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Advanced Features of Spider Project

that are necessary for creating adequate project model and are absent in most scheduling tools

Introduction

- During last 20 years popular project management software packages improved user interface, added collaboration functionality and project portfolio reporting but did very little in improving scheduling functionality.
- In this presentation we will discuss some features of Spider Project that are required for creating and analyzing project models, but absent in most project management packages.
- There are many other unique features of Spider Project that could be discussed but the time for this presentation is limited.

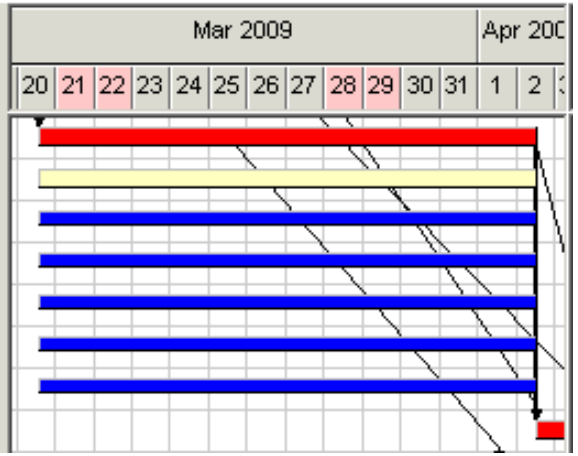
Introduction

- We will discuss selected unique features of Spider Project in the following order:
- Initial Data for schedule model,
- Project Scheduling,
- Project Budgeting,
- Risk Simulation,
- Performance Analysis,
- Portfolio Management,
- Project Reporting.

Initial data - Activity Data

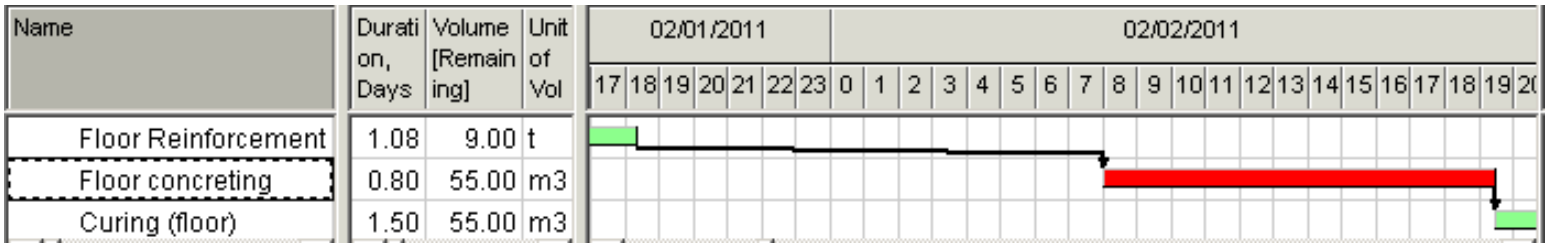
- For most activities initial information that defines their durations and efforts needed for their execution is an amount of work to be done. We call this amount **Activity Volume.**
- If activity volume is known then duration is calculated basing on total **productivity** of assigned resources.

Name	Quantity	Volume [Remaining]	Unit of Vol	Productivity	Duration, Hours [Remaini
Road Layout		12 000.00	m2		120.00
Layout Crew	1	12 000.00	m2		120.00
Bulldoser	1	12 000.00	m2		120.00
Grader	1	12 000.00	m2		120.00
Machinist	3	12 000.00	m2		120.00
Worker	5	12 000.00	m2		120.00
Scraper	1	12 000.00	m2	100.00	120.00
Ditches		2 000.00	m		100.00



Initial data - Activity Properties

- Among other activity properties it is practical to define if its execution shall be **continuous**. If *Yes* then an activity shall not start if it could not be finished until the end of the work day (an example - concreting).
- If an activity is **interruptible** then resources assigned to this activity can be moved to another activity with higher priority and then returned to finish their work. This is **activity property** and not the schedule property!



Name	Duration, Days	Volume [Remaining]	Unit of Vol
Floor Reinforcement	1.08	9.00	t
Floor concreting	0.80	55.00	m3
Curing (floor)	1.50	55.00	m3

Initial data - Activity Dependencies

- There are four traditional dependency types and all of them define **No Earlier Than** relationship.
- But in practice there is also a need in **Strict** (Just In Time) activity dependencies.
- Dependencies may be classified as **Mandatory, Discretionary, External, etc**. It is useful to be able to sort and to filter dependencies basing on their **kinds**.
- It is useful to be able to **switch dependencies on and off** playing *what if* with the project schedule. So there is an option if to use certain dependencies in project scheduling.

Initial data – Dependency Lags

- Dependency Lags are usually defined in time units. It is not rare when time lags have their own **Lag calendars** that differ from the calendars of preceding and succeeding activities.
- But in most cases lag is defined by the volume of work that shall be done on preceding activity before succeeding activity can start or finish. So there is a need to use **Volume Lags** defining activity dependencies.
- Usually time lags are defined by estimating the duration necessary for doing certain work volume. But if the work will be done not exactly as planned time lags shall be reconsidered. With volume lags it is not necessary.

Initial data – Dependency Properties

- For high level schedules it is necessary to use **Double Dependencies** when certain point of preceding activity is linked with certain point of succeeding activity. This dependency has two lags: after certain part of preceding activity was finished certain part of succeeding activity can be done.
- When project scheduling is done dependencies obtain additional properties like if they are **Driving** (and define the start of succeeding activities) or **Critical** (driving for critical activities).
- It is possible to sort and to filter dependencies showing only those that have required properties (like mandatory and driving, discretionary and not driving, etc.).

Initial data – Conditional Networks

- Sometimes project scope, network dependencies and activity properties depend on some conditions not known at the moment when project model is created. If the software is able dynamically select the way to proceed with project execution it saves a lot of project planner efforts. We call this **Conditional Scheduling.**
- Besides, conditional networks are required for proper risk simulations. When project is late managers apply some corrective actions and this shall be taken into account in Monte Carlo simulations.

Initial data – Switch activities

- So Spider Project includes activities of type **Switch** that have zero duration and two positions *Yes* and *No*. If *Yes* project schedule will include one branch of succeeding activities, if *No* – then another.
- Switch position may be selected manually or automatically basing on conditions that are applied to switch activity (like if Switch activity is one moth late then we add resources or select different technology for succeeding works).

Initial data – Trigger activities

- Another unique activity type we called **Trigger**.
- Trigger activity has zero duration and some probability to happen. If trigger activity happens then the project may proceed different ways, each with certain probability. This is the way to simulate **risk events.**
- Trigger activities are used in Monte Carlo simulation. In deterministic schedule certain trigger position is selected but can be easily changed for estimating different what if scenarios.

Initial data – Project Resources

- Project resources are divided into renewable (labor, machines) and consumable (materials).
- In Spider Project it is possible to define that **renewable resource consumes materials** whenever it works (a car consumes gas in certain amount per mile or per hour).
- It is possible to define **resource crews (multi-resources**) and then assign them to project activities. Each crew consists of certain resources and assigning crew we assign all of them. Changing the set of resources belonging to the crew we can automatically change crew resource assignments and corresponding activity durations that depend on crew productivity.

Initial data – Resource Skills

- It is also useful to be able to assign not individual resources but resource **skills**.
- Spider Project includes **skill scheduling** capability automatically selecting and assigning resources that have necessary skills basing on their availability, cost, productivity and user defined assignment priorities.
- To do this it is necessary to define what resources have certain skills.

Initial data – Resource Assignments

- Resources can be assigned to work on some activity for only a part of their work time. In this case it is necessary to define both assigned resource **quantities and workloads.**
- Total workload (quantity multiplied by workload) is not sufficient. An information that 200% of some resource are assigned does not tell us if there is a need for two resource units with 100% workload or four resource units with 50% workload.

Initial data – Variable Resource Assignments

- Some activities can be done by variable resource crews. In Spider Project project planners may assign not certain resource quantity but resource quantity and workload range (minimal and maximal quantity, minimal and maximal workload) and the software will select what resources and with what workload to use on activity at any moment basing on current resource availability and resource requirements on parallel activities.
- We call this **Variable Resource Assignments**.

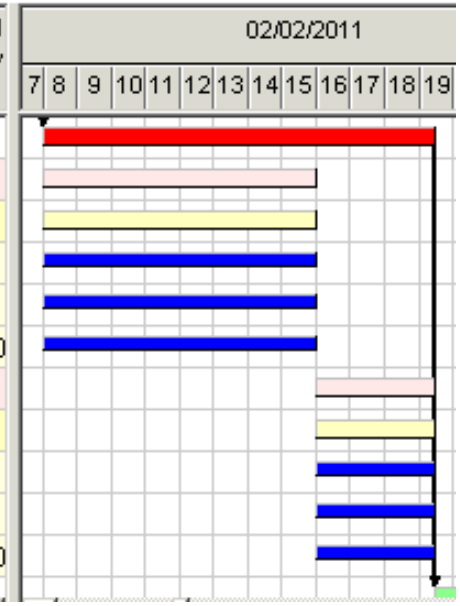
Initial data – Team and Independent Assignments

- In practice there are two types of resource assignments – teamed and independent.
- **Team assignment** means that assigned resources work as a team – if some member of the team is not available other team resources will wait, because they can work only as a team.
- **Independent resource assignment** means that assigned resources may work on activity without interaction with others using their own calendars and availability periods.

Initial data – Resource Shifts

- In construction projects it is necessary to model working in **several shifts**.
- It is not known before project scheduling when each activity will be able to start. If an activity can start during certain shift work time Spider Project selects and assigns resources of that shift and if an activity will not be finished next shift shall continue the work that began in the previous shift.

Name	Quantity	Duration, Days	Volume [Remaining]	Unit of Vol	Productivity
Floor concreting		0.80	55.00	m3	
Team 1		1.04	38.40	m3	
Concreting 1	1	1.04	38.40	m3	
Concrete pump	1	1.04	38.40	m3	
Vibrator	2	1.04	38.40	m3	
Worker 1	4	1.04	38.40	m3	1.20
Team 2		0.43	16.60	m3	
Concreting 2	1	0.43	16.60	m3	
Concrete pump	1	0.43	16.60	m3	
Vibrator	2	0.43	16.60	m3	
Worker 2	4	0.43	16.60	m3	1.20



Initial data – Project Costs

- Project cost consists of **cost components** like cost of materials, cost of machines, salaries, indirect costs, taxes, etc. It is necessary to be able to create and to analyze not only total cost but also project, activity and resource cost by cost components.
- There is a need to use several types of cost assignments: **fixed, per work hour, and per volume unit.**
- Introduction of volumes and volume units permits to build a bridge between estimating and creating project model, and model costs and payments not only for time but also **for amounts of work done.**

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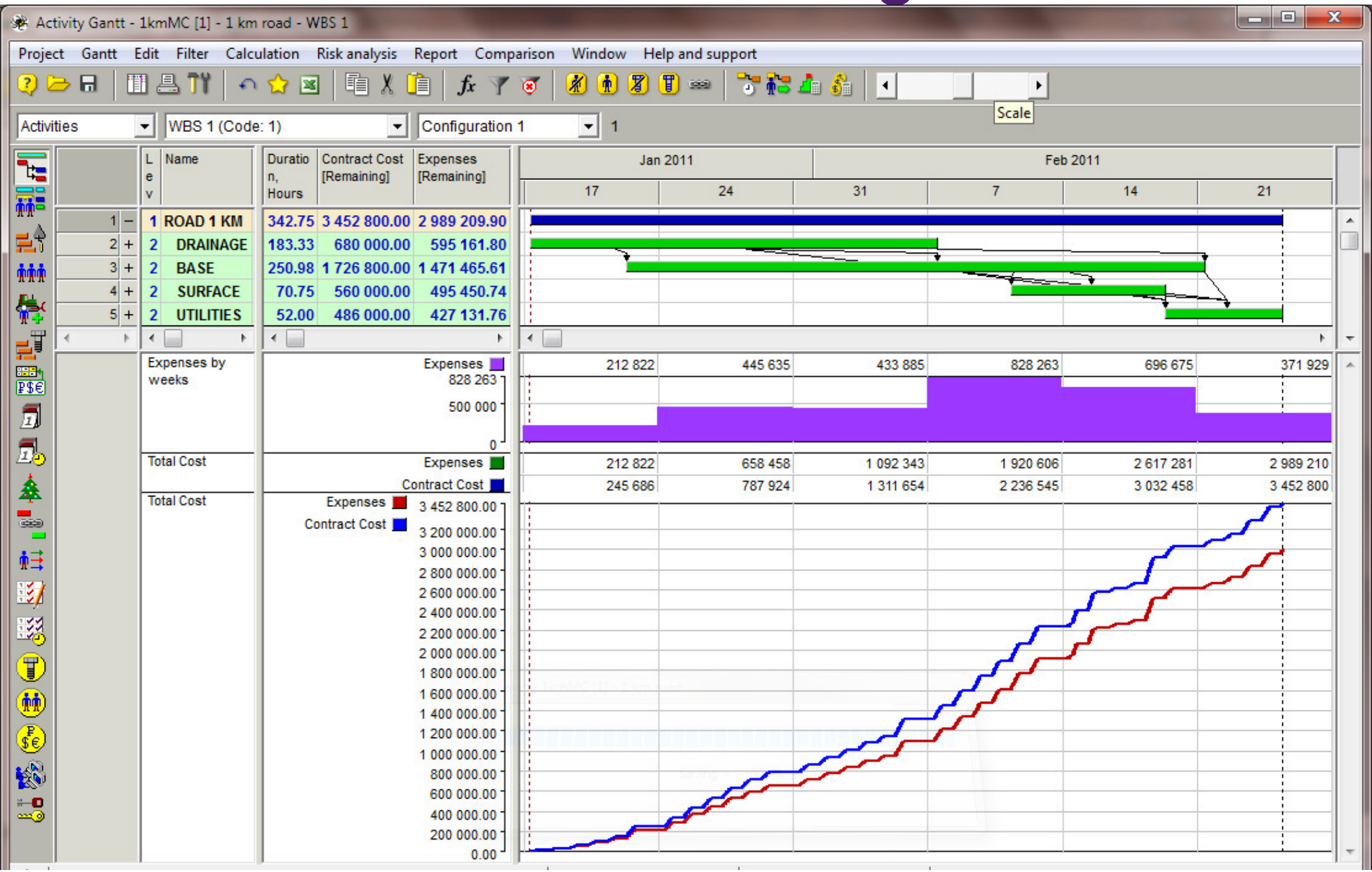
- Spider Project includes several types of cost assignments: **fixed, per work hour, and per volume unit.** Costs may be applied to activities, materials, resources and resource assignments.
- Introduction of volumes and volume units permits to build a bridge between estimating and creating project model, and model costs and payments not only for time but also **for amounts of work done.**

Initial data – Project Costs

- Spider Project simulates not only **expenses** but also **income**. With this option available project planners may manage not only project budgets but also project cash flows.
- It is not rare when projects have not one but **several cost estimates** for the same activities.
- For example, contractors may want to manage both internal expenses and contract costs.
- So Spider Project permits to manage **several project budgets in parallel** in the single project model.

Initial data – Parallel Budgets



Initial data – Corporate Databases

- Corporate project management system shall be based on the **corporate norms and standards**. It is useful to integrate estimating with scheduling and budgeting. To achieve this it is necessary to be able to apply corporate databases creating project models.
- Spider Project permits to create databases of resource crews, resource skills, resource productivity on typical assignments, material requirements per unit of typical work, unit costs, etc. and to link them with the project models.
- Changing data in these databases of corporate norms we are able to update all projects where these norms are used.

Initial data – Corporate Databases

Resource_assignment_productivities [4] - Resource ass...

Document Table Edit Filter Transfer Window Help and Support

	Type Name	Produ ctivity	Unit of Volume
1	Backfilling Bulldozer Heavy	330.00	m3
2	Ditching RE Excavator Rotary	80.00	m
3	Coating (Insulation) Control Mobile Labor	140.00	m
4	Field Joint Control Mobile Laboratory	1.25	pc
5	Field Joint Coating Insulator	1.10	jn
6	Lowering in Ditch Pipelayer Heavy	28.00	m
7	Pipe Transportation Pipe Transport	6.88	m
8	Welding (CRC) Welder	23.33	m

Filter - None

Resource_assignment_productivities [3] - Resource assignment productivities

ocument Table Edit Filter Transfer Window Help and Support

	Type	Type Name	Produ ctivity	Unit of Volume
1	CFWI_WRK	Column formwork installation Worker	0.60	m2
2	CFWR_WRK	Column formwork removal Worker	1.20	m2
			0.40	m3
			0.25	m2
			0.15	m2
		eeping Worker	0.30	m3
		rker	2.50	m
			1.10	m3
			2.50	m2
			4.50	m2
			0.06	
		de &) Worker	0.04	t
			0.50	m3
			0.20	m2
			0.40	m2
			0.01	t
			0.60	m3
		vator node) Worker	1.50	m2
		er	3.00	m2

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- Activity cost and material requirements (pe...

Activity_cost_and_material_requirements__p

				itu hen [Per	Crush Stone [Per	Sand [Per Unit]	Asphalt [Per Unit]	Paint [Per Unit]	Steel [Per Unit]	Sign [Per Unit]	Contr act Cost
1	blb	Black Base	m2				0.12				
2	brr	Barriers	m						0.05		
3	cot	Prime Coat	m2	0.25							
4	mrk	Marking-out	m					0.10			
5	rds	Roadsides	m2		0.15						
6	snb	Sand Bed	m3			1.00					
7	srf	Bituminous Concrete Surface Wearing Course	m2				0.12				
8	stb	Stone Bed	m3		1.30						
9	str	Sand and Crush Stone Transportation	m3								10.00
10	trs	Traffic signs	pc							1.00	

Filter - None

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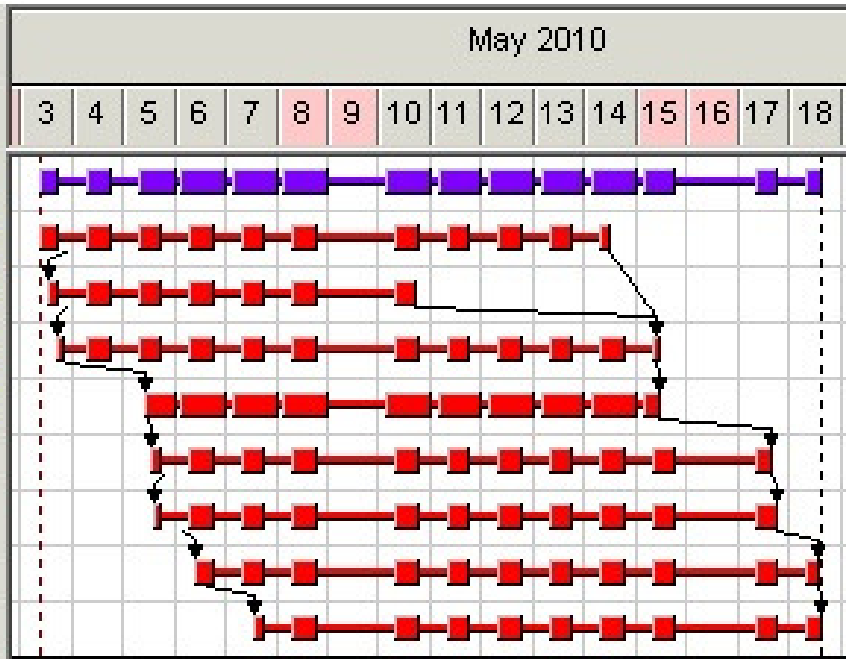
Initial data – Typical Fragment Library

- Besides, it is very useful to create and to use **Typical Fragment Library.**
- This library consists of small projects that model typical project work packages.
- If project fragments were developed, creating project model is easy: develop WBS, replace project work packages with corresponding typical fragments adjusting work volumes and durations, and enter dependencies between activities of different work packages.
- An example of typical fragment for construction of 10 km of oil pipeline is shown in next slide.

Initial data – Typical Fragment

Name	Duration Days	Volume	Unit of Volume	Float Super, Days
CRC10	**22.58**			
Pipe Transportation	10.21	10 000.00	m	0.65
Ditching RE	6.25	10 000.00	m	3.78
Welding (CRC)	10.23	10 000.00	m	0.00
Field Joint Control	9.02	451.00	pc	1.10
Field Joint Coating	10.25	451.00	jn	
Coating (Insulation) Control	10.23	10 000.00	m	
Lowering in Ditch	10.23	10 000.00	m	
Backfilling	9.09	30 000.00	m3	



Initial data – Network Analysis

- Schedule model shall be easily analyzed for consistency and common errors. It means applying different filters that show necessary data.
- In particular Spider Project network analysis may be done using following filters:
  - Activities without predecessors,
  - Activities without successors,
  - Activities and activity paths that precede and succeed any selected activity,
  - Dependencies that have certain lags,
  - Dependencies that have certain properties,
  - Activities of certain types, etc.

Project Scheduling
Resource Constrained Scheduling

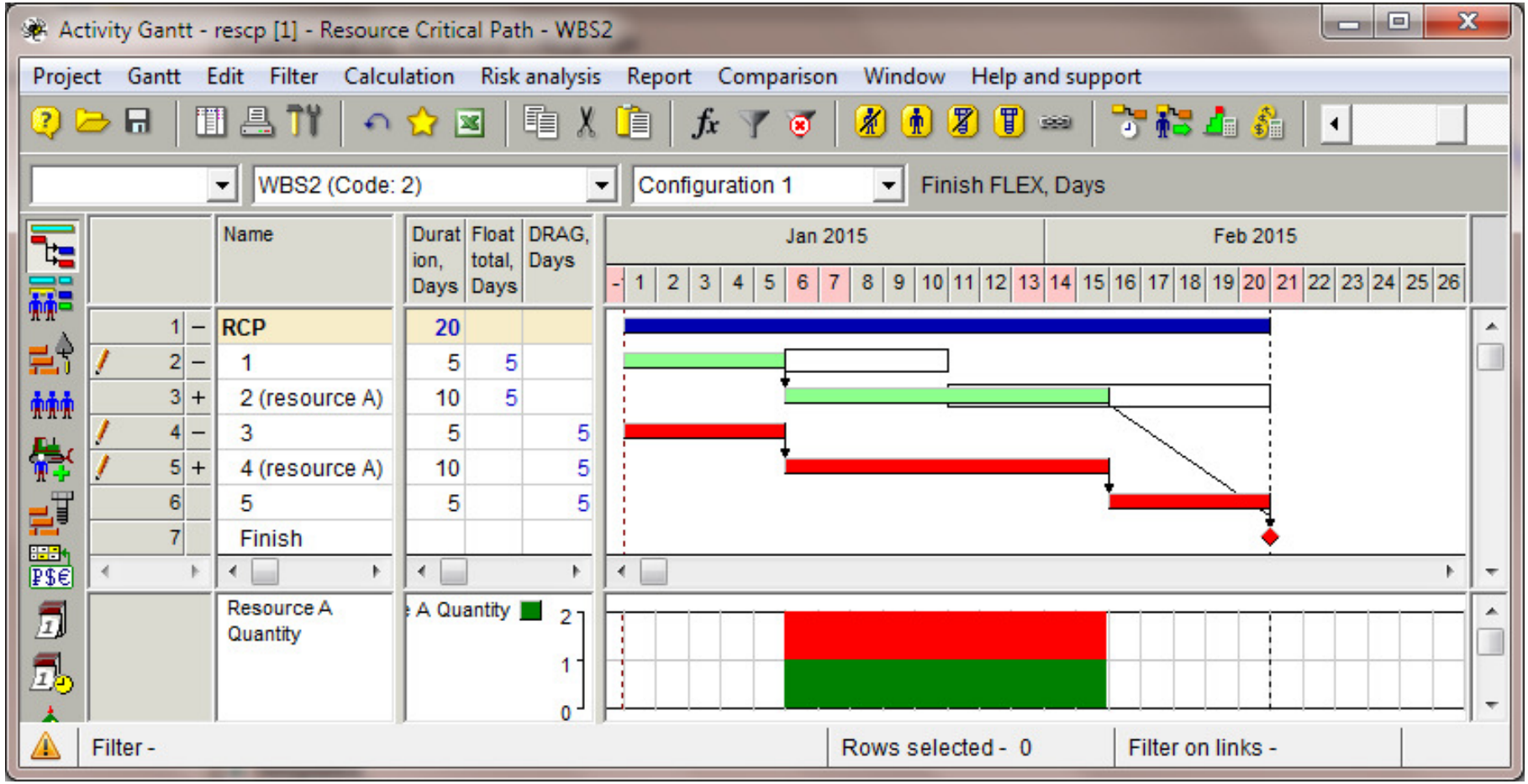
- It is necessary to be able to calculate project schedule taking into account **all project constraints** including calendar constraints, resource limitations and resource skills, supplies and financial constraints, space constraints and imposed dates
- Resource, space, supply and funding constrained schedules shall be **optimized** – delays cost too much and creating suboptimal schedules is a waste of time and money.
- Unfortunately only few packages like Spider Project and Aurora try to optimize resource constrained schedules.
-

Project Scheduling
Resource Constrained Scheduling

- Spider Project calculates and shows **resource constrained activity floats** and **Resource Critical Path** that may consist of activities that do not depend on each other.
- Resource Critical Path is also known as **Critical Sequence** or **Critical Chain.**
- Determining which activities delayed current activity because they used required resources (resource dependencies) helps to analyze resource constrained schedules.

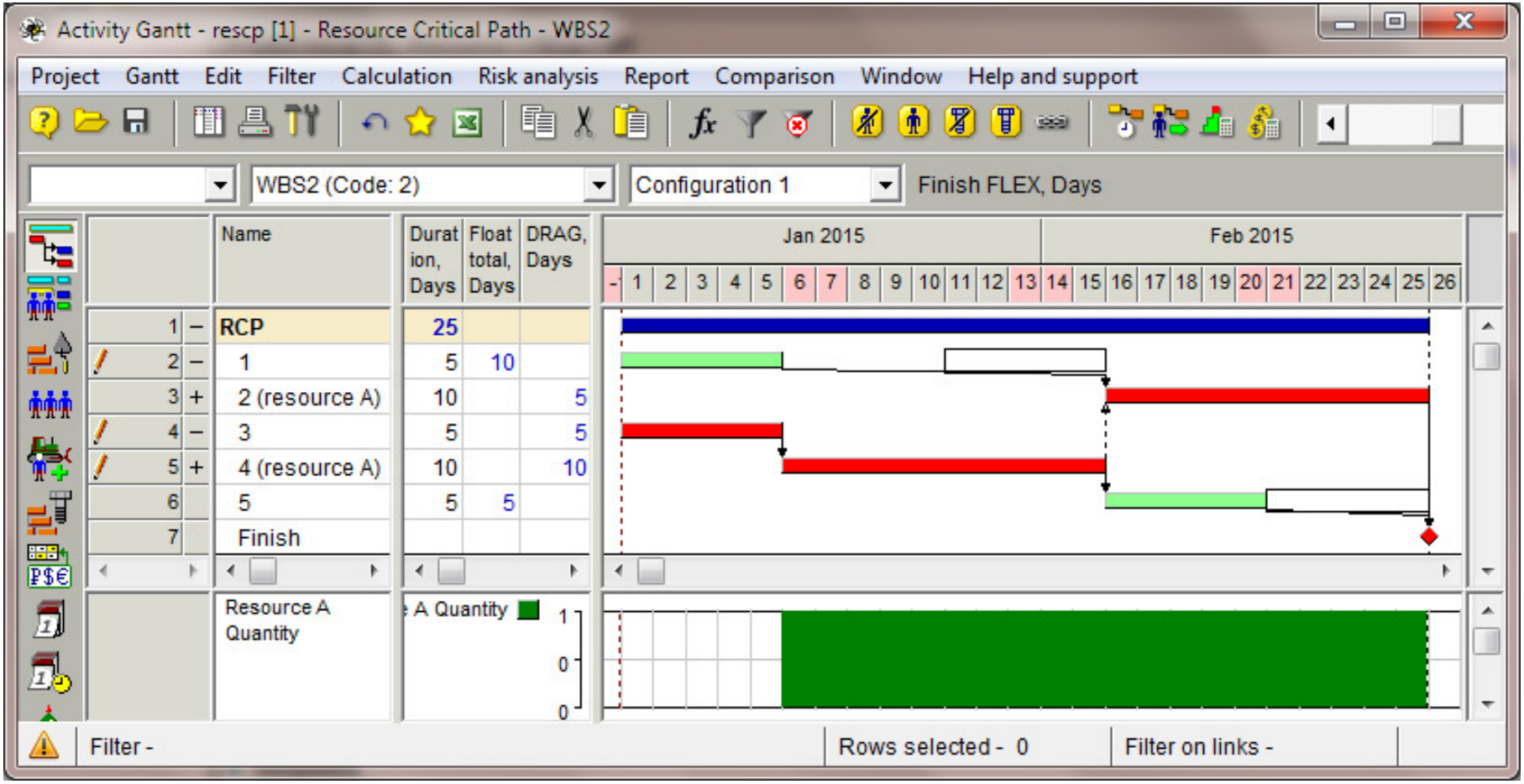
Project Scheduling
Resource Constrained Scheduling

- Let's consider simple schedule, consisting of five activities and Finish milestone. CPM schedule of this project is shown below:



Project Scheduling
Resource Constrained Scheduling

- This slide shows Resource Constrained Schedule of the same project. Critical Path and activity floats were changed, resource overloads fixed.

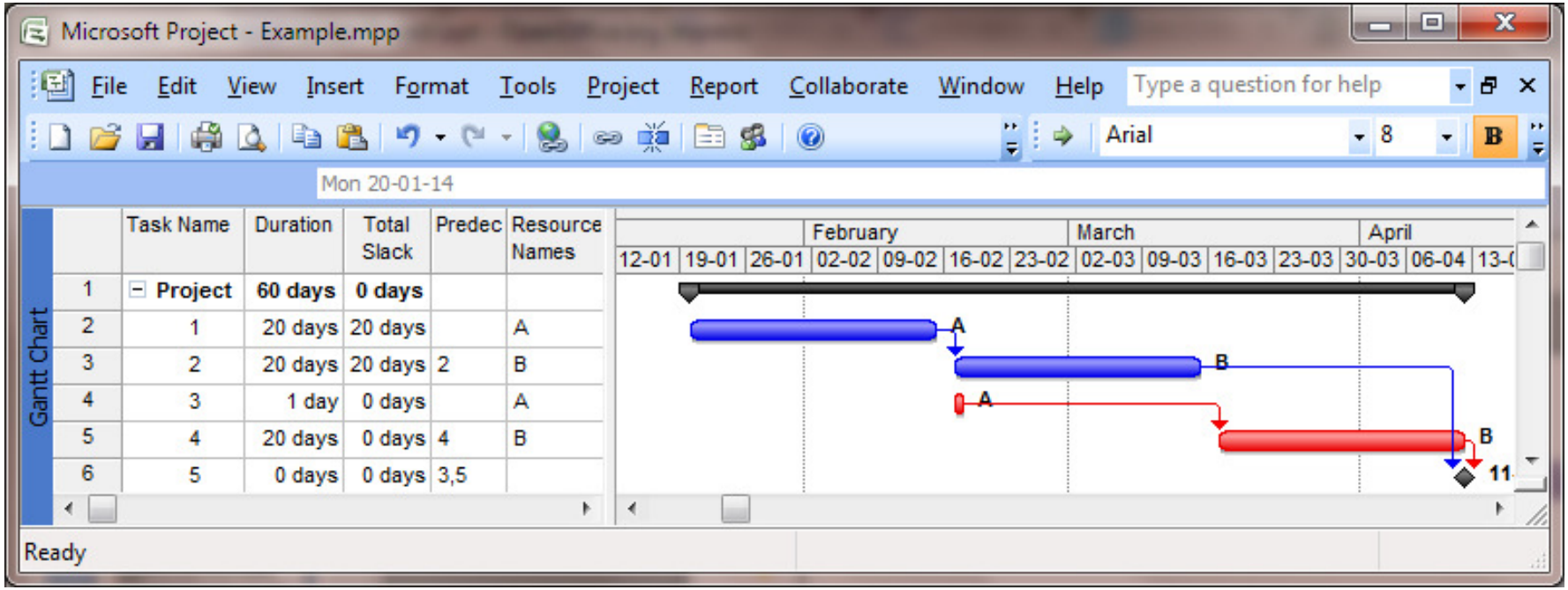


Project Scheduling
Resource Constrained Scheduling

- Activities 4 and 2 are linked with resource dependency (presented as dotted arrow) that shows why activity 2 was delayed. Resource dependencies are not considered during scheduling – they are the results of the schedule analysis.
- Activity Total Float shows the period for which an activity may be delayed without delaying project finish in current resource constrained schedule.
- In resource constrained schedules most packages show wrong activity floats. Look at the example of MS Project schedule in the next slide.

Project Scheduling
Resource Constrained Scheduling

- Activity 3 is shown as critical though it has 19 days free float, activities1 and 2 have total float though their delays cause the delay of the project finish.
- Right schedule for this project has 41 days duration.



Project Scheduling
Resource Constrained Scheduling

- Spider Project also calculates **DRAG**, that shows what decrease of critical activity duration removes it from Critical Path. Suggested by Steven Devaux DRAG is especially useful when schedule crashing is considered.
- But not only renewable resources may be restricted.
- Next slide shows the schedule that was calculated taking into account both resource and supply constraints.
- Activities that required not available materials were delayed as shown in the Gantt Chart.
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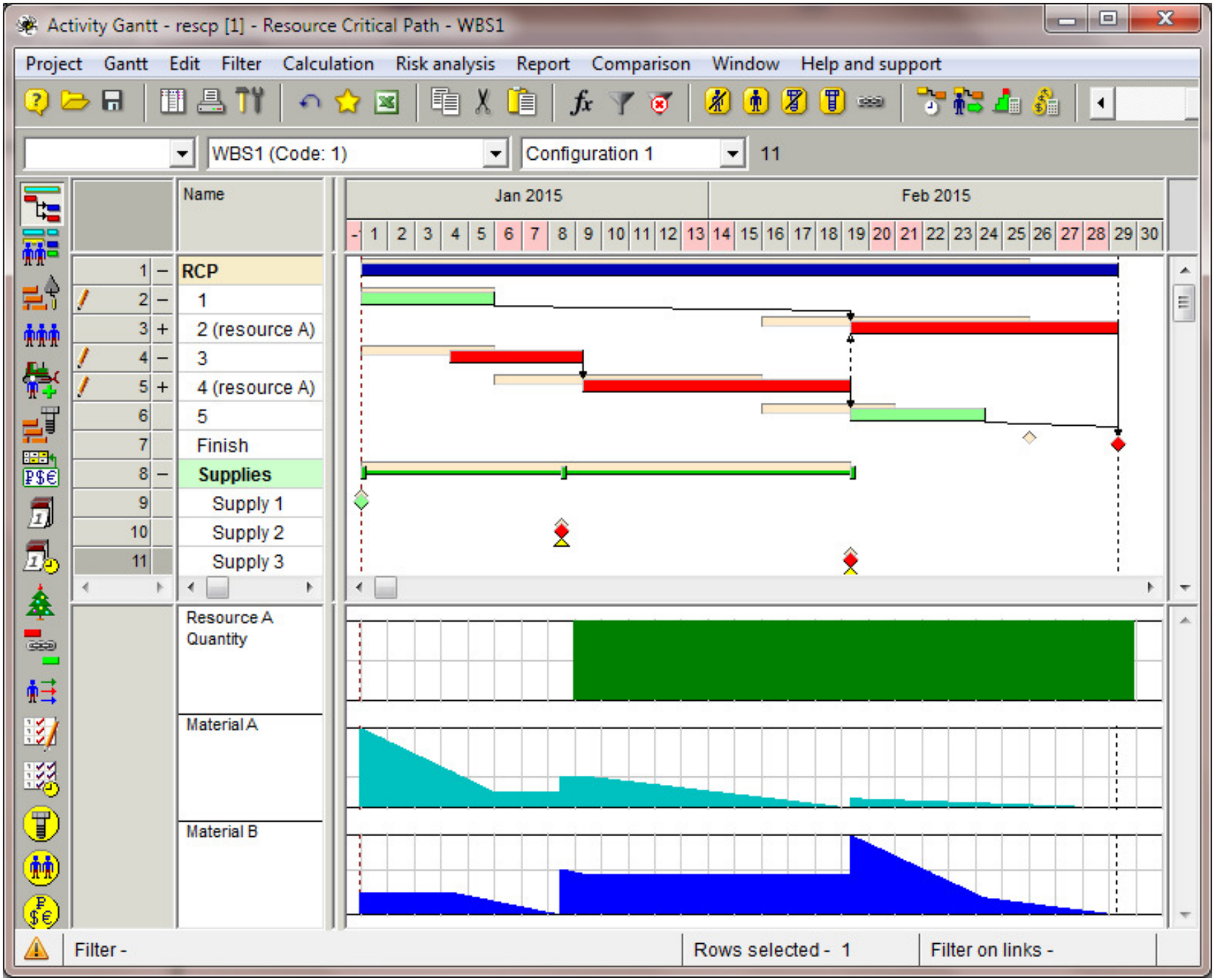
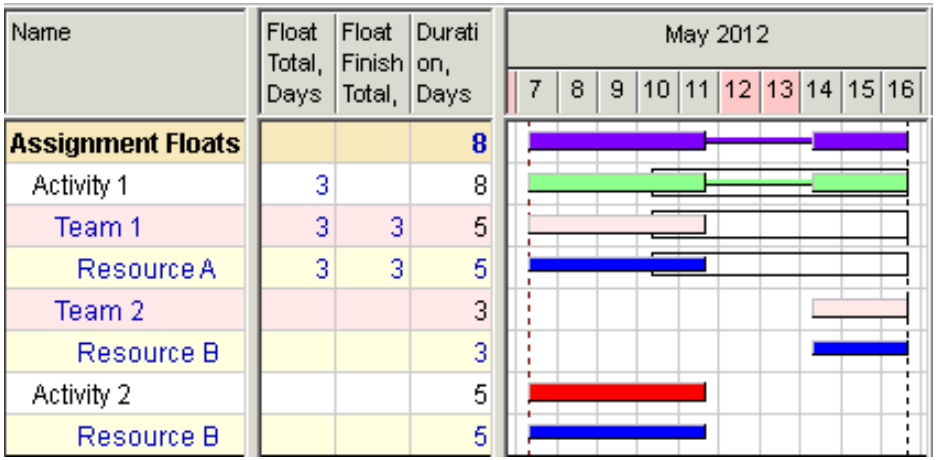
Material Constrained Scheduling

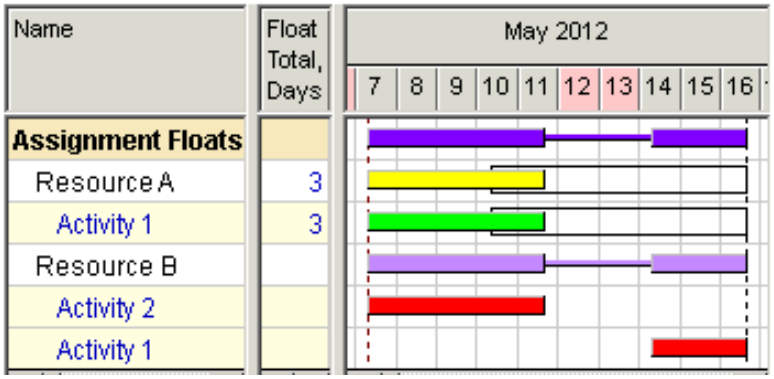


Project Scheduling
Assignment Floats

- With independent assignments activity floats and **assignment floats** are not the same and it is useful to know not only activity floats but also assignment floats.
- Resource assignments on non-critical activities may be critical as shown below. Activity 1 start may be delayed but delay of resource B assignment delays project finish.



Name	Float Total, Days	Float Finish Total,	Duration, Days
Assignment Floats			**8**
Activity 1	3		8
Team 1	3	3	5
Resource A	3	3	5
Team 2			3
Resource B			3
Activity 2			5
Resource B			5



Name	Float Total, Days
Assignment Floats	
Resource A	3
Activity 1	3
Resource B	
Activity 2	
Activity 1	

Management of Project Budgets

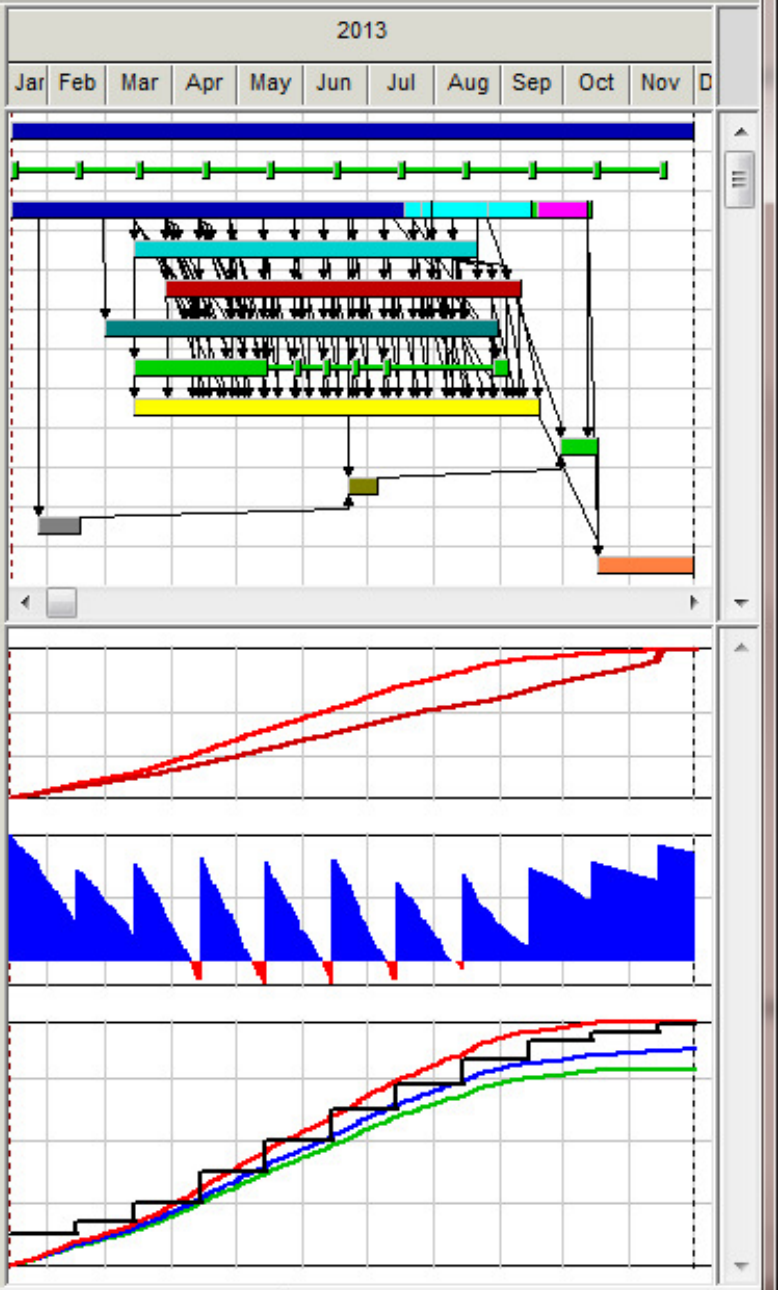
- As was discussed earlier it is useful to manage several parallel budgets of the same project, to model project income and payments together with expenses.
- It is natural to set tight schedule and budget for project workforce and subcontractors, to add and to manage contingency reserves for project management team, and to add additional management reserves and expected profit to contract budget.
- Modeling expected payments permits to manage project cash flow. It is nice to know what money will be required at any moment of project execution.
- Nest slide shows how Spider Project shows this information for real project.

Activity Gantt - arbat_cashflows [1] - Arbat Building 13 Stores - Object

Project Gantt Edit Filter Calculation Risk analysis Report Comparison Window Help and support

Activities | Object (Code: 1) | Layout 1 | 77765416.34

		Name	Duration, Days [Remain	Workforce Cost [Remaining]	PM Team Cost [Remaining]	Contract Cost [Remaining]
1	−	1 Arbat Building	381.11	63 762 678.37	69 354 210.55	77 765 416.34
2	+	2 Payments				
3	+	2 Structural Works	331.93	38 204 743.35	39 264 485.43	42 833 984.11
4	+	2 Water and Sewer Systems	159.90	6 259 224.58	6 887 583.29	8 766 015.10
5	+	2 Heating	166.69	4 968 337.19	5 456 709.04	6 944 902.42
6	+	2 Electricity, TV, Radio, Telecom	79.38	5 296 686.97	5 828 522.85	7 418 119.99
7	+	2 Ventilation, Air Conditioning	30.30	2 218 100.33	2 439 910.36	3 105 340.46
8	+	2 Finishing	80.92	4 113 948.66	4 505 198.55	4 914 762.06
9	+	2 Landscaping	17.02	654 833.32	720 316.65	916 766.64
10	+	2 Serving buildings	13.44	808 356.44	889 192.08	1 131 699.02
11	+	2 Underground Communications	18.81	1 238 447.54	1 362 292.29	1 733 826.56
12	+	2 Buffer	45.35		2 000 000.00	



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Project Leveling Options

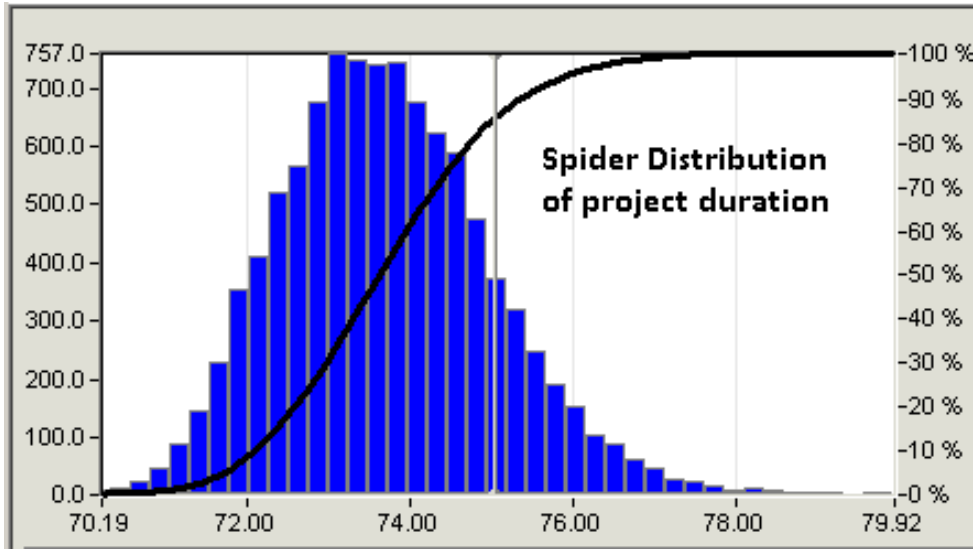
- Spider Project calculates not only renewable resource constrained schedules but takes into account all other constraints including supply constraints, funding constraints, space constraints. This unique feature is required in many projects and project portfolios.
- But there is another leveling problem: instability of resource constrained schedules. With small changes of initial information users may get project schedules with quite different order of activity execution. In the middle of the project execution it could become a serious problem.
- That is why Spider Project includes leveling option “Previous version support”. If this option is selected Spider Project creates resource-constrained schedule that keeps the order of activity execution in the selected archived schedule.

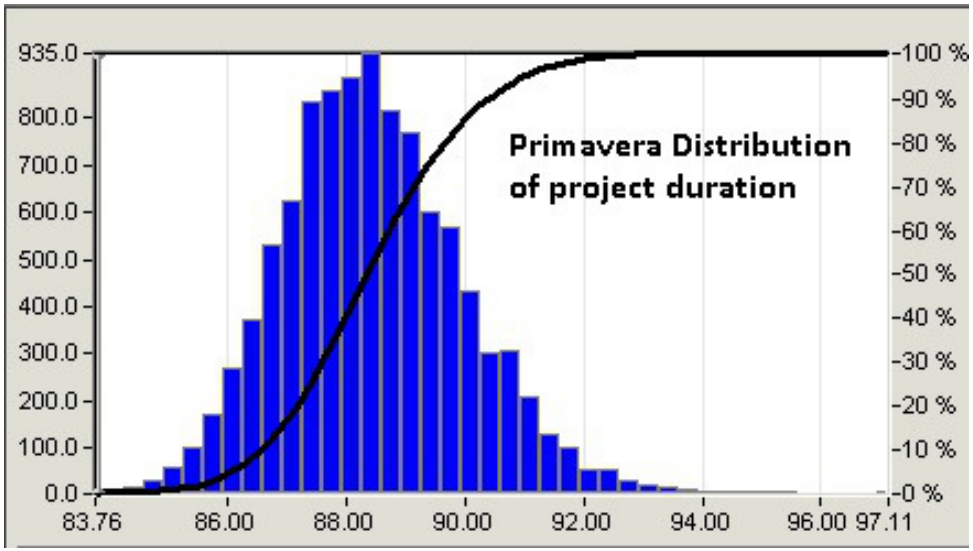
Project Risk Analysis

- Good scheduling tool shall be able to consider risks and uncertainties.
- Methods of risk simulation and analysis like **Monte Carlo, Three Scenarios**, etc. create probability curves for project duration, total cost and other project parameters.
- If project resources are limited these curves are valid only if resource leveling heuristics that is used in risk simulation process is the same as used for project scheduling and management.
- It means that risk simulation add-ins to some scheduling package shall use the same scheduling engine. In other case risk simulation results will not be valid.

Project Risk Analysis

- Look at the project duration distributions created with Spider Project and Primavera leveling algorithms for the same project.
- Applying Spider distribution to P6 based management or P6 distribution to SP based management does not make sense.





Project Risk Analysis

- Project model shall include risk events and their impacts that may lead to reworks, different ways of further project execution with secondary risk events, etc. In Spider Project risk events are modeled by trigger activities.
- So project model shall include **probabilistic branches** that may happen with certain probabilities.
- If risk event (trigger) happens risk response actions shall be modeled together with potential responses to late performance or cost overruns (**conditional branches**).
- Monte Carlo simulation shall be applied to the model that includes both uncertainty and risk events.

Project Risk Analysis
Three scenarios method

- Spider Project also includes simplified but practical method of project risk analysis that we call **Three scenarios method**.
- Project Planner creates three project versions:
  - Optimistic version that is based on optimistic estimates of project parameters and includes only those risk events that have 90% or higher probabilities to happen,
  - Expected version that is based on most likely estimates of project parameters and includes those risk events that have 50% or higher probabilities to happen,
  - Pessimistic version that is based on pessimistic estimates of project parameters and includes all risk events.

Project Risk Analysis
Three scenarios method

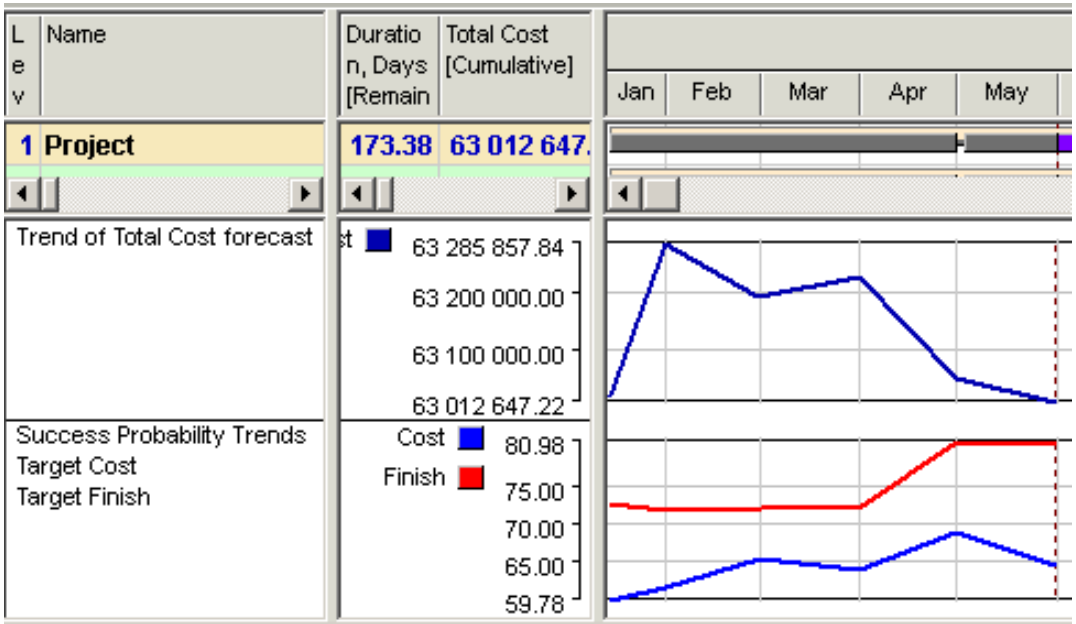
- Basing on three estimates of overall project performance Spider Project creates probability curves for project parameters and calculates contingency reserves that shall be created for meeting project targets with the user defined probabilities.
- When actual data are entered in any of these three models all three are updated and synchronized.
- So it is easy to manage three schedules in parallel using optimistic for managing project workforce, most likely as the schedule for project management team, and pessimistic as contract schedule. This approach is popular among General Contractors.
-

Project Risk Analysis

- Setting reliable targets that have reasonable probabilities to be met (**success probabilities**) means that we define project **time and cost buffers** (contingency reserves) that shall be added to project duration and total cost.
- Project management team shall manage these buffers estimating **buffer penetrations** and project management software shall provide tools for buffer penetration estimation and analysis.

Project Performance Analysis

- Performance measurement techniques included in most packages produce reports on **project status.**
- But **trends of project parameters** are even more important for timely management decisions.
- Wise project managers pay most attention to project trends and it is necessary to supply them with the information on project performance trends



Success Probability Trends

- **Trends of probabilities to meet project targets** (success probabilities) are most valuable and integrated project performance indicators.
- They depend not only on project performance but also on **project environment**. These trends may be negative even if project performance is perfect but new risks were identified or uncertainties increased.
- Negative trends of success probabilities require considering corrective actions.

Project Portfolio Planning

- Spider Project portfolio planning includes **portfolio resource, supply and financing constrained scheduling** that takes into account **project priorities.**
- It is not enough to prepare reports on total workloads of portfolio resources – manual leveling of project portfolios is even more complicated and less reliable than leveling of separate projects.

Project Portfolio Planning

- Portfolio project selection shall be confirmed by **portfolio leveling.**
- Including projects that look most attractive may seriously damage portfolio success criteria if they require the same resources at the same time as other portfolio projects. It may cause project delays and loss of profits.
- Other projects that require portfolio resources when they are available may be much more profitable even if calculated separately project parameters are less attractive.
- Only modeling the whole portfolio it is possible to select right projects that maximize portfolio ROI.

Project Portfolio Planning

- For strategic portfolio management it is necessary to simulate project incomes and manage portfolio cash flows calculating **NPV, IRR, payback periods** of separate projects and portfolio as a whole taking into account cost **discounting**, cost **escalation**, project profits **re-investments.**
- Projects in the portfolio shall be **prioritized**. Multitasking (performing several projects in parallel by the same resources) usually leads to delays of first portfolio project deliveries.
- But if projects are prioritized resources will perform projects one after another and profits will be achieved earlier that leads to much better portfolio results.

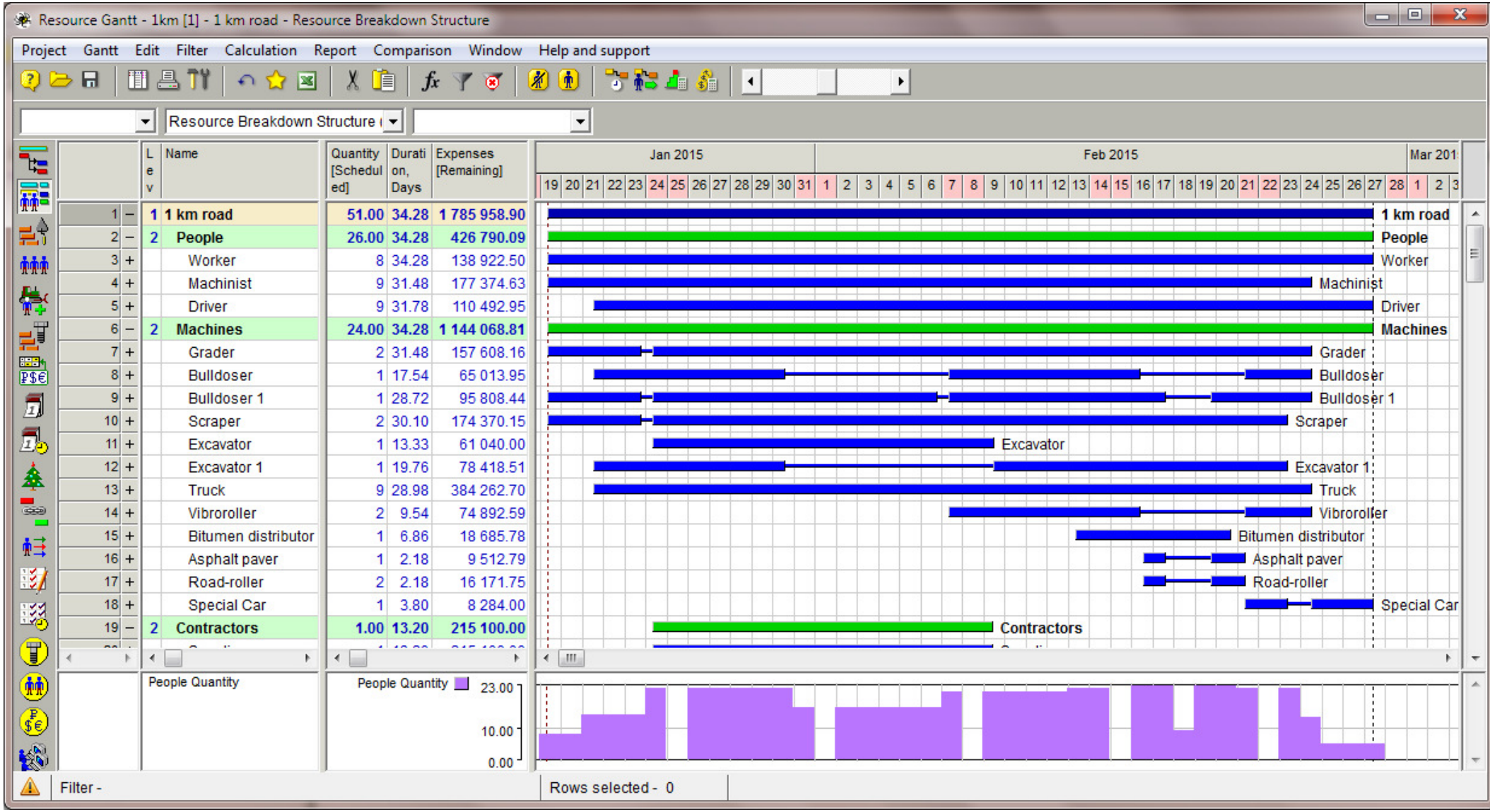
Project Portfolio Risk Analysis

- Spider Project applies Risk analysis not only on project but also on portfolio level.
- Only considering risks and uncertainties it is possible to set reliable portfolio and project targets and create sufficient and reasonable contingency reserves.

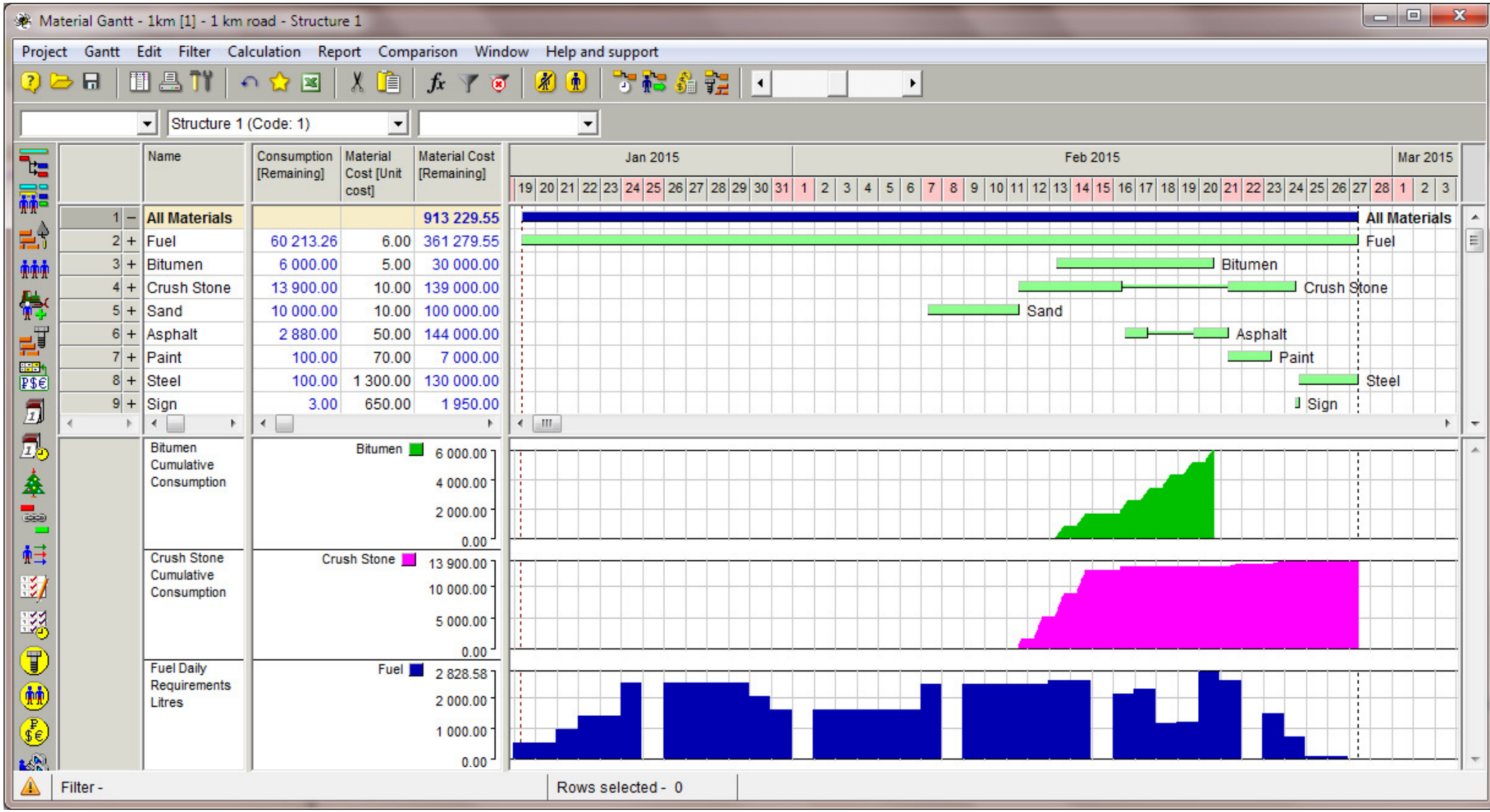
Spider Project Reports

- Spider Project graphical reports include:
  - Activity, Resource and Material Gantt Charts,
  - WBS and OBS Charts,
  - Network Diagrams,
  - Trigger Charts,
  - Resource, Cost and Material Histograms and S-curves,
  - Earned Value Graphs and Trends,
  - Time-Location Charts (with animation),
  - Probability distributions and curves,
  - Scatter Diagrams,
  - Trends of any project parameter,
  - Success Probability Trends.
- Some examples are shown in the next slides.

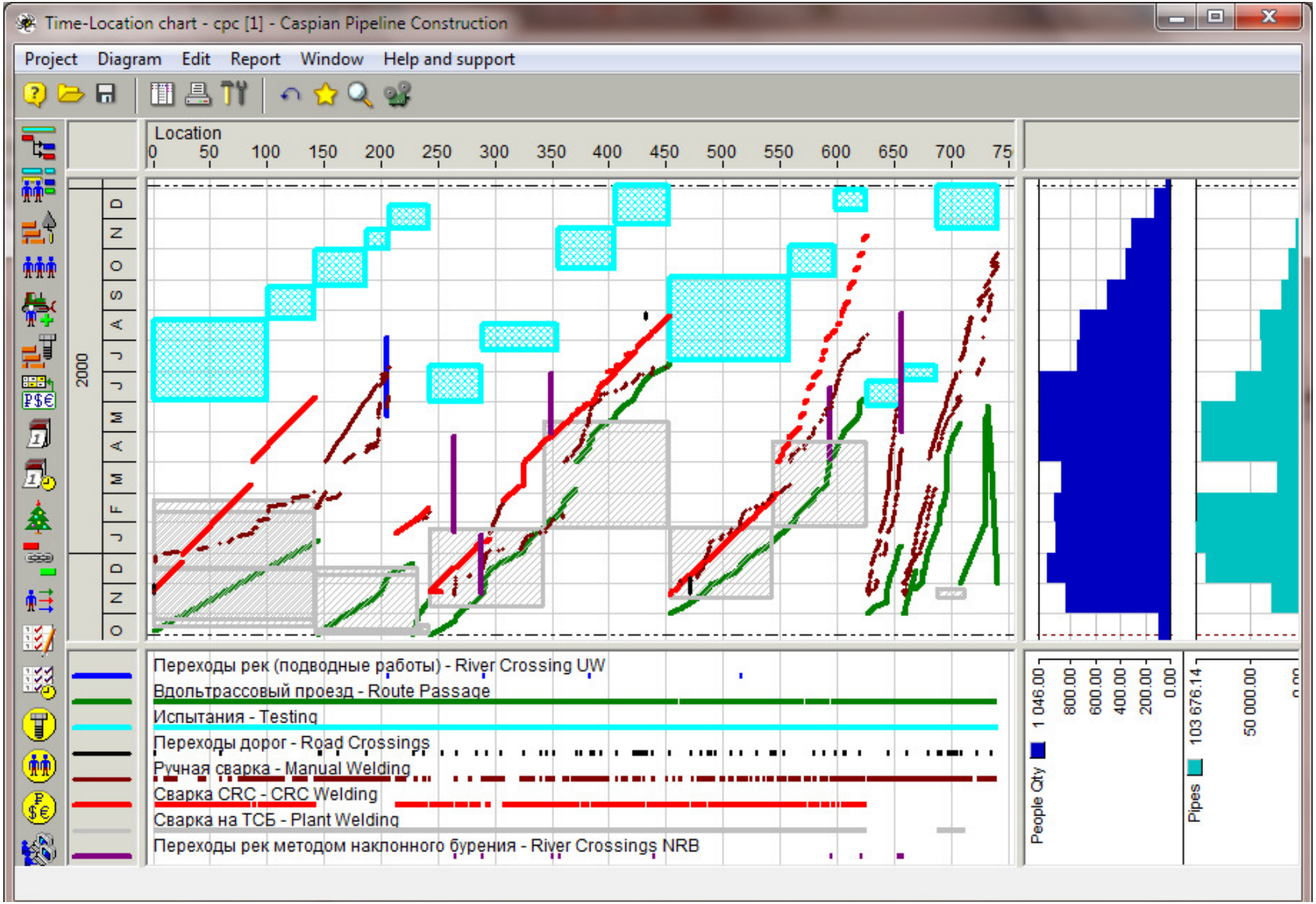
Resource Gantt Chart



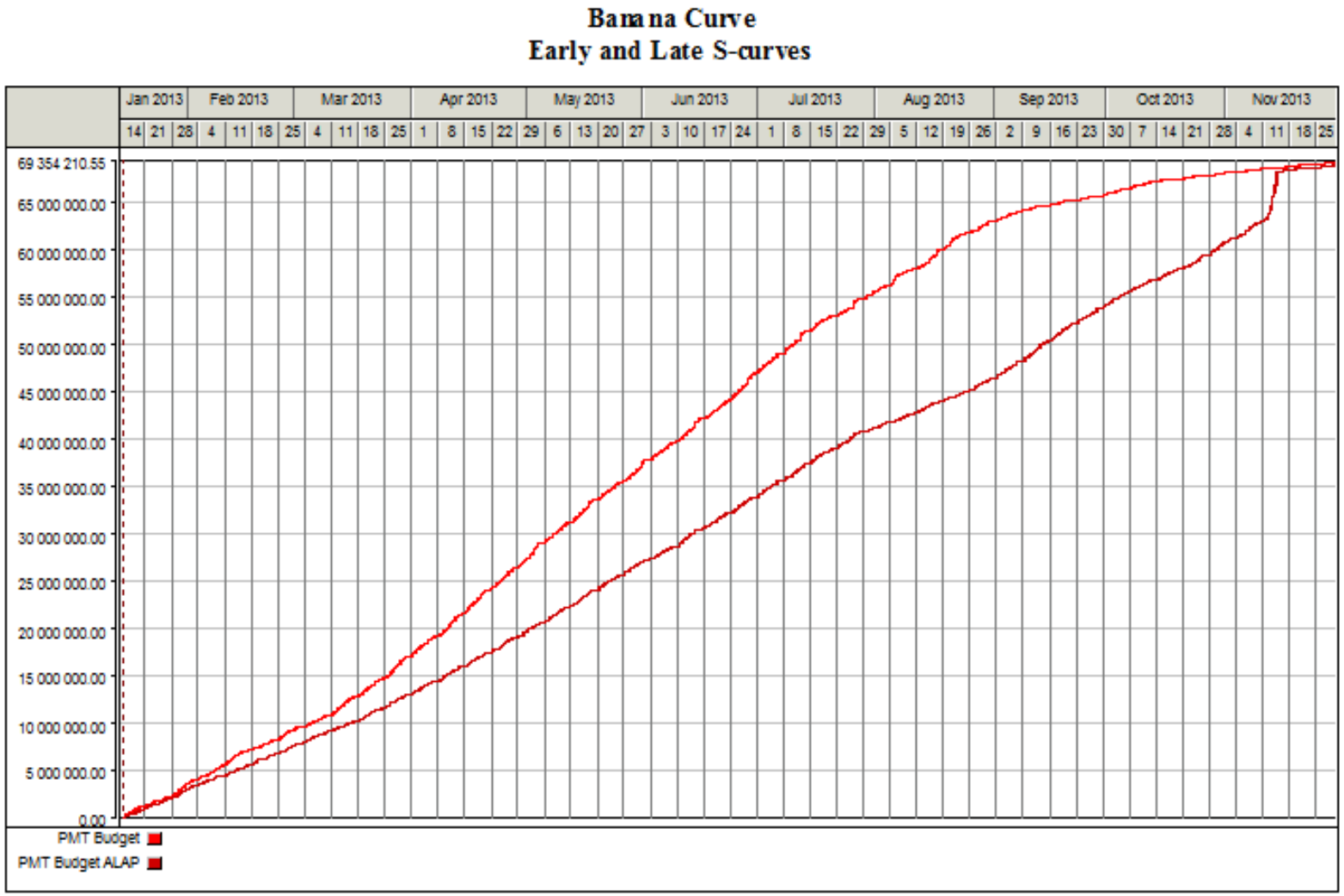
Material Gantt Chart



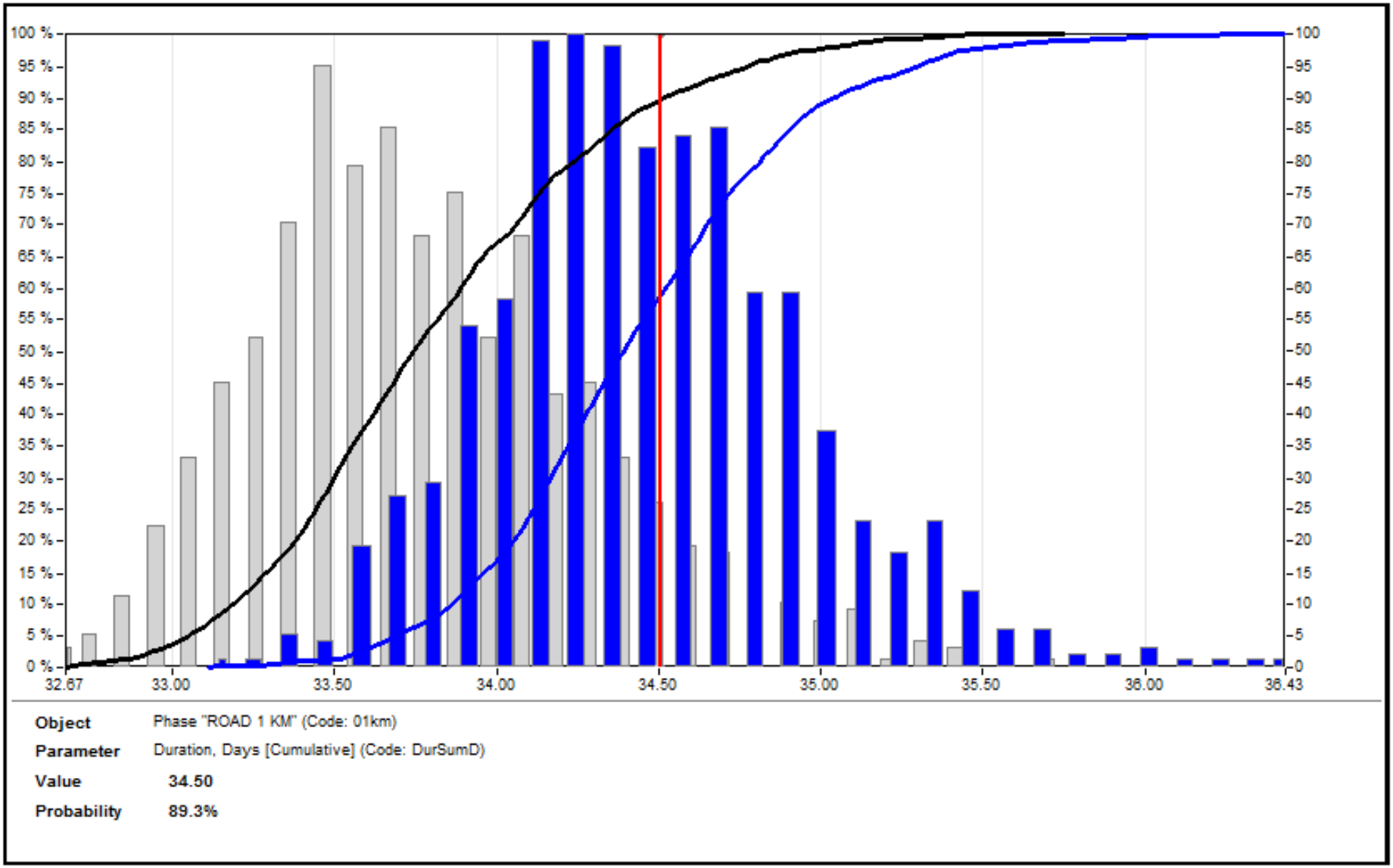
Time-Location Chart



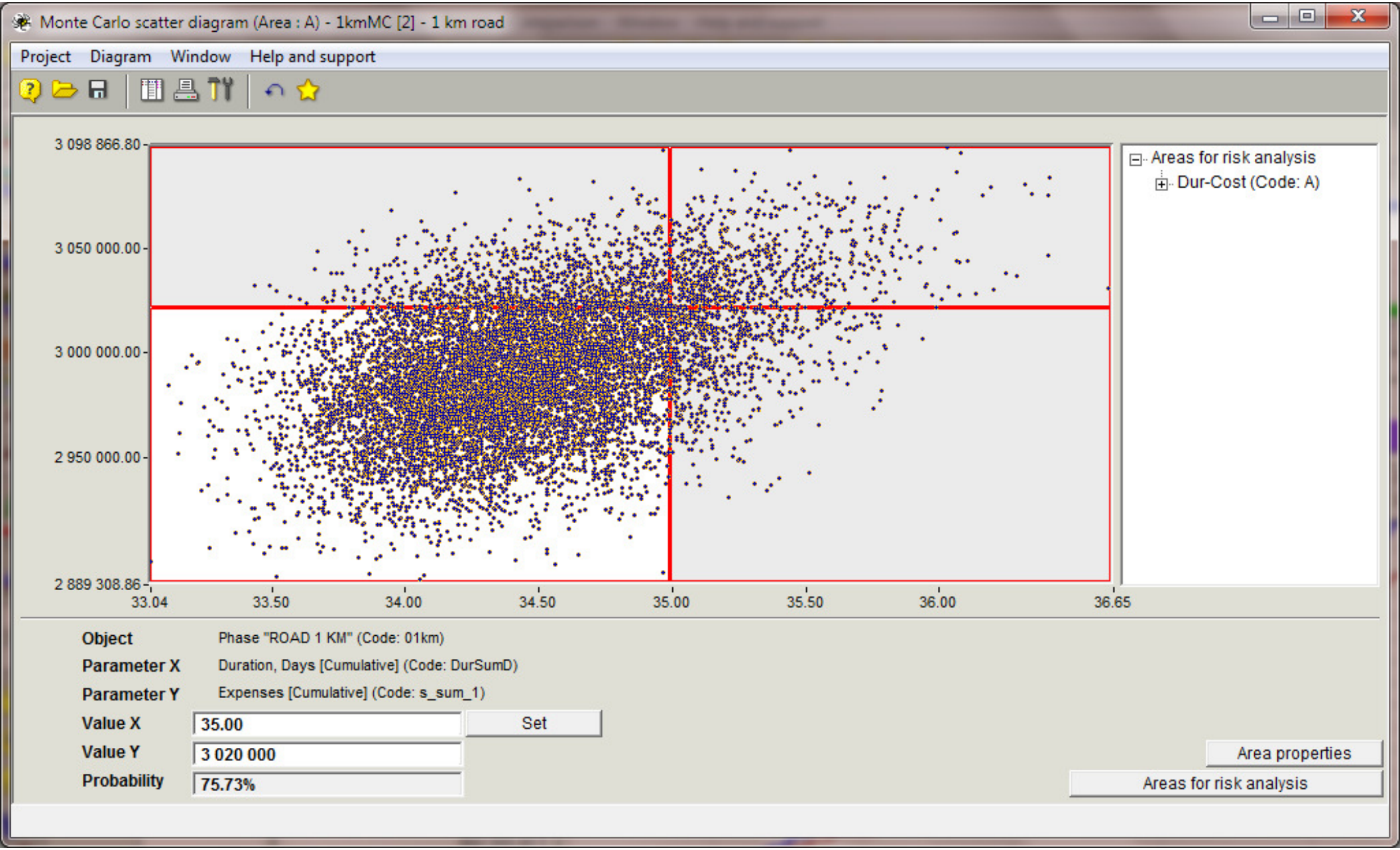
Banana Curve



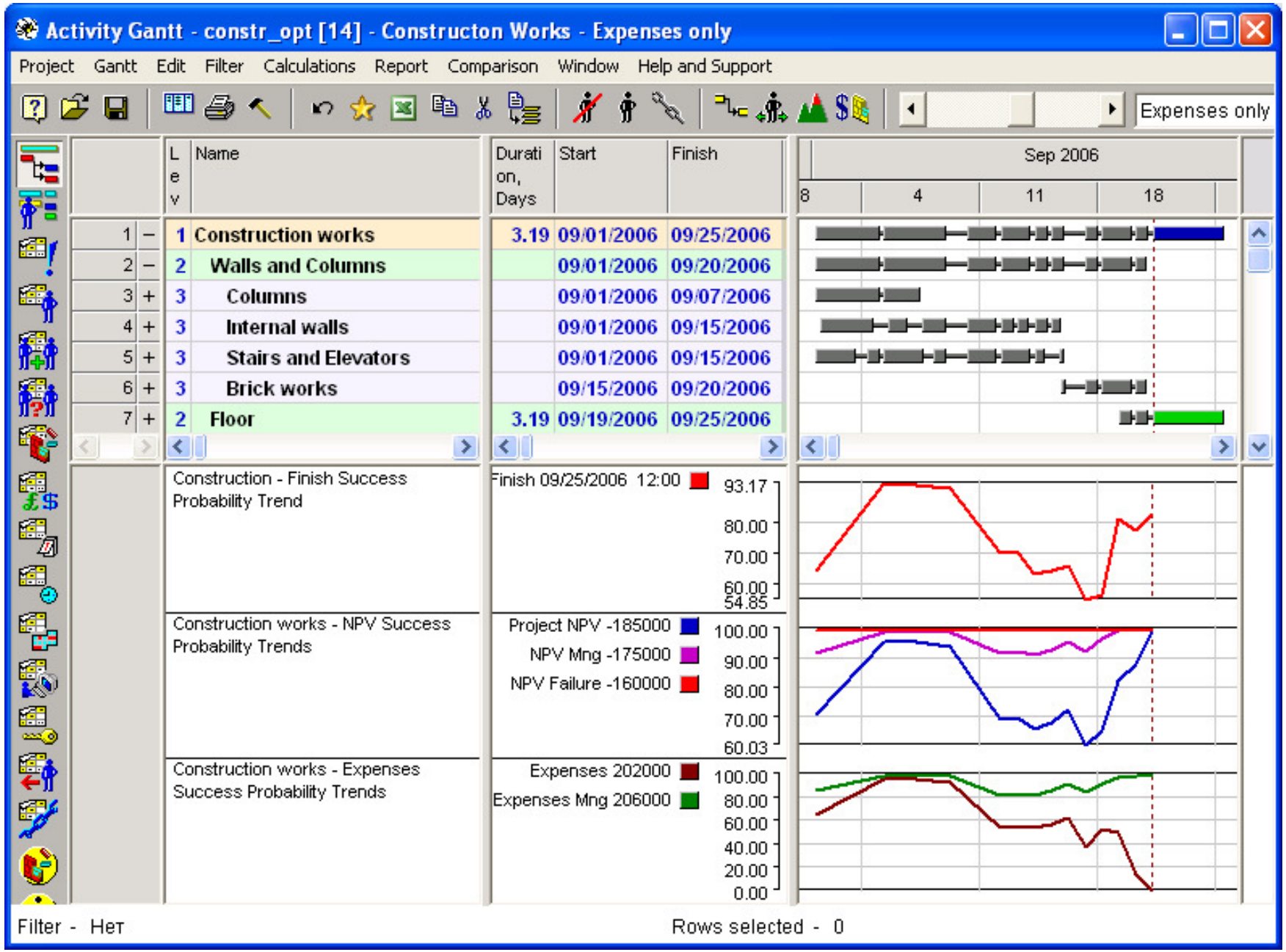
Comparative Probability Distributions



Scatter Diagram



Success Probability Trends



Conclusions

- We have done very brief review of some Spider Project features required for creating adequate project and portfolio models and absent in most packages
- It would be interesting to get the proposals of other useful functions missed both in PM software and in this presentation. Project management software market development shall be based not on capabilities of largest market players but on practical user requirements.
- Some planners require tools for drawing pretty Gantt Charts; others need tools for creating reliable project models that may be used for what if analysis and decision making.

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