Tools and Techniques of Project and Portfolio Management with Resource Constraints

Vladimir Liberzon, PMP
Portfolio Management Requirements

• Project Portfolio planning and management can be efficient if all projects that are included into the project portfolio are managed following common methodology, using the same project and portfolio management software, the same coding of common resources and costs, the same cost structures, the same templates for project WBS, process modeling, reporting, etc.

• These corporate project and portfolio management standards shall be developed, maintained and applied in all projects belonging to the corporate project portfolio.
Portfolio Management Requirements

• Project Portfolio planning and management can be efficient if all projects that are included into the project portfolio are managed following common methodology, using the same project and portfolio management software, the same coding of common resources and costs, the same cost structures, the same templates for project WBS, process modeling, reporting, etc.

• These corporate project and portfolio management standards shall be developed, maintained and applied in all projects belonging to the corporate project portfolio.
Project and Portfolio Constraints

- Project and Portfolio planning and management shall consider all existing constraints that may include:
  - Renewable resource constraints,
  - Material and Equipment supply constraints,
  - Funding constraints,
  - Calendar Constraints,
  - Imposed Dates (like Start No Earlier Than).
Project and Portfolio Constraints

- Missing these constraints may lead to unrealistic schedules, wrong budgets, project portfolios that include wrong projects and will not meet their targets.
- Besides, it is necessary to consider uncertainty and risks. Any decision that does not take risks into consideration is not reliable.
Project Success Criteria

• Triple constraint (Cost, Schedule, Scope) is the usual way for setting project success criteria but this approach is not practical.

• It is hard to estimate if project is successful if finished later but for less cost, or earlier but over budget.

• It makes decision making rather complicated because it is not easy to answer for the question: what money is reasonable to pay for project acceleration for certain period?
Portfolio Success Criteria

• Creating project portfolio we want to maximize portfolio benefits.

• These benefits may include many factors like economical, political, ecological, etc.

• With multiple success criteria decision making is complicated – increasing one of them we may decrease another.

• There is a need for some weighting factor that may be used for decision making. It is necessary to be able to measure overall benefits of projects and portfolios, to be able to compare options and to select the best management decisions.
Project Success Criteria

• We suggest to set one integrated criterion of the project/portfolio success or failure.

• One of the potential approaches is to use money for measurement of everything (cost of one day acceleration and delay, cost of the market share, etc.).

• Other approaches like using different weighting factors do not differ much.

• In this presentation we will use profit (NPV, IRR) as success criterion but our money may be artificial.

• Project/Portfolio decisions shall be justified by their positive impact on selected success criterion.
Creating Project Portfolio

• Creating project portfolio looks easy: estimate each project potential benefits, prioritize them and select those projects that add most to portfolio success.

• But portfolio projects use the same limited resources, activities of different projects may be interdependent, funding restrictions are usually applied to the portfolio as a whole.

• So it is not right to select projects one by one, without taking into account common portfolio restrictions.

• Project selection process shall include portfolio resource, material and cost constrained scheduling that takes into account project priorities.
Sample Project Portfolio

• Sample Project Portfolio consists of 6 projects.
• Each project has investment phase and then income phase.
• Projects of this portfolio use resources A and B and only two units of each resource are available.
• Next slide shows the portfolio that was scheduled without considering resource and funding constraints.
• Internal Rate of Return and Net Present Value of each project are shown in the IRR and NPV columns.
Sample Project Portfolio calculated without considering portfolio constraints
Portfolio resources are overloaded, funding does not cover required expenses, so the schedule that was created by collecting project schedules is not feasible.

Portfolio shall be scheduled taking into account existing portfolio resource constraints.

The resulting schedule is shown in the next slide.

Expected NPV and IRR of portfolio and portfolio projects become much lower (65.52%).

But funding restrictions are still not met.
Sample Project Portfolio scheduled considering resource constraints
Sample Project Portfolio

• Next slide shows balanced portfolio schedule that met both resource and funding restrictions.

• But you may notice that project investment phases are delayed, NPV and IRR become lower (63.47%), resources are multitasking jumping from one project to another.
Sample Project Portfolio schedule calculated considering both resource and funding constraints.
Portfolio Resource Schedule

[Image of a Gantt chart showing project timelines and resource allocation]
Sample Project Portfolio

• Scheduling project portfolio it is always profitable to set and to apply project priorities.

• In our case it looks natural to apply highest priorities to projects with highest IRR.

• With project priorities portfolio IRR increased to 95.39% though some projects were delayed. But projects with highest priorities get resources first and their investment phases finish earlier. As the result the revenues come earlier too.

• As the side effect resource multitasking is minimized.
Sample Project Portfolio schedule calculated considering all constraints and project priorities
Project Success Criteria

• But priorities that looked logical were based on project data got when the projects were scheduled separately.

• With constrained resources the best resource priorities may depend on the project distributions of limited resource requirements.

• At the next slide project priorities were changed and portfolio NPV and IRR were increased though we assigned rather large priority to the project with the least initial NPV.
Sample Project Portfolio schedule calculated considering all constraints and new project priorities
Portfolio Management Tasks

• Portfolio Management includes the following tasks:
  – Project Prioritization and Selection for including into Portfolio,
  – Portfolio Scheduling and Budgeting that considers all project and portfolio constraints and dependencies,
  – Portfolio Risk Analysis,
  – Setting Reliable Project and Portfolio Targets,
  – Portfolio Performance Analysis and Corrective Actions.

• Most publications and discussions concern only the first task.
Project Selection

• Our Sample Portfolio shows that portfolio project selection and prioritization cannot be properly done without modeling portfolio performance and estimating overall portfolio parameters instead of estimating them for separate projects.

• Though Total Portfolio expenses do not exceed Total Funding time distribution of expense requirements do not meet funding restrictions.

• Though individual projects did not have resource shortages portfolio resource requirements exceed their availability and some portfolio projects were delayed.
Project Selection

- Let's exclude project 5 from our portfolio:
Project Selection

• The result:
  – Portfolio NPV becomes approximately 20000 lower but Portfolio IRR increased as IRRs and NPVs of portfolio projects.
  – It looks like attractive alternative.
Conclusions

- Project Portfolio is not just the sum of portfolio projects. Only creating project portfolio model and estimating alternatives using this model we can optimize Portfolio project selection.

- It is always profitable to minimize resource multitasking applying project priorities when calculating portfolio resource constrained schedule.

- Project priorities that maximize portfolio value are not easy to set. Projects that looks most attractive may have resource requirements profile that conflict with requirements of other portfolio projects. It may lead to delays and less added value than adding projects less attractive individually but with “right” resource requirements.
Project Portfolio Risk Analysis

• Risk analysis is usually applied on the project level but there are certain risks and restrictions that exist and shall be modeled only on portfolio level.

• In our Sample Portfolio we had portfolio funding and resource constraints that just cannot be modeled on the project level.

• Methods of quantitative risk analysis like Monte Carlo and Method of Three Scenarios shall be applied not only to separate projects but also to portfolio as a whole.

• Let's do it for our 5 projects Sample Portfolio and consider two options: if project revenues could be reinvested in portfolio projects or not.
Portfolio NPV Probability Distribution
(Reinvestment allowed)
If Reinvestment is not allowed

- Probability to achieve profit that was calculated in deterministic portfolio model is only 16.7%
- When reinvestment is not allowed project execution is adjusted to funding schedule and though in our portfolio funding restrictions do not delay project execution, in Monte Carlo simulation it happens.
- Probability to achieve 223 328 units portfolio profit becomes lower: 12.8% instead of 16.7%
- Portfolio NPV probability distribution in case when reinvestment is not allowed is shown in the next slide. With high probability existing funding schedule will lead to the delay of some portfolio projects.
If Reinvestment is not allowed.
Setting Targets

• Risk Analysis showed that targets set without considering risks and uncertainty have low probability to be achieved.

• When probability distributions of main project and portfolio parameters are known it is possible to set reliable targets.

• In particular let's set project and portfolio targets for expected profits, expenses and investment phase durations and assume that profit reinvestment is allowed.

• Our targets together with probabilities to be achieved are shown in the next slide.
## Project and Portfolio Targets

![Activity Gantt - Portf5 [1] - Project Portfolio - WBS 1](image)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Portfolio</td>
<td></td>
<td>223 328</td>
<td>12/31/2017</td>
<td>214 000.00</td>
<td>69.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Project 1</td>
<td>6</td>
<td>54 784</td>
<td>12/31/2017</td>
<td>52 000.00</td>
<td>60.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Investments</td>
<td>3</td>
<td>-26 000</td>
<td>03/26/2015</td>
<td>04/09/2015</td>
<td>70.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Profits</td>
<td>3</td>
<td>80 784</td>
<td>12/31/2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Project 2</td>
<td>5</td>
<td>66 880</td>
<td>12/31/2017</td>
<td>-63 500.00</td>
<td>69.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Investments</td>
<td>3</td>
<td>-26 000</td>
<td>02/24/2015</td>
<td>03/14/2015</td>
<td>71.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Profits</td>
<td>3</td>
<td>02 880</td>
<td>12/31/2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Project 3</td>
<td>1</td>
<td>25 240</td>
<td>12/31/2017</td>
<td>-23 500.00</td>
<td>69.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Investments</td>
<td>3</td>
<td>-26 000</td>
<td>02/19/2016</td>
<td>03/14/2016</td>
<td>72.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Profits</td>
<td>3</td>
<td>51 240</td>
<td>12/31/2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Project 4</td>
<td>3</td>
<td>42 856</td>
<td>12/31/2017</td>
<td>-40 500.00</td>
<td>71.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Investments</td>
<td>3</td>
<td>-26 000</td>
<td>05/25/2015</td>
<td>06/09/2015</td>
<td>73.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Profits</td>
<td>3</td>
<td>68 856</td>
<td>12/31/2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Project 6</td>
<td>4</td>
<td>33 568</td>
<td>12/31/2017</td>
<td>-31 100.00</td>
<td>70.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Investments</td>
<td>3</td>
<td>-26 000</td>
<td>06/24/2015</td>
<td>07/14/2015</td>
<td>72.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Profits</td>
<td>3</td>
<td>59 568</td>
<td>12/31/2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Funding</td>
<td></td>
<td></td>
<td>04/01/2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Phase “Portfolio” (Code: PS)**

<table>
<thead>
<tr>
<th>NPV</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>353 328.00</td>
</tr>
<tr>
<td></td>
<td>200 000.00</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Profit**

|      | 223 328.1 |
|      | 99 000     |

Filter: None  
Rows selected: 0  
Filter on links: None
Setting Targets

• When risk simulation is applied project and portfolio targets are set basing on reasonable probability to be achieved.

• Target Finish does not belong to any specific schedule, Target Profit is not achieved in any specific portfolio schedule, etc. So setting targets this way we do not define traditional schedule baseline.

• Instead of Baseline schedule we have a set of target dates and costs that may be set for the whole portfolio, for each project, for project phases, etc.
Setting Targets

• Now we have portfolio schedule based on most likely estimates of durations, costs, profits that has low probability to be met and a set of reliable project and portfolio targets that do not belong to any schedule.

• It creates problems with application of traditional methods of performance analysis like Earned Value and Variance Analysis.

• **Baseline schedule that finishes on target dates does not exist**, being late to most likely schedule does not mean that project performance is not successful.
Setting Targets

- We can also estimate expected values of other project parameters if main targets will be achieved. In particular we may expect portfolio expenses = 131 300 units.
Project and Portfolio Baselines

• We may apply Earned Value Analysis using the schedule based on most likely estimates as project and portfolio baselines. But in this case if CPI and SPI are below 1 it does not mean that performance is not successful and target dates and profits will not be met.

• Earned Value Analysis gives useful information but only through risk simulation and probability analysis we can estimate the chances to meet targets.
Portfolio Performance Analysis

• There are four main performance analysis techniques:
  – Earned Value Analysis,
  – Variance Analysis
  – Success Probability Trend Analysis
  – Trend Analysis
Earned Value Analysis

- Earned Value Analysis may be applied to analysis of Project and Portfolio Investments performance but it does not show what is happening with expected profit.

- If risk analysis is applied and targets are set basing on reasonable probability to be achieved portfolio baseline schedule does not exist. Using most likely schedule as the baseline means that negative cost and schedule variance does not mean that the portfolio is in trouble.

- Earned Value Analysis is applied to past performance, does not look to the future and cannot be used for estimating if project portfolio will meet set targets.
Variance Analysis

• By Variance Analysis we understand comparing current and baseline schedules and analyzing differences.

• The problem with this method is the same – if risk simulation was applied the baseline schedule that finishes on target dates and has target profit does not exist.

• Comparing with most likely schedule is useful but does not give full information for decision making.
Success Probability Trend Analysis

- Trends of probabilities to achieve project targets provide most useful and integrated information on portfolio performance.

- Success probability trend depends on portfolio performance but looks into the future: if estimates of future expenses and revenues are changed or new risks are identified it is also reflected in probability to achieve portfolio target.

- Next slide shows success probability trends for our portfolio and the first project of the portfolio that have serious problems with meeting target finish date of the investment phase.
Success Probability Trend Analysis

• Negative success probability trends require considering corrective actions.

• Positive success probability trends show that project performance is improving and contingency reserves are utilized slower than expected.

• But probability also depends on estimates of uncertainty and risks that may change during portfolio execution.

• An information on probabilities to meet set targets and what happens with these probabilities may be used as the integrated project and portfolio performance analysis report.
Trend Analysis

• Trend analysis is a cornerstone for good management and timely decision making.

• In deterministic models it makes sense to look at trends of project/portfolio success criteria. Additional trends, like the trend of expected project/portfolio investment duration, may be also useful for timely decision making.

• Negative trend disclose existing problems even if the project/portfolio status is good.

• Trends of expected Portfolio Investment duration, Portfolio profit forecasts, trends of EV SPI and CPI are shown in the next slide.
Trend Analysis
Trend Analysis

- Deterministic Trends are negative (both forecasts are rising) because the schedule that is used as the baseline is too optimistic. Like other deterministic methods it does not take into account changes in estimates of uncertainty and risks.

- Cost and Schedule Performance Indexes are below 1.

- The problem is the same as for all methods of deterministic project performance analysis that use some schedule as an initial baseline.

- Thus Success Probability Trends provide more reliable estimates of project and portfolio “health”.
Conclusions

• Portfolio targets shall be set taking into account existing risks and uncertainty basing on reasonable probability to be achieved.

• These targets do not belong to any portfolio schedule and so project and portfolio performance measurement baselines in usual sense do not exist.

• Instead of the traditional baseline we get a set of portfolio, project and subproject targets.

• Project Performance Analysis shall show if these targets will be achieved.
Conclusions

• Traditional methods of performance analysis like Variance analysis and Earned Value analysis do not supply us with reliable information on the chances to achieve set targets.

• Earned Value analysis compares project and portfolio past performance with the baseline but does not consider changes in future resources, expenses and income.

• Besides, when the targets are set taking into account uncertainty and risks, project and portfolio baseline schedules do not exist and comparing execution with some schedule makes result interpretation complicated.
Conclusions

• Project and Portfolio management decisions shall be based on trend analysis that shows if there are current problems with project and portfolio execution. Timely corrective actions prevent negative tendencies development.

• The best performance analysis is based on success probability trends that show what happens with probabilities to achieve project and portfolio targets. This analysis looks to the future and supplies management with the integrated information on project and portfolio “health”.
Thank You!

Additional information on project and portfolio management methods discussed in this presentation may be found at www.spiderproject.com.

Vladimir Liberzon
v.liberzon@gmail.com