# Resource Critical Path Approach to Project Schedule Management

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## RCP definition

A Guide to the Project Management Body of Knowledge® defines the Critical Path as *those activities with float less than or equal to a specified value, usually zero. Float is the amount of time that an activity may be delayed from its early start without delaying the project finish date. Early start is the earliest possible point in time at which the uncompleted portions of an activity (or the project) can start, based on the network logic and* ***any schedule constraints****.*

Project schedule constraints include resource constraints, finance and supply constraints, calendar constraints and imposed dates. The critical path in the projects with imposed dates and different activity and resource calendars can consist of only one final activity. Managing project schedules, one should pay more attention to activity floats. The activities with shorter floats are more critical than the activities with longer floats. However the float should be calculated with **all** schedule constraints as well as the network logic taken into account. Most project management packages (with the exception of the Russian package Spider Project) do not calculate true activity floats because they do not consider resource constraints during the backward pass. The total float determined by these packages shows the time reserve for the execution of activity, however the availability of resources is completely ignored. Such time reserves cannot be used in practice. They are not the actual activity floats as defined by *A PMBOK Guide®.*

True critical path should take into consideration all schedule constraints including resource and financial limitations. We call it Resource Critical Path (RCP) to distinguish it from the traditional erroneous interpretation of the critical path definition. The calculation of RCP is similar to the calculation of the traditional critical path with the exception that both the early and the late dates are calculated during forward and backward resource (and material, and cost) levelling. Activity floats calculated this way are called resource floats.

RCP definition is similar to the definition of the Critical Chain though I never came across a clear description of the Critical Chain calculation. It appears that by adding financial and supply constraints to the Critical Chain definition as well as the way of its calculation, we will obtain that something very similar to RCP. We have a ten year experience of using RCP in project management and developed the approaches to project management and analysis similar to those presently suggested by Critical Chain theory in some aspects and quite different in the other aspects. Thus the proven technology of project management based on RCP described below may be of particular interest for Critical Chain theory supporters.

## RCP properties

By way of example let us consider a simple project consisting of only three activities, with the two of them having planned duration of ten days, with the planned duration of the third activity equal to fifteen days. The first two activities need resource A to be executed, while the third activity needs resource B. If these activities are not interdependent, the third is critical in its

classical sense, while the first two have a 5-days total float (Exhibit 1). Activity late dates are shown in the Gantt Chart as the hollow bars.

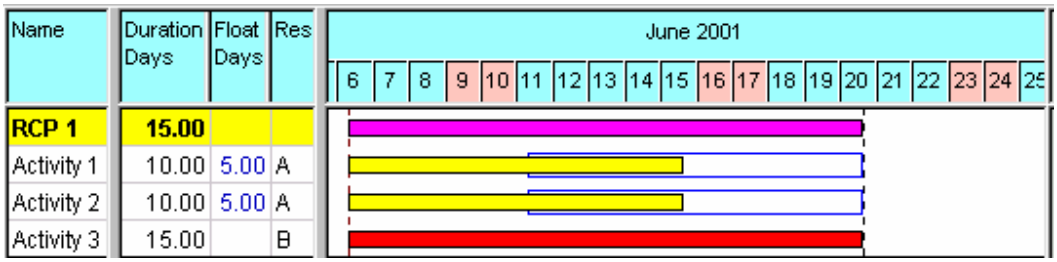



**Exhibit 1. Critical Path and activity resource floats before levelling.**

However if the schedule is calculated assuming that only one unit of each resource is available, the first two activities can only be executed one after another, and a 5-days float emerges for the third activity (Exhibit 2).

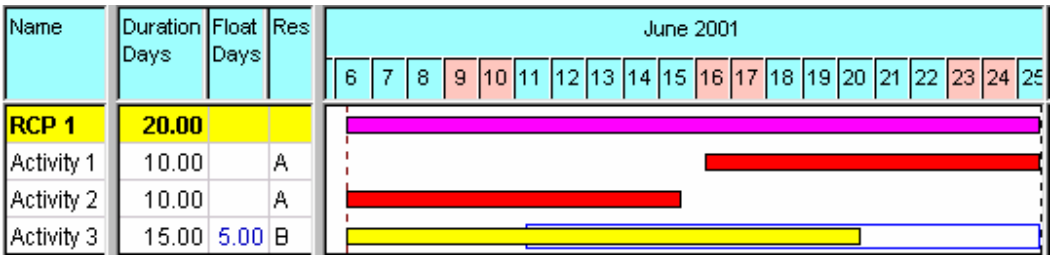



**Exhibit 2. Resource Critical Path and activity resource floats after levelling.**

RCP can consist of activities that are not linked to each other. Traditional critical path approach assumes that this may be due to the different activity calendars and imposed dates. In case of resource critical path calculation, it can also be due to resource constraints, financial and supply limitations. The Exhibit 3 shows an example of a project with resource critical path consisting of activities belonging to the different network paths.

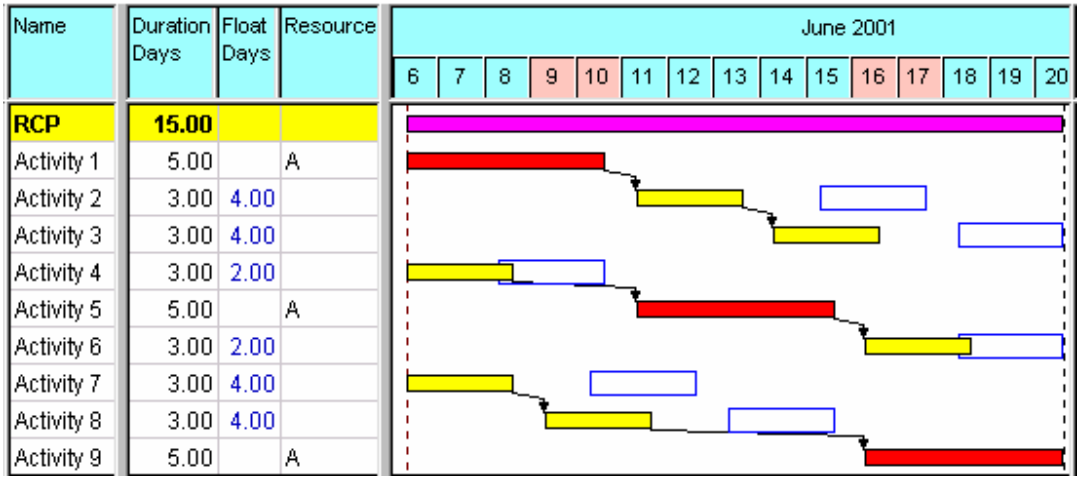



**Exhibit 3. Resource Critical Path consisting of activities from the different network paths**

Activity resource floats have one large advantage over the total floats calculated by most PM software. This advantage is feasibility. Traditional total float shows the period for which activity execution may be postponed if project resources are unlimited. Activity resource float shows the period for which activity execution may be postponed within the current schedule with the set of resources available in this project.

## RCP project planning technology

This section briefly describes the RCP technology of project planning step by step. Some details will be omitted due to the limitations on paper size and the time allocated for the presentation. This technology is not just a theory – it is supported by Spider Project and has been used in Russia for many years.

### Step 1. Risk estimation

Our experience of project planning shows that the probability of successful implementation of deterministic project schedules and budgets is very low. From our experience, the maximal probability of meeting target finish date and cost in a deterministic project schedule never exceeds 38%. Therefore project planning technology should always include risk simulation to produce reliable results.

The project planner obtains three estimates (optimistic, most probable and pessimistic) for all initial project data. These data are used to calculate optimistic, most probable and pessimistic project schedules and budgets. The most reliable and pessimistic project versions may contain additional activities and costs and employ other resources and different calendars than the optimistic schedule. In these versions, resources may have different cost and productivity, activities may have different work volumes and duration, financing and supply schedules may be different, etc. All project data including WBS can be different with the exception that WBS of the optimistic project version should be the subset of the WBS of most reliable and pessimistic versions. All schedule constraints should be taken into consideration when the three project versions are scheduled. The schedules will show project boundaries (optimistic and pessimistic duration and budget).

### Step 2. Risk tolerance estimation

Organisations are characterised by the different levels of tolerance for cost and duration overruns in the different projects. The planner should estimate target probabilities of meeting target dates, costs, and material consumption rates at every project milestone, including project finish, and every cost centre. Basing on these probabilities, the package calculates target dates, costs, and material requirements. These target data form the basis for contract negotiations and decision making.

### Step 3. Target schedule calculation

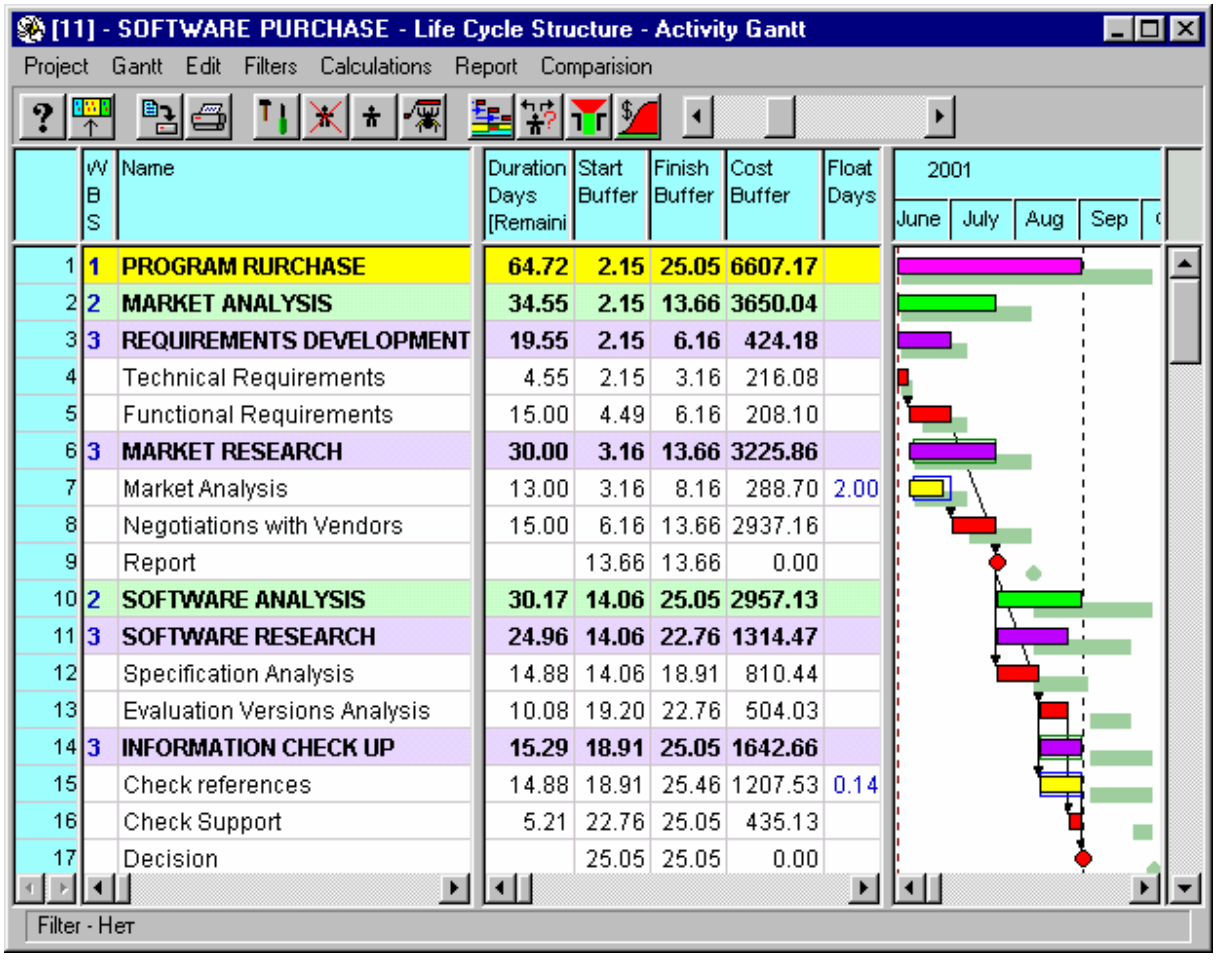
Target schedule is the backward project resource constrained schedule with the most probable (or optimistic) activity duration, material requirements and costs and scheduled milestone target dates. The finish dates of the project and its main milestones are usually defined by the contract and used as the target dates in the target schedule.

## Step 4. Calculation of time, material and cost contingency reserves

We recommend to use the optimistic project version for setting tasks for project implementers while the calculated contingency reserves should be used by the PM team for the management purposes. So we calculate not only the optimistic dates and cost of activities but also contingency reserves – as the difference between the current (usually optimistic) and the target versions in activity start and finish dates, material requirements and costs. Project manager obtains the following estimates necessary for effective project control:

a) activity target start and finish dates, resource and material requirements and cost in the optimistic project schedule,
b) activity resource floats that show the time for which activity execution may be postponed without delaying project finish date in the current schedule,
c) activity contingency reserves of time, cost and materials.

The Exhibit 4 shows the scheduling and risk analysis information for the sample project – the purchasing of a software package. The columns show optimistic duration of activities, time buffers (time contingency reserves) for activity start and finish dates, cost buffers (cost contingency reserves) and resource floats. Target project schedule is shown as the green bars on the Gantt Chart.




| | WBS | Name | Duration Days [Remaini | Start Buffer | Finish Buffer | Cost Buffer | Float Days |
|---|---|---|---|---|---|---|---|
| 1 | 1 | **PROGRAM RURCHASE** | **64.72** | **2.15** | **25.05** | **6607.17** | |
| 2 | 2 | **MARKET ANALYSIS** | **34.55** | **2.15** | **13.66** | **3650.04** | |
| 3 | 3 | **REQUIREMENTS DEVELOPMENT** | **19.55** | **2.15** | **6.16** | **424.18** | |
| 4 | | Technical Requirements | 4.55 | 2.15 | 3.16 | 216.08 | |
| 5 | | Functional Requirements | 15.00 | 4.49 | 6.16 | 208.10 | |
| 6 | 3 | **MARKET RESEARCH** | **30.00** | **3.16** | **13.66** | **3225.86** | |
| 7 | | Market Analysis | 13.00 | 3.16 | 8.16 | 288.70 | 2.00 |
| 8 | | Negotiations with Vendors | 15.00 | 6.16 | 13.66 | 2937.16 | |
| 9 | | Report | | 13.66 | 13.66 | 0.00 | |
| 10 | 2 | **SOFTWARE ANALYSIS** | **30.17** | **14.06** | **25.05** | **2957.13** | |
| 11 | 3 | **SOFTWARE RESEARCH** | **24.96** | **14.06** | **22.76** | **1314.47** | |
| 12 | | Specification Analysis | 14.88 | 14.06 | 18.91 | 810.44 | |
| 13 | | Evaluation Versions Analysis | 10.08 | 19.20 | 22.76 | 504.03 | |
| 14 | 3 | **INFORMATION CHECK UP** | **15.29** | **18.91** | **25.05** | **1642.66** | |
| 15 | | Check references | 14.88 | 18.91 | 25.46 | 1207.53 | 0.14 |
| 16 | | Check Support | 5.21 | 22.76 | 25.05 | 435.13 | |
| 17 | | Decision | | 25.05 | 25.05 | 0.00 | |

**Exhibit 4. Results of risk analysis for the sample project**

Additional management reserves can be added to the calculated contingency buffers to allow for unknown potential risk events.

These data should be used for contract negotiations. When the contract is signed and/or project budget and duration is approved, the project management team can calculate the probability of successful project execution. The target schedule and contingency reserves should be updated in accordance with the new target probability of project success.

Optimistic, most probable and pessimistic initial data should be stored in the special project databases providing the opportunity for fast updating of project information and transformation of the current version into the optimistic, most probable or pessimistic one. These databases should be updated regularly.

## Project Control

Let's consider the main principles of RCP methodology for project control:

a) Plan day-to-day activities using optimistic estimates but pay special attention to resource floats and to contingency and management reserves. Resource floats show time reserves that can be used without delaying project target dates in the current optimistic schedule. Contingency reserves show additional time, material and cost reserves that may be used without violating target schedule dates, budget and material requirements. Management reserves show the extra reserves provided for unknown risk events.
b) Performance reports include the causes of delays in activity completion and cost overruns. If these causes have not been included in the list of potential risk events then the risk database has to be updated. Project managers should always control available management reserves and recalculate contingency reserves regularly.
c) Project management team regularly estimates the probability of completing the project in time and without exceeding approved project budget (it is one of the options in Spider Project risk analysis). If this probability is too low, the team should take corrective actions.
d) Project management team regularly updates the estimates in the optimistic, most probable and pessimistic project databases.

We advise our customers to use the optimistic estimates for setting tasks for project implementers. Using the optimistic schedule for project control, we reduce the risk of inefficient usage of resource time. It is in agreement with the Critical Chain theory approach. But we cannot agree with the recommendation that multitasking should be avoided. The following example (Exhibit 5) shows the sample project schedule in which the execution of activity 2 is interrupted for the better usage of project resources.

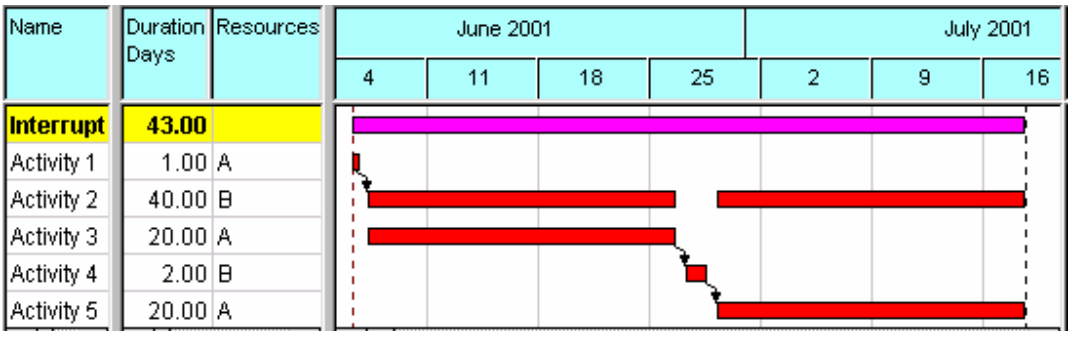



**Exhibit 5. The sample project with interrupted activity performance**

You can choose another option: to delay the execution of activity 4 and avoid multitasking that will extend project duration by 22 days. This is hardly the best solution.

Usually there are many subcritical activities belonging to the different network paths and even the minor delays in the execution of subcritical activities can lead to the changes in the RCP. This comes into conflict with a Critical Chain theory's assumption that the Critical Chain never changes during project execution.

## Assignment Floats

Activity floats do not provide all the data necessary for project control. In the projects with the complicated resource assignments there may be situations when an activity has different start and finish floats. Its start cannot be postponed without delaying project finish date, although its finish can be delayed without serious consequences. Resources are often separately assigned on an activity. There are several types of independent assignments. Thus, a team of resources can be assigned on an activity to do a certain amount of work, or for a certain period of time, while other resource teams perform the rest of activity work independently - earlier, simultaneously or later. An example of such project is shown in the Exhibit 6.

This project consists of only two activities. Activity 1 should be performed by resources A and B independently. Resource A is assigned for 5 days, resource B – for 3 days. Duration of Activity 2 is 10 days and it needs resource B to be performed. The project duration is 13 days, so the start of activity 1 can be postponed for 8 days but its finish can not be delayed without delaying project finish date. In this schedule activity 2 is critical though it finishes earlier than non-critical activity 1.

Resource assignments can be also characterised by floats. Assignment float can be defined as the amount of time that resource assignment may be delayed without delaying the project finish date. In case of complicated resource assignments when resource teams can execute the same activity independently of each other, resource assignments may be critical even on non-critical activities.

| Name | Duration Days | Start | Finish | Float Days |
|---|---|---|---|---|
| **Assignment floats** | **13.00** | **06.06.2001** | **18.06.2001** | |
| Activity 1 | 8.00 | 06.06.2001 | 18.06.2001 | 8.00 |
| Team 1 | 5.00 | 06.06.2001 | 10.06.2001 | 8.00 |
| A | 5.00 | 06.06.2001 | 10.06.2001 | 8.00 |
| Team 2 | 3.00 | 16.06.2001 | 18.06.2001 | |
| B | 3.00 | 16.06.2001 | 18.06.2001 | |
| Activity 2 | 10.00 | 06.06.2001 | 15.06.2001 | |
| B | 10.00 | 06.06.2001 | 15.06.2001 | |

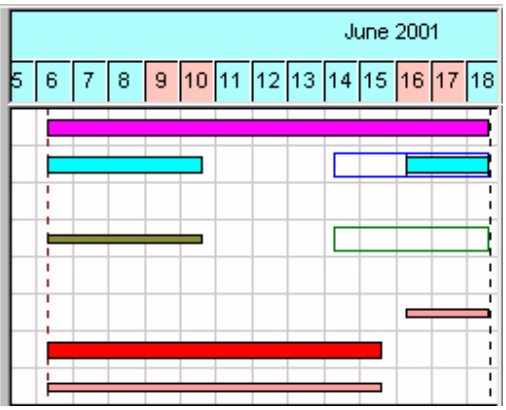
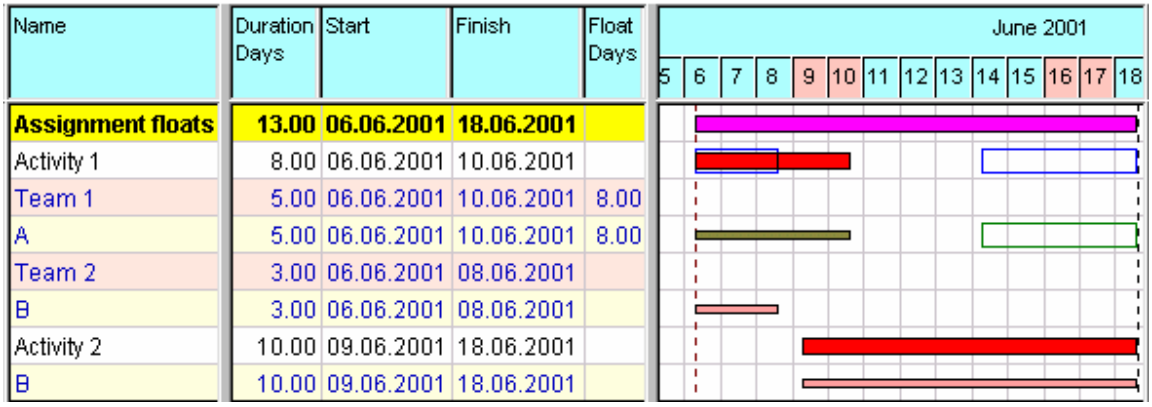



**Exhibit 6. Assignment floats 1**

If the order of activity execution is reversed in the sample project shown in the Exhibit 6, activity 1 became critical though its finish can be delayed without delaying project finish date (Exhibit 7). Resource B's assignments remain critical. In both schedules resource B's assignment floats are zero.



| Name | Duration Days | Start | Finish | Float Days |
|---|---|---|---|---|
| **Assignment floats** | **13.00** | **06.06.2001** | **18.06.2001** | |
| Activity 1 | 8.00 | 06.06.2001 | 10.06.2001 | |
| Team 1 | 5.00 | 06.06.2001 | 10.06.2001 | 8.00 |
| A | 5.00 | 06.06.2001 | 10.06.2001 | 8.00 |
| Team 2 | 3.00 | 06.06.2001 | 08.06.2001 | |
| B | 3.00 | 06.06.2001 | 08.06.2001 | |
| Activity 2 | 10.00 | 09.06.2001 | 18.06.2001 | |
| B | 10.00 | 09.06.2001 | 18.06.2001 | |



**Exhibit 7. Assignment floats 2**

The notion of assignment float is very useful for resource management and even more informative for project control.

Assignment critical path shows resources that are critical during the different stages of project lifecycle. At the different stages of the project lifecycle different resources can become critical.

## Conclusions

Resource critical path is a true critical path as *per* A PMBOK Guide® definition. If project resources are unlimited, then RCP is equivalent to the traditional critical path. Activity floats should be calculated considering all schedule constraints. Only resource floats can be used for project control because they show the actual activity time reserves. Assignment floats are the tools that are even more powerful in project control. They show resource time reserves that may be used for project resource management.

When the Critical Chain is correctly defined it may appear that it is the same as the RCP. Both the RCP and the Critical Chain recommend to use optimistic estimates of activity duration and contingency and management buffers for project control. RCP approach offers to calculate contingency reserves by simulating project risks. Project risk simulation allows to simulate not only uncertainties of activity duration and cost data but also all possible risk events. The most probable and pessimistic schedules may include activities and resources that are lacking in the optimistic schedule.

These theories differ in their conclusions. Thus, we believe that:
- RCP can change during the project execution
- multitasking is sometimes necessary, and
- critical resources can be different at the different stages of project life cycle.

## References

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