resources to Activity D we still have more
labor resources left over, that we can apply to other Activities. So, what is the Activity
with the next greatest number of successors immediately following it?

Actually, there is a tie for second place: Activity A has two immediate successors, but so
does Activity H. So, we will apply the remaining additional labor resources in order of
total downstream Activity count. Activity A precedes nine Activities, whereas Activity H
precedes only three Activities.
II.E.2: Analysis of Schedule Acceleration Approach

Here is what the Most Immediate Successors acceleration approach accomplished:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total Float</th>
<th>TF/Length Ratio</th>
<th>FF/Length Ratio</th>
<th>Critical Activities</th>
<th>Near-Critical Activities</th>
<th>Percent Critical/Near Critical</th>
<th>Aggregate DAF</th>
<th>DAF/Aggregate Duration Ratio</th>
<th>DAF/Length Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity J</td>
<td>11</td>
<td>2.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Activity I</td>
<td>3</td>
<td>1.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Count</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Duration</td>
<td>92</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Project Length</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Earliest Finish</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Total Float</td>
<td>128</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Free Float</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This approach seems almost as good as the Longest Path approach. Both improve Aggregate Total Float by **42 days**, compared to the Least Total Float Path option with improvement of only **34 days**, or the Largest Duration option's paltry **6 days**!

Likewise, while the Least Total Float option shortened the overall schedule by **six days**, this option shortened it by **5 days** -- compared to Least Total Float's **two days**. The Largest Duration option did not shorten the schedule at all.

The Most Immediate Successors option was more judicious in its distribution of “help” to the two Project Execution Milestones. The Longest Path option benefited the Final Milestone (**Activity J**) with **six days** of increased Total Float and the Intermediate Milestone (**Activity I**) with **two days** of Total Float. Compare that to the Most Immediate Successors option which improved **Activity J** by **five days** and **Activity I** with **three days**. They both provided a collective **eight days** of Total Float improvement; only the Most Immediate Successors was more balanced in its distribution of that improvement.
II.F: Schedule Acceleration Approach: Nearest Milestone

In this acceleration approach we apply the additional labor resources to the Activities that are closest to a Project Execution Milestone. Those who advocate this technique argue that Activities just ahead of a Milestone have no “mop up” support from other downstream Activities, as would be the case with any other Activities. For example, if Activity E slips, there is still Activity F and Activity J to possibly make up the time loss.

II.F.1: Applying the Acceleration Approach

Figure F012 identifies the two Activities that, each, immediately precede a Project Execution Deadline. Activity J precedes FNLT 50 (Final Deadline) and Activity I immediately precedes FNLT 20 (Intermediate Deadline). We favor the Intermediate Milestone since it comes first. Therefore, the first application of additional labor is to Activity I.
Here are the labor allocation details:

<table>
<thead>
<tr>
<th>Activity I needs 32 workdays</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Additional Labor Used</td>
<td>16 Worker-Days. Duration Reduction, four days. Duration goes from 8 to 4.</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

| Activity J needs 24 workdays | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|
| Before Deployment            | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| After Deployment             | 8 | 8 | 4 | 4 | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| Additional Labor Used        | 8 Worker-Days. Duration Reduction, two days. Duration goes from 6 to 4. |

II.F.2: Analysis of Schedule Acceleration Approach

It is interesting to see what this acceleration approach was able to accomplish.

<table>
<thead>
<tr>
<th></th>
<th>8</th>
<th>4</th>
<th>10</th>
<th>92</th>
<th>50</th>
<th>42</th>
<th>112</th>
<th>66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity J Total Float:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity I Total Float:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Count:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Duration:</td>
<td>8</td>
<td>4</td>
<td>10</td>
<td>92</td>
<td>50</td>
<td>42</td>
<td>112</td>
<td>66</td>
</tr>
<tr>
<td>Maximum Project Length:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Earliest Finish:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Total Float:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Free Float:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TF/Length Ratio:</td>
<td>2.24</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FF/Length Ratio:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Activities:</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near-Critical Activities:</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Critical/Near Critical:</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate DAF:</td>
<td>39.44</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAF/Aggregate Duration Ratio:</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One thing it accomplished was a modest improvement in Total Float at the Intermediate Milestone, FNLT 20. The Total Float reported at Activity I went from +0 to +4. As for the Final Milestone, FNLT 50, Activity J's Total Float only slightly increased, from +6 to +8. And the Project Earliest Finish only inched backward, from Day 44 to Day 42.

II.G: Schedule Acceleration Approach: Multi-Path Analysis

What we have seen from the previous exercises is that, while there is more than one way to skin a cat, no way is ideal. The greatest gain on Project Earliest Finish, from Day 44 to Day 36, was the result of the Longest Path Option. But this Schedule acceleration approach did very little for the Intermediate Milestone, FNLT 20.

When one considers that the Intermediate Milestone occurs only 20 days into the Schedule, whereas the Final Milestone (FNLT 50) is twice as far from Project outset, there is twice the urgency and need for the kind of temporal cushioning provided by Total Float. By
emphasizing the protection of the Final Milestone over the Intermediate Milestone, as happened when the Longest Path option was taken, the Intermediate Milestone was made that much more vulnerable to slippage.

II.G.1: Understanding the Concept of Multiple Paths

So is there an approach that is more even-handed? Cognitive Project Management recommends an acceleration approach that it pioneered, called the Multi-Path Analysis option. It is based on the reality that most Activities in a Schedule actually reside on more than one Path.

This fact is not well understood or discussed in Dominant Project Management literature. This is hardly surprising, since that same literature fails to provide a simple definition of the term, path, even as it speaks at length about the Critical Path. So we must take a few minutes to demonstrate how Activities can reside simultaneously on multiple Paths.

Take a long look at Figure F014, which shows seven distinct Path Segments.
Six of the Paths span from SNET 0 to FNLT 50. The seventh Path (black line) connects SNET 0 to FNLT 20. The diagram should be self-explanatory as to the Activities through which each Path winds.

What may not be so obvious is the isolated Total Float that each Path actually enjoys. To find this value, simply calculate the length of the Path and then subtract this value from the Maximum Project Length. Let’s try this.

What is the length of the Blue Path, through Activity A, Activity C, and Activity J? Add up the durations of the Activities.

\[ 4 + 7 + 6 = 17 \]

Thus, the Blue Path is only 17 days in length. If this were the only work to be completed by FNLT 50, then it would have Total Float of +33. Would it not?

It is your turn to calculate the Total Float of the Purple Path, which runs through Activity A, Activity B, Activity G, and Activity J. Your answer should be +12. The sum of the four Activities’ durations are 38 days \((4 + 8 + 20 + 6)\).

Now that you understand how to determine the Total Float for any isolated Path, let us consider an Activity that resides on more than one Path. Take a look at Activity G. Do you see that it resides on both the Brown Path and the Purple Path? The Purple Path has a length of 38 days and a Total Float value of +12, as we just calculated in the previous paragraph. We compute the Brown Path to be 36 days long, and therefore have a Total Float value of +14.

The rule of the Forward Pass Process (in the Critical Path Method) is to always report the lowest Total Float value, when faced with multiple choices. That is why we see a Total Float value of +12 for Activity G. With respect to the Brown Path, Activity G enjoys Total Float of +14, but it is the Purple Path than reduces its Total Float to +12. Are you following all of this?

So now, let us consider Activity A, which resides on no less than seven Paths. Of course the Total Float reported against Activity A is +0, because the Black Path, connecting SNET 0 and FNLT 20 has Total Float of +0. But, with respect to the other Paths upon which Activity A resides, it enjoys six different Total Float values.

II.G.2: Applying the Acceleration Approach

You may be thinking that, “all of this is interesting, but not terribly relevant in the real world.” But you would be wrong. It is extremely relevant. When we come to realize that an Activity can reside on multiple Paths simultaneously, we quickly appreciate that a reduction in duration on such an Activity benefits all of the Paths it resides upon.

Logically, then, to get the “biggest bang for the buck,” as the original assignment was
worded, we would want to apply the additional labor resources to the Activity that resides on the most Paths.

In our example, that would be Activity A, which resides on seven Paths. Next in line would be Activity J, which resides on six Paths. Let's see what happens when we apply the additional labor to just these two Activities. Follow along in Figure F016. Here are the labor allocation details:

### Activity A needs 16 workdays

<table>
<thead>
<tr>
<th>Activity A needs 16 workdays</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Additional Labor Used: 8 Worker-Days. Duration Reduction, two days. Duration goes from 4 to 2.

### Activity I needs 24 workdays

<table>
<thead>
<tr>
<th>Activity I needs 24 workdays</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
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<td>4</td>
<td>4</td>
</tr>
<tr>
<td>After Deployment</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Additional Labor Used: 12 Worker-Days. Duration Reduction, three days. Duration goes from 6 to 3.

### Activity H needs 32 workdays

<table>
<thead>
<tr>
<th>Activity H needs 32 workdays</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deployment</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>After Deployment</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<td>8</td>
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<td>8</td>
</tr>
</tbody>
</table>

Additional Labor Used: 4 Worker-Days. Duration Reduction, one day. Duration goes from 8 to 7.
We still have four Worker-Days left, that we can apply somewhere else. Activity H resides on three Paths, so it is our next target for appropriation of additional labor.

II.G.3: Analysis of Schedule Acceleration Approach

Finally, we are able to see how the Multi-Path Analysis approach fared, and compare it to the other approaches.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Original</th>
<th>Least</th>
<th>Longest</th>
<th>Largest</th>
<th>Most</th>
<th>Nearest</th>
<th>Multi-Path</th>
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<tbody>
<tr>
<td>Activity J Total Float</td>
<td>12</td>
<td></td>
<td>12</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Activity I Total Float</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Activity Count</td>
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<td>6</td>
<td>2</td>
<td>0</td>
<td>4</td>
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<tr>
<td>Aggregate Duration</td>
<td>92</td>
<td>92</td>
<td>92</td>
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<td>Maximum Project Length</td>
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<td>Project Earliest Finish</td>
<td>39</td>
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<tr>
<td>Aggregate Total Float</td>
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<td>Aggregate Free Float</td>
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<td>64</td>
<td>64</td>
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<tr>
<td>Length/TF Ratio</td>
<td>1.72</td>
<td>2.40</td>
<td>2.56</td>
<td>2.56</td>
<td>2.56</td>
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<td>2.44</td>
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<td>Length/FF Ratio</td>
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<td>1.24</td>
<td>1.04</td>
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<td>1.16</td>
<td>1.32</td>
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<td>Near-Critical Activities</td>
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<td>4</td>
<td>4</td>
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<td>4</td>
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<tr>
<td>% Critical/Near Critical</td>
<td>70%</td>
<td>30%</td>
<td>30%</td>
<td>70%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
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<tr>
<td>Discrete Activity Float (DAF)</td>
<td>29.36</td>
<td>43.22</td>
<td>47.59</td>
<td>30.92</td>
<td>48.45</td>
<td>39.44</td>
<td>51.13</td>
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<tr>
<td>DAF/Aggr Duration Ratio</td>
<td>0.30</td>
<td>0.47</td>
<td>0.52</td>
<td>0.34</td>
<td>0.53</td>
<td>0.43</td>
<td>0.56</td>
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<tr>
<td>Length/DAF Ratio</td>
<td>0.59</td>
<td>0.86</td>
<td>0.95</td>
<td>0.62</td>
<td>0.97</td>
<td>0.79</td>
<td>1.02</td>
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</tbody>
</table>

Immediately we see that the Total Float values for Activity I and Activity J are as good as the best that we have seen so far, matching the results of the Longest Path approach. And in terms of Project Earliest Finish, the Multi-Path approach is the next best acceleration result – Day 39 instead of Day 38 – second only to the Longest Path approach.
But there are other statistics where the Multi-Path Analysis approach is actually better than the Longest Path approach. It is time to compare all of the approaches we have examined. Consider Figure F018.

We have highlighted (yellow font) the best results for each statistical variable. As a few examples, the most Total Float improvement went from +6 to +12, using the Longest Path option. And the best increase in Aggregate Free Float (a gain of +6) was achieved with both the Least Total Float option and Largest Duration option.

As we can see, each option did better in certain aspects and worse in others. So how do we pick the best of all options? Well, it depends on what matters most to those doing the evaluating. If the primary goal is to accelerate the Final Milestone (FNLT 50) at the cost of any other objectives, then the Longest Path option is the best choice. Conversely, if the primary interest is in achieving the Intermediate Milestone (FNLT 20) as soon as possible, then the Least Total Float option is a better choice.

But if the desire is to improve the overall ability of the entire project to meet its temporal goals then the Multi-Path Analysis option is the best choice. Just look at the statistics.

- **Final Milestone:** Achieves maximum Total Float improvement by adding six days of Total Float to the predominant Path leading to FNLT 50. That Path is 44 days long. The six days of increase in Total Float equates to a 15% cushion along this all-critical Path.

- **Intermediate Milestone:** Achieves two days of Total Float over a 20 day period. This means that it builds a 10% cushion on the Path that drives FNLT 20.

- **Aggregate Total Float:** Achieves the best Aggregate Total Float value of any of the options. Even though this value is essentially bogus, when compared against all other options, it still suggests that this option provides the greatest overall insulation against future delay.

- **Length/TF Ratio:** This option yields the best Length/TF Ratio, 2.62. This means that for every day of the Project Length (44 days) there are 2.62 days of reported Total Float. If you are wondering how that is possible, it is because Total Float is reported redundantly, which is our earlier point. Still, the other options were unable to match 2.62; Least Total Float only earned 2.40.

- **Aggregate DAF:** This is the more meaningful Total Float value. To repeat the earlier explanation, Discrete Activity Float is the portion of a Path's Total Float that belongs to each Activity. For instance, if four Activities comprise a Path with Total Float of +12 and each Activity has the same duration, then each Activity would have Discrete Activity Float of +3. The sum of DAF for all Activities along a given Path equals the Total Float value for that Path. There is no redundant reporting.
Under the Multi-Path Analysis option, Aggregate DAF was the highest of any of the options, clocking in at 51.13. Compare these results to the Longest Path option at 47.49, Least Total Float option at 43.22, or even the Largest Duration option at 30.92. As for the improvement over the Original Schedule (before acceleration attempt), the Original Schedule had a DAF reading of only 29.36. This means that the Multi-Path Analysis improved true Total Float (DAF) by a whopping 74%!

**DAF/Aggregate Duration Ratio:** This value conveys the practical application of the Aggregate DAF value. Under the Multi-Path Analysis option, this ratio is 0.56. Under the Original Schedule it was an appalling 0.30. Think what this means: Under the Original Schedule, for any single Crew-Day of work true Total Float (DAF) was only 30%. Translated into reality, across an eight-hour workday (480 minutes), there were roughly 144 minutes of Discrete Activity Float. However, applying the Multi-Path Analysis option, there are 269 minutes of Discrete Activity Float, a gain of 125 minutes of cushion for each and every Crew-Day of each and every Activity!

**Length/DAF Ratio:** Likewise, and finally, the Length/DAF Ratio measures the amount of Discrete Total Float available for any single day of the Project Length. In the Original Schedule that value was 0.59. Under the Multi-Path Analysis option this value practically doubled, to 1.02. By comparison, the Longest Path option – which, you will recall, did so much for the Final Milestone – only achieved a 0.95 rating for this value.

### III: Conclusion

The point of this White Paper was to explain the concept of Multiple Path Residency and demonstrate how knowledge of its existence can help the Project Team make better, more informed, decisions when it comes to deployment of resources.

While not explicitly stated, it should be obvious to the reader that the principles that apply to acceleration of a schedule are equally useful in understanding the effect of deficiencies in resource performance – whether potential or actual.

For instance, now that we know that Activity A resides simultaneously on seven different Paths, it should be obvious to us that any delay to Activity A will have a corresponding, and profound, effect felt throughout the Project Schedule. While you may have already known (or guessed/sensed) this about Activity A (based on it being the first Activity in the Schedule), you might not have appreciated the potency of, say, Activity H.

We hope this White Paper inspires meaningful discussion about, and encourages the use of, Activity Multi-Path Residency and Discrete Activity Float.
Definitions of Terms Used in this White Paper

The following definitions, for technical or unusual terms used in this White Paper, are excerpted from the ICS-Dictionary. You may wish to consult the ICS-Dictionary for additional terms not defined in the following glossary.

- **Activity**: The most basic building block of a Project Schedule, an Activity represents a discrete portion of the overall Scope of Work to be performed through Project Execution, with support from Project Administration. Resident in a CPM Network Diagram, an Activity is an artificial representation of its real life counterpart, a Project Execution Action. The dimensions of a single Activity's included Work Scope are circumscribed by the Activity Description and Activity Duration, as well as the corresponding Action's location, complexity, performers, and other limiting factors.

- **Activity Path**: In a CPM Network Diagram, an Activity Path is a unique Series of Activities that spans from Path Start to Path Finish.

- **Backward Pass Process**: Used to determine the Latest Start and Latest Finish Dates of a series of Progressively-related Activities in a CPM Network Diagram, the Backward Pass Process is a combination of (a) Computational Procedures that utilize (b) Arithmetic Formulas in accordance with (c) condition-specific Computational Rules that are mandated by particular (d) Date Calculation Variables.

- **Cognitive Project Management**: The ICS-Compendium advocates Cognitive Project Management as a superior alternative, designed specifically for Construction Project Management as practiced in North America. Conversely, the ICS-Compendium uses the term Dominant Project Management to refer to the broadest grouping of contemporary literature, dogma, standards, best practices, and other formal writings and teachings on Project Management topics. In a word, Dominant Project Management refers to today’s “conventional wisdom” on Project Management topics.

- **Critical Path**: In principle, as Dominant Project Management explains it, the Critical Path is that string of logically-tied Activities that has the greatest potential or actual influence on the timely completion of a downstream Finish Milestone. In practice, however, definitions among the most respected Project Time Management authorities differ widely on what constitutes a Critical Path.

- **Date Constraints**: Date Constraints are computational criteria for Calculated Dates that are superimposed on a given Activity, such that any Activity Path Segments
(to which the Activity belongs) may be artificially accelerated, delayed, or fixed in time.

**Deadline Milestone:** A Deadline Milestone is an Anchored Finish Milestone that reflects a formal Project Execution Commitment to complete one or more Work Elements by a specific future date. A Substantial Completion date is an example of a Deadline Milestone.

**Default Restriction:** A Performance Restriction in which the commencement of a Restricted Activity is constrained by the prior completion of the Restricting Activity. The extent of a Default Restriction is expressed as a Restriction Delay, an amount of Time by which the start of the Restricted Activity is constrained by the completion of the Restricting Activity. According to Cognitive Project Management, the Restriction Delay of a Default Restriction represents a passage of time. The Default Restriction corresponds to the Finish-to-Start Relationship Type of Dominant Project Management. Its Restriction Abbreviation is "FS."

**Dominant Project Management:** The term Dominant Project Management is used throughout the ICS-Compendium to refer to the broadest grouping of contemporary literature, dogma, standards, best practices, and other formal writings and teachings on Project Management topics. In a word, Dominant Project Management refers to today’s “conventional wisdom” on Project Management topics. In contrast, the ICS-Compendium advocates Cognitive Project Management as a superior alternative, designed specifically for Construction Project Management as practiced in North America.

**Earliest Finish:** An estimate of the earliest possible Calculated Date by which an Activity can be reasonably expected to finish, assuming the flawless performance of all prior Activities to which the Activity is Logically connected in a Progressive Relationship.

**Earliest Start:** An estimate of the earliest possible Calculated Date by which an Activity can be reasonably expected to start, assuming the flawless performance of all prior Activities to which the Activity is Logically connected in a Progressive Relationship.

**Finish Date Constraint:** A Finish Date Constraint establishes the latest that an Activity can finish. The Finish Date Constraint corresponds to a Finish-No-Later-Than (FNLT) Software Setting. A Finish Date Constraint constitutes a Path Finish and, as a result, its effect is that if the Finish Date Constraint advances the Path Finish Activity (Deadline Milestone), it necessarily advances the entire Activity
Path that it terminates. In the inverse, if the Finish Date Constraint recedes and allows the Path Finish Activity to finish later, the performance urgency for the entire upstream Activity Path is correspondingly eased.

**Finish Restriction:** A Performance Restriction in which the completion of a Restricted Activity is constrained by the prior completion of its Restricting Activity. The extent of a Finish Restriction is expressed as a Restriction Delay, an amount of time required by the Restricted Activity to perform the final portion of its work. According to Cognitive Project Management, the Restriction Delay of a Finish Restriction represents work performance time (contained in the duration of the Restricted Activity) — as opposed to the mere passage of time. The Finish Restriction corresponds to the Finish-to-Finish Relationship Type of Dominant Project Management. Its Restriction Abbreviation is "FF."

**Forward Pass Process:** Used to determine the Earliest Start and Earliest Finish Dates of a series of Progressively-related Activities in a CPM Network Diagram, the Forward Pass Process is a combination of (a) Computational Procedures that utilize (b) Arithmetic Formulas in accordance with (c) condition-specific Computational Rules that are mandated by particular (d) Date Calculation Variables.

**Free Float:** Applying only to situations in which multiple Activity Path Segments feed into a common downstream Restricted Activity, Free Float quantifies how much shorter (measured in consecutive Duration Days) a given Activity Path Segment is when compared against the longest Activity Path Segment feeding into the common downstream Restricted Activity. Thus, Free Float is expressed as either a positive number, or zero; it cannot be negative.

**ICS-Compendium:** A ten-volume set of books that provide a comprehensive treatment of Project Time Management for the Construction Industry. The first four volumes, further designated as the Dominant Project Management Series, fully discuss Project Time Management as currently practiced in Construction Project Management. The next four volumes, dubbed the Cognitive Project Management Series, comprehensively explain the innovations in and improvements to Project Time Management as offered by Cognitive Project Management. The final two volumes contain general reference information, including the ICS-Dictionary, and ground-breaking ICS-White Papers.

**Latest Finish:** An estimate of the latest plausible date to which an finish may be postponed without rendering as unachievable the required completion of any downstream Deadline Milestones to which the Activity is Logically connected in a Progressive Relationship.
**Latest Start:** An estimate of the latest plausible date to which an start may be postponed without rendering as unachievable the required completion of any downstream Deadline Milestones to which the Activity is Logically connected in a Progressive Relationship.

**Project Execution Commitment:** As the words suggest, a Project Execution Commitment refers to a promise made by members of the Project Team with respect to how, when, and where Project Execution will be performed. Whether initially required by Contract or the result of negotiated, mutual Execution Strategy — what begins as a Commitment, once captured in the Project Schedule, transforms into a sacred promise. In the Project Schedule, Project Execution Commitments come in two forms: Events and Milestones.

**Series of Activities:** A Series of Activities is a unique arrangement of Activities in temporal progression, such that each Activity has one Restricting Activity before it and one Restricted Activity after it.

**Start Date Constraint:** A Start Date Constraint establishes the earliest that an Activity can start. The Start Date Constraint corresponds to a Start-No-Earlier-Than (SNET) Software Setting. A Start Date Constraint constitutes a Path Start and, as a result, its effect is that if the Start Date Constraint delays the Path Start Activity, it delays the entire Activity Path, correspondingly. In the inverse, if the Start Date Constraint allows for an advanced start to the Path Start Activity, the probability of timely completion of the downstream Activity Path is correspondingly improved.

**Start Restriction:** A Performance Restriction in which the commencement of a Restricted Activity is constrained by both (a) the commencement and (b) partial performance of a Restricting Activity. The extent of a Start Restriction is expressed as a Restriction Delay, an amount of time required by the Restricting Activity to perform an opening portion of its work as a prerequisite to commencement of the Restricted Activity. According to Cognitive Project Management, the Restriction Delay of a Start Restriction represents work performance time (contained in the duration of the Restricting Activity) — as opposed to the mere passage of time. The Start Restriction corresponds to the Start-to-Start Relationship Type of Dominant Project Management. Its Restriction Abbreviation is "SS."