Management of process control in innovative projects

Chapter 6
Planning of terms and terms of implementation of innovative projects

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Lecture content

- Principles of managing the terms of the innovation project
- Methods of network planning of innovative projects
- Calendar planning of the innovation project
- Grid schedule when planning innovative projects
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- Development of the project schedule

01

Principles of managing the terms of the innovation project

Definition 1. Project Time Management - a section of project management that includes the processes necessary to ensure the timely implementation of the innovation project.

Innovation project time management processes:

1. Scheduling management planning - a process that establishes certain policies, procedures, and documentation for planning, developing, managing, implementing and controlling a project schedule. The toolkit is used as analytical methods, expert assessments and meetings.

2. Defining operations - the process of identifying and documenting clear actions that need to be taken to achieve project objectives. Decomposition and expert evaluation are used.

3. Determining the sequence of operations - the process of identifying and documenting the relationships between the operations of the innovation project. This uses tools such as the method of precedence charts, dependency detection, or advance and delay.

4. Estimation of operations resources - the process of estimating the types and quantities of materials, human resources, equipment, or supplies required to perform each operation. Expert evaluation and multicriteria evaluation methods are used here.

5. Estimation of duration of operations - the process of estimating the number of working periods required to complete individual operations, taking into account the estimation of resources. Here they use the tools of assessment by analogues, parametric assessments and others.

6. Scheduling - the process of analyzing the sequence of operations, their duration, resource requirements and scheduling constraints to create a project scheduling model. Use of tools that are common and well-known, such as scheduling network analysis, critical path or chain method, resource optimization methods, modeling, and others.

7. Schedule control - the process of monitoring the status of project operations to update project progress and manage changes to the baseline schedule in order to comply with the plan.

Definition 2. Schedule management planning is the process that establishes policies, procedures, and documentation for planning, developing, managing, implementing and controlling an innovation project schedule. The advantage of this process is that it provides guidance and guidance on project schedule management throughout the life of the project.

Definition 3. Defining operations is the process of defining clear operations that need to be done to obtain project objectives.

The hierarchical structure of works determines the results of the lowest level - work packages. Project work packages are usually broken down into smaller elements called "operations", which describe the work required to complete a work package. Operations provide the basis for the evaluation, planning, implementation, monitoring and control of project work to ensure that the objectives of the innovation project are achieved.

There is also such a thing as a sequence of operations, which means the process of defining and documenting the relationships between project operations and is carried out through logical relationships.

Sometimes it is necessary to use the time ahead or delay between operations to maintain a determination can be performed using project management programs, automatic or manual methods.

The initial step in project planning is structuring, which involves planning the scope of work. The structuring stage does not allow to answer the question: how much time and what time is needed to complete all the work on the innovative project? Very often in innovative projects there are works, the terms of which are much longer than originally declared in the plan. This is natural, because a new one is being created that has no analogues and cannot be compared with similar developments of similar project.

For example, innovative software is being developed to evaluate startup project developers. To do this, you need to develop a number of models, such as: information, mathematics, aggregation of results, etc. It took a long time to create a mathematical model that did not exist before in nature, which does not coincide with the declared terms. That is, there is a need to plan another main goal of the innovation project - its implementation in time.

To solve this problem, project management uses grid and calendar planning. Given that a manager needs to process large amounts of data quickly to successfully work on a project, special tools such as grid and calendar charts that combine time, cost, and resource parameters are important.

The advantages of using these tools in planning an innovation project are as follows:

- identify and illustrate the full scope of work in the form of a schedule;
- set realistic goals for the project in terms of time, cost, and resources that can be achieved;
- estimate the project budget;
- monitor the implementation of works during the project implementation and anticipate the further course of events;
- effectively distribute responsibility for project work among team members;
- identify critical work, move resources, reduce risks and uncertainty.

02

Methods of network planning of innovative projects

The organizational and technological model of an innovative project is called a formalized reflection of the order (sequence) of work in time, relationships, and dependencies between them, established in accordance with the requirements and restrictions.

Today, the most common in the practice of project management are the following types of organizational and technological models: linear diagrams (represented by a linear calendar graph), cyclograms (time diagram in the form of a cycle), grid models (based on graph theory).

Definition 4. Grid model - a set of interconnected elements to describe the technological dependence of individual works and stages.

Grid planning is to create logical diagrams of the sequence of project work - grid schedules - and determine the duration of these works and projects in general for further control.

The following important customer questions can be answered when applying network planning:

1. How long does it take to complete the project?
2. At what time should the individual stages of the project begin and end?
3. What works are crucial in the project and should be performed exactly on schedule, so as not to disrupt the deadlines of the project as a whole?
4. How long can the implementation of minor works be postponed so that it does not affect the implementation of the project?

Definition 5. Network planning methods are called methods, the main goal is to minimize the duration of the project.

The most well-known and effective methods of network planning are:

- **Critical Path Method (CPM)** - causal relationships are established between tasks. At the same time, it allows to calculate possible calendar schedules of their performance, and also provides receipt of the network plan of performance of works;
- **Program Evaluation and Review Technique** (PERT) method - takes into account uncertainty when evaluating the timing of a project or individual works. Provides the manager with the ability to graphically compare different tasks and types of work performed, with the definition of the minimum, maximum and expected time to complete certain works, taking into account resources;

- **Method of graphical evaluation and review of plans** (GERT - Graphical Evaluation and Review Technique) - allows you to graphically display different options for each stage of the project, to obtain a projected estimate of the time of completion of various types of work. That is, taking into account the time factor and uncertainty;
- **Venture Evaluation and Review Technique** (VERT) and **Structure, States and Deviation graph** (SSD) method are modified variants of network planning, the first method allows to take into account risk, the second - take into account deviations in the performance of works.

The last three methods are used if it is necessary to take into account situations of risk and uncertainty.

In the PERT method, the sequence and types of work are defined unambiguously, and when calculating their duration, the risk of changing the time of each work, which affects the entire project, is taken into account.

The GERT method provides the ability to model project scenarios that simulate a situation of uncertainty.

The method of critical chains allows taking into account the use of limited resources in the project and involves optimizing the organization of their movement. He is an example of the development and improvement of CPM and PERT methods.

The critical path method (CPM) is a method of planning work within the project, including the management of these works and scheduling their implementation. The key point of the method is the so-called "critical path". It calculates a determined project implementation schedule based on a single estimate of the duration of each work. The dates of the beginning and end of works in the innovative project and reserves are calculated - the time intervals for which it is possible to postpone the execution of operations without violating restrictions and the dates of completion of the project.

According to this method, for each type of work, the sequence, time, and resources required to perform the work are indicated. After that, a graph (grid graph) is constructed, which reflects the sequence of works and deadlines for their implementation. Next, the graph looks for a critical path, this is a path that requires maximum time.

The critical path method in project management is an example of the practical application of the provisions of general constraint theory: any complex system of operation has some limitations ("bottlenecks"), which determine the end results of its operation. Under the CPM concept, such constraints may be the duration of the project or individual works, and the critical process may be time management. At the same time, they assume that there are no resource constraints, this is they believe that all the necessary resources are sufficient and available.

A great advantage of the critical path method is the ability to manipulate the timing of work that is not on the critical path.

The PERT method is an analytical calculation method that allows you to predict optimistic, medium or pessimistic deadlines (based on the assessment of the convolution), eliminating the repetition of the same work at the same time. It takes into account uncertain values to calculate the possibility of performing both individual works and the entire project in the declared time. Each of the scenarios has its own estimate of the duration of the work.

PERT and CPM methods are used to determine the longest time in the chain of work, which is the basis for planning and monitoring the progress of the project. Directed lines and nodes are used in both methods to graphically represent this sequence.

Graphic Evaluation and Review Program (GERT).

The method of graphical evaluation and review of programs (GERT) allows you to perform probabilistic processing of both network logic and estimates of the duration of work. GERT makes it possible to take into account the risk of changes in the composition of work in the event of certain events or the results of previous work: some work may not be performed at all, others - partially performed, and others are performed several times.

The GERT method allows to determine the estimated duration of the project on the basis of three probabilistic estimates of time. The grid model is a probabilistic grid that takes into account the possibility of different composition of the project. Thus, it is possible to take into account not only the risks (uncertainty) at the level of individual works, but also at the level of the project as a whole. As a result of GERT modeling, several graphs will appear, taking into account the probability of different duration and uncertainty of the composition of the project.

Each of the above modeling methods is a very important place in the methodology and practice of project management, including innovative.

03 Calendar planning of the innovation project

Definition 6. Calendar planning is the process of compiling and adjusting the schedule, in which the work performed by different organizations participating in the project, agree in time with each other and with the ability to provide them with different types of resources.

At the same time, compliance with the set restrictions and optimal (according to the accepted criteria) distribution of resources must be ensured.

Definition 7. Calendar plan - a project plan submitted in real time format (actual calendar dates).

Calendar planning is performed at all stages of the project life cycle. Thus, at the stage of preparation the basic (target) calendar plan is formed, and at the stage of implementation - detailed plans, which are constantly adjusted taking into account the actual implementation of tasks on the project.

The algorithm of the calendar planning process involves the following steps:

1. Project identification.
2. Structuring the project.
3. Development of organizational and technological model of the project.
4. Development of a schedule of project work.
5. Development of a project management schedule.
6. Cost evaluation of project elements, determination of project budget.
7. Optimization of plans according to the selected criteria.

Calendar plan, as a list of only the planned parameters of project work loses its meaning without comparison with the actual timing of their implementation, so often use calendar charts.

Calendar planning aims to coordinate the activities of all project executors in order to achieve the main goal of the project, create conditions for responding to market opportunities and timely income, which guarantees the efficiency of investments.

The goals of the calendar plan are as follows:

- ensure timely receipt of funding;
- coordinate the flow of resources;
- provide the necessary resources in a timely manner;
- predict at different times the level of required financial costs and resources and their rational distribution between projects;
- ensure timely implementation of the project.

The calendar graph reflects the planned and actual data on the start, end, and duration of each WBS work item. It also notes the possible flexibility in the start date without complicating the implementation of the whole project.

Thus, the purpose of the calendar plan is to coordinate the activities of the contractors involved in the project to ensure its successful completion, create conditions for responding to market opportunities and timely income, which ensures the effectiveness of investment.

The parameters of the calendar plan are the start and end dates of each work, their duration and the necessary resources.

Duration of work - the main parameter of planning, depends on the total complexity and number of performers.

Critical duration - the minimum duration during which the full range of project work can be performed.

Compliance with existing restrictions (duration of work, resource limits, etc.) and optimal allocation of resources must be taken into account in calendar planning.

Today, there are the following types of calendar plans:

- calendar plan for early beginnings - used to stimulate project executors;
- calendar plan for late endings - used to present the project as good as possible for consumers;
- calendar plan "in the middle" - is created either to optimize the resources consumed, or to show the customer the most likely result.

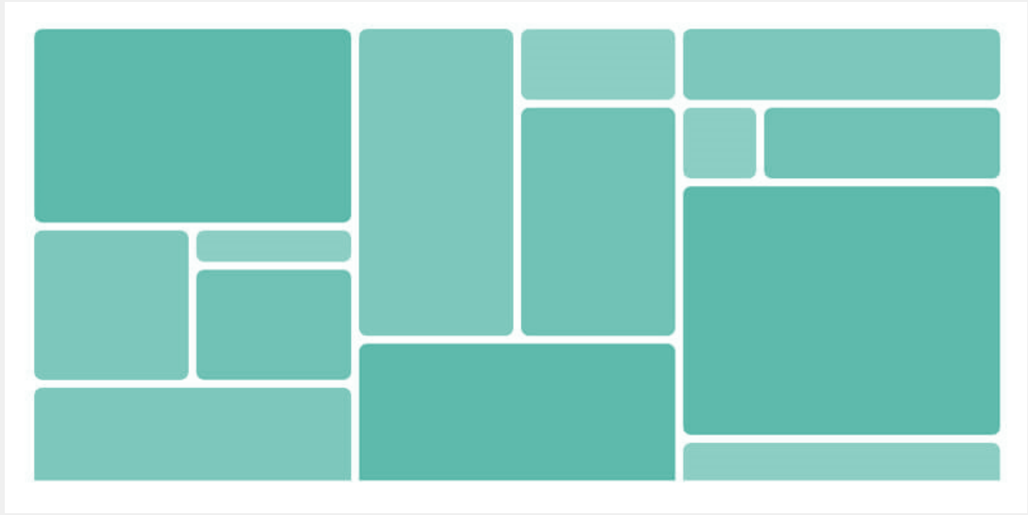
Types of calendar charts

There are two acceptable ways to present a calendar schedule:

- tabular - with a list of works indicating the duration of their implementation;
- chart (Gantt charts).

04

Grid schedule when planning innovative projects



Grid planning is to build a grid schedule and calculate its parameters. A grid graph is based on the use of a mathematical model - a graph that represents a geometric figure consisting of a finite or infinite number of points and lines connecting them. Points are called vertices, and lines are called edges if they are undirected, and arcs if they are directed. If all segments are directed, the graph is called oriented, if undirected - undirected. With the help of such a graph, a grid of project works is created.

Definition 8. A grid graph is a graphical representation of project work that reflects their sequence and relationship.

The main means of visualizing the project's grid graph is the Gantt Chart.

Gantt chart is one of the most popular ways to graphically represent a project plan, used in many project managements programs. The Gantt chart is named after the American engineer Henry Gantt (1861-1919).

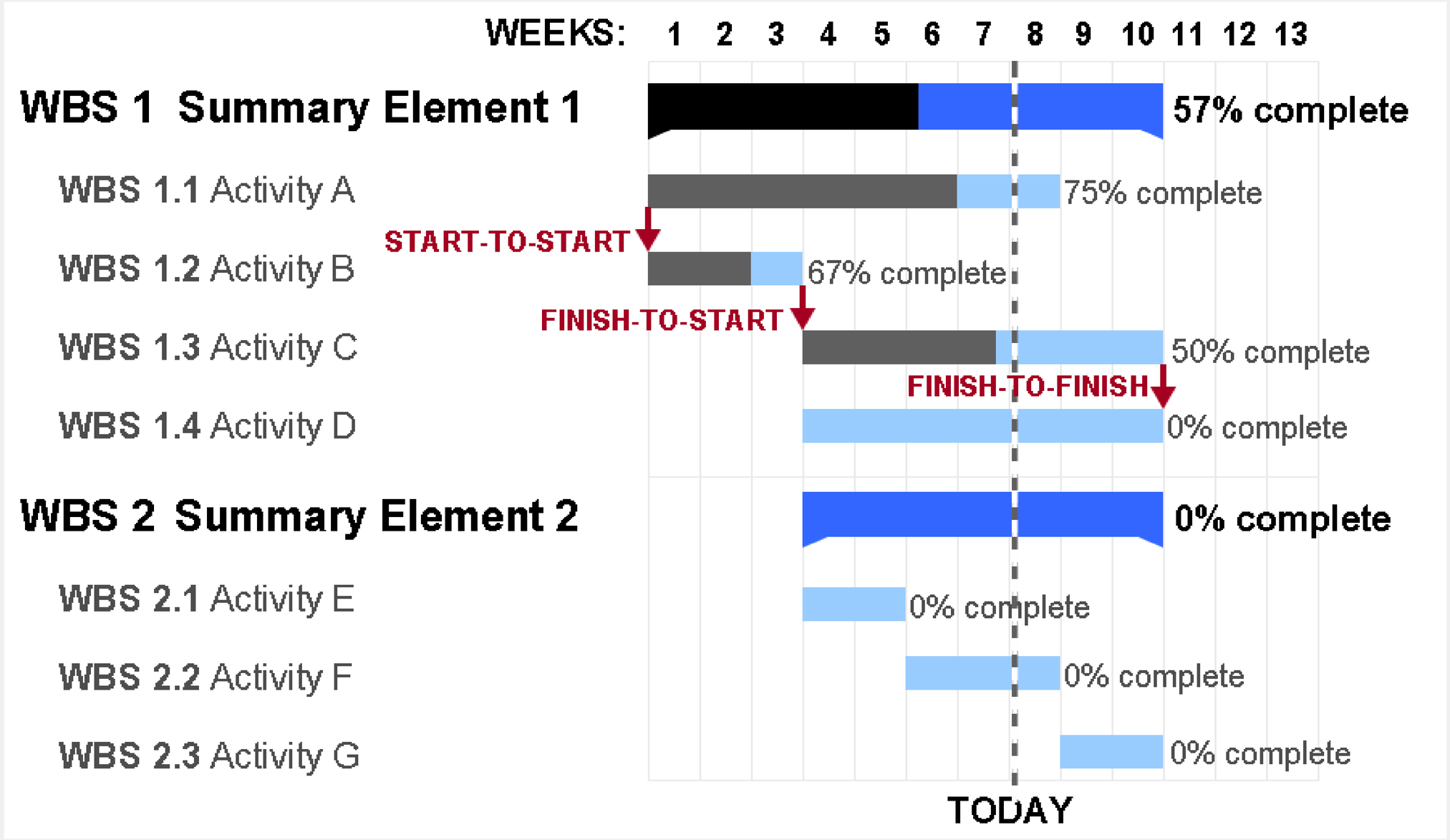


Fig. from the source: https://uk.wikipedia.org/wiki/Діаграма_Ґанта

Main elements:

1. Work (operation) can be defined as an action required for project implementation. In grid graphs, robots are assigned a number or code when compiling WBS. Work is understood as a process (production, management, etc.) that requires time and resources (labor, material, technical, information, etc.) and provides a certain result or product creation.
2. Event - the final results of previous work; start and / or end of operation, group of operations.
3. Path - a continuous sequence of work from start to finish.
4. Duration - the time from start to finish. Determine the duration on the basis of norms, evaluate - from experience or calculated analytically.
5. Logical connections. Before building a grid chart, you need to determine the relationships between the jobs, which can be of two types:
    - consistent, when one job is performed after another;
    - parallel, when several works can be performed simultaneously.

There are two main types of work: work with a fixed duration (has a certain duration, which does not depend on the amount of resources involved in its implementation); work with a fixed volume (the volume of work is constant, and its duration depends on the amount of resources, their productivity, technological method of execution, etc.).

An important indicator on all grid graphs is the path that determines the sequence of work or events performed, in which the result of one stage coincides with the initial value of the next phase. There are several ways on any chart:

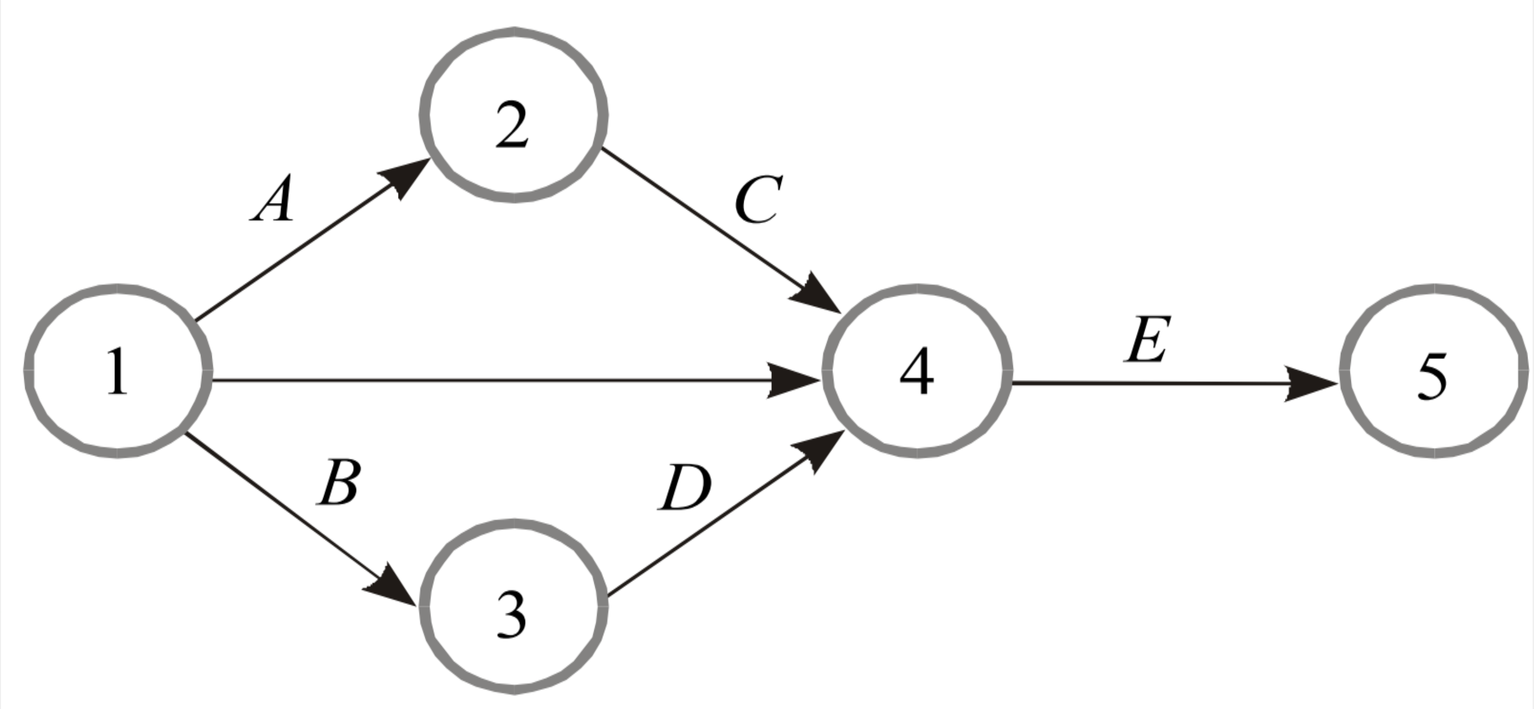
- Full path from the initial to the final event;
- The path that precedes the event from the initial;
- The path following the event to the final;
- The path between several events;
- Critical path from the initial to the final event of maximum duration.

Defining Relationships of Operations is the process of defining and documenting the relationships of a project's operations.

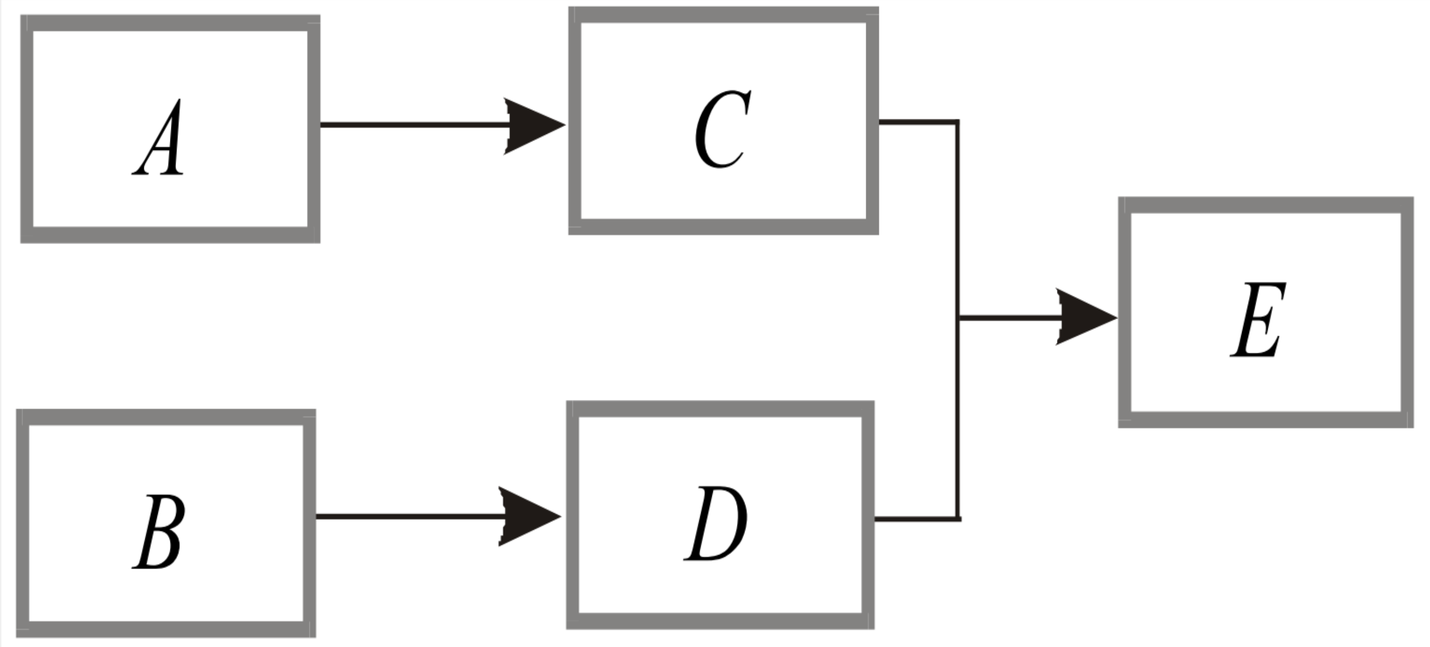
Depending on the image method, there are two types of grid charts:

- arrow diagram method (ADM) (arrow graphs, event vertices) are diagrams in which the work is modeled in the form of arrows directed from the start event to the end event;
- predecessor diagram method (PDM) - diagrams in which the work is modeled as graph vertices and each of the works is associated with its "predecessors" - works that, according to technological, organizational or other requirements, must precede the current during the project.

Arrow graphics. They are characterized by the image of the work in the form of an arrow (hence the name of this graph), and logical connections between the works are established by so-called events, depicted in the form of circles indicating the beginning and end of a work.



Precedence charts have been developed with the widespread use of software and today have supplanted arrow charts. Unlike the previous ones, the works are presented in the form of rectangles, and the arrows indicate logical connections. For the example above, the lead schedule will look like this.



To build a model of any kind, you need to: create an orderly list of works (i.e. - develop a WBS), estimate or calculate the duration of each and establish links between them. There are two classes of grid models - deterministic and stochastic. In the first nomenclature, sequence and duration of work is set unambiguously, and in the second - in the form of probability distribution.

Types of reasons for establishing dependence between project works:

1. Logically.

Mandatory dependency (Hard logic) - the sequence of works cannot be changed.

For example, you cannot edit text before it is written.

2. Resource constraints.

External dependency - the sequence of works is determined by external influences in relation to the project.

For example, if there is only one painter, it is impossible to paint four walls in a room at the same time.

3. At its discretion.

Discretionary dependency (Preferred logic) - the sequence is determined by the project team and can change.

For each of the project works, the manager must set the time required to perform this work. Technically, the task of duration of work (duration) is performed simply - by entering a number in the appropriate field. You can also set temporal relationships between related work. You can set the lead time and lag time. In addition, time limits can be set for each work or phase by tying it to a specific date.

Definition 9. Lag is the minimum amount of time for which the start or end of a dependent operation can be delayed.

Rules for plotting grid charts:

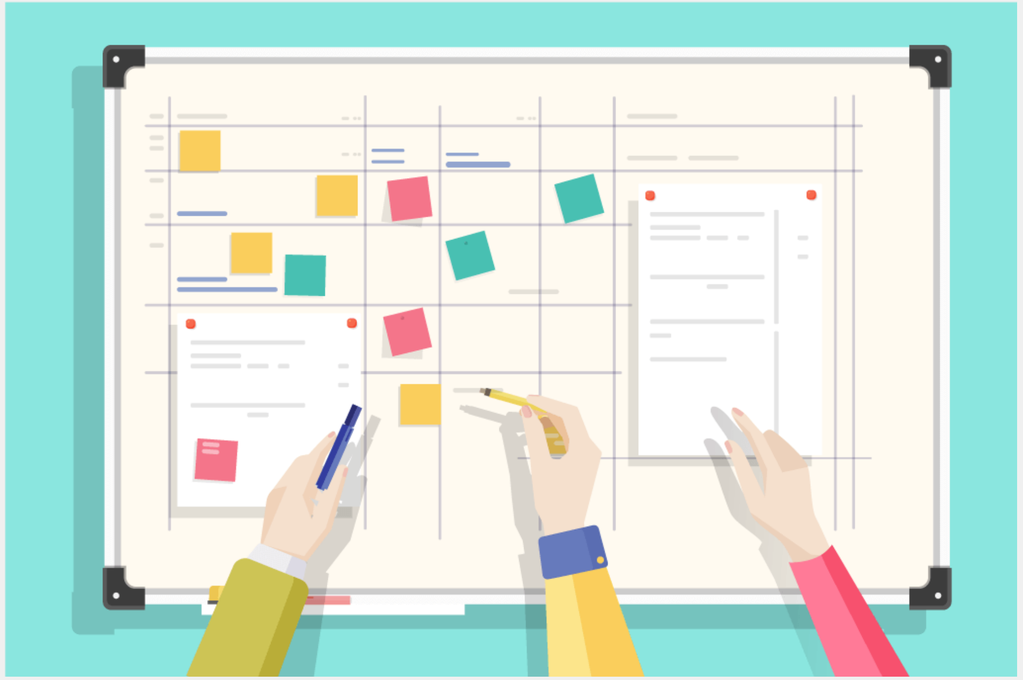
1. The grid graph unfolds from left to right. You can move on the grid only in one direction - to the finish.
2. No operation may be initiated until all previous operations related to it have been performed.
3. Completion of one work may be associated with the beginning of more than one.
4. Arrows in the grid graph reflect the relationship of precedence and passage. In the figure, the arrows may intersect.
5. Each operation must have its own number.
6. The number of the next operation must be greater than the number of any previous operation.

Rules for plotting grid charts:

7. The formation of loops is unacceptable (in other words, there should be no looping of the progress of the established set of operations).
8. Conditional transitions from one operation to another are not allowed (meaning the definition of the sequence of operations by conditions such as: "If success is achieved, do ...").
9. Experience shows that when there are several initial projects of the project, the general node of the beginning of all complex of works can be defined. Similarly, one node can be used to clearly indicate the end of the project.

05

Features of network planning in conditions of uncertainty



Since the characteristic feature of innovative projects is their uniqueness, it is often difficult to determine the exact duration of individual works, so it is necessary to take into account the uncertainty of the timing of certain types of project work.

The method of analysis and evaluation of PERT programs (Program Evaluation and Review Technique) has advantages over methods of critical path and communication networks in situations where the achievement of project objectives is associated with uncertainty.

PERT analysis involves a three-dimensional assessment of the expected duration of work:

- optimistic (Tmin) - the minimum real period of time during which the operation can be performed;
- pessimistic (Tmax) - the maximum real period of time during which the operation must be performed;
- most probable (Tm) - the most accurate assumption of the period of time required to perform a particular operation.

PERT The use of three estimates not only allows you to estimate the duration of the operation, but also allows you to get a reliable estimate (Probability Estimate) of the completion time of all operations included in the network schedule. Briefly, this procedure can be described as follows: Estimated Activity Time is a weighted average value in which the most probable estimate is given to the most probable estimate and the maximum to the maximum and minimum duration.

The following formula is used to calculate the expected duration of TE (Expected Time) according to three-time estimates:

$$TE = \frac{T_{min} + T_{max} + 4T_m}{6} \qquad (1)$$

Where: Tmin - the minimum possible duration of work; Tmax - the maximum allowable duration of work; Tm is the most probable duration of work.

Experts have the opportunity to give three estimates of the duration of work, which allows varying degrees to take into account the risks that affect their performance.

Instead of one value of duration of works, this method allows receiving normal distribution of probability of duration.

The distribution of the variable is the regularity of the probability of meeting its various values.

The normal distribution is characterized by the fact that the extreme values of the variable in it are quite rare, and values that are close to the average value - quite often. The graph of the normal distribution is a "bell-shaped" curve.

Experts have the opportunity to give three estimates of the duration of work, which allows varying degrees to take into account the risks that affect their implementation.

Optimization of grid schedules is to improve the processes of planning, organization and formation of a set of works to reduce the cost of economic resources, and increase financial resources with given planning constraints.

The project manager can use the following methods to reduce the duration of work:

1) redistribution of resources from non-critical to critical work (in order to reduce the time of their implementation) within the time reserve;

2) change of logical connections (where possible): instead of sequential - parallel;

3) a new calculation of the duration of the critical path (as more information becomes available);

4) change of work schedule (instead of five-day week - six- or seven-day), but it is necessary to take into account the decrease in productivity and increase in labor costs;
5) if internal resources are overloaded - the use of subcontractors (or temporary workers);
6) change of means of transportation of materials (if due to the applied, delay is caused): instead of the railway or ships - planes;
7) technical changes that reduce the duration of the work and simplify its content (alternative materials, other means of assembly, etc.);
8) material incentives - bonuses for reducing the duration of work;
9) raising the level of qualification, which increases work efficiency;
10) improving working conditions and motivation (using the theories of Maslow, Herzberg, McGregor).

Algorithm for reducing the duration of work in an innovative project:

1. Identify the critical path.
2. Identify works within the critical path that need to be reduced.
3. Determine the priority of reducing work:
   a) work with the lowest cost of reduction per day;
   b) works that are easiest to reduce;
   c) work, the reduction of which will most effectively affect the duration project implementation.
4. Reduce work by one day and see if a new one is formed critical path.

06

Development of the project schedule

Scheduling is the process of analyzing the sequence of operations, their duration, resource requirements, and time constraints to create a project schedule.

Entering operations, durations, and resources into the scheduling tool generates a schedule with scheduled project completion dates. Developing an acceptable project schedule is often an iterative process. It determines the planned start and end dates of operations. Developing a schedule may require analyzing and verifying estimates of duration and resources to create an approved project schedule that can serve as a baseline plan to track performance. Revision of the schedule and maintenance of its realism continues throughout the project as work is carried out, the project management plan is changed and the nature of risk events is identified.

Scheduling tools are used in conjunction with content and cost planning tools, and their joint use results in a consolidated project plan:

1) **Network analysis** is a technology for creating a project schedule. It uses a variety of analytical methods, such as the critical path method, the critical chain method, the analysis of "what if" scenarios and the equalization of resources to calculate the dates of early and late start and end of unfinished parts of the project. Some pathways in the network may have merging points or discrepancies that can be detected and used in schedule compression analysis and other types of analysis.

2) **The critical path method** calculates the theoretical dates of early start and finish, as well as the dates of late start and finish, for all operations without taking into account resource constraints by analyzing the passage back and forth through the project network. The obtained dates of early start and finish are not necessarily the schedule of the project; rather, they indicate the periods of time within which operations can be planned, taking into account the duration of operations, logical connections, advances, delays, and other known constraints.
3) **The critical chain method** - an approach to solving uncertainties in any project and is an extension of the theory of constraints in the field of project management.

4) **Resource equalization** - a method of network analysis used for scheduling, which has already been analyzed by the critical path method. Resource equalization can be used when the total or critical resources required are available only at a certain time or only in limited quantities, or to maintain resource use at a constant level. Resource alignment is necessary when reallocating resources, for example, when a resource has been assigned to perform two or more operations in the same time period, when shared or critically important resources are available only at a certain time or only in limited quantities. Equalization of resources can often lead to a change in the original critical path.
5) **Application of anticipation and delays.** Advances and delays are clarifications made during network analysis to develop a viable schedule.

6) **Analysis of the scenario "what if".** This is an analysis of the question: "What will happen if the situation develops according to scenario 'X'?" In this case, a network analysis is performed in which different scenarios are calculated using the schedule model (for example, delays in the supply of basic elements, increasing the duration of individual engineering operations) or simulating the impact of unforeseen external factors. The results of the what-if analysis can be used to assess the feasibility of a project schedule under adverse conditions and to draw up contingency and response plans to overcome or mitigate the consequences of emergencies. Simulation involves the calculation of different project durations using different assumptions about the duration of operations. The best-known method is Monte Carlo, in which the distribution of probable values of the duration of the operation is determined for each operation and is used to calculate the distribution of probable outputs of the whole project.

7) **Schedule compression** - analysis of trade-offs between cost and schedule to determine how to minimize deadlines at minimum cost (disadvantage: does not always allow getting an acceptable solution; may increase the cost of the project due to the allocation of additional resources for the operation). Fast transition - parallel execution of operations, which, as a rule, are performed sequentially (disadvantage: the risk of additional improvements increases).
8) **Scheduling tool.** Automatic scheduling tools facilitate the scheduling process by generating start and finish dates based on transaction information, network charts, resources, and transaction timelines. The scheduling tool can be used in conjunction with other project management software or non-automated methods.

Conclusions

In this lecture, we considered the important issue of planning the timing and timing of innovative projects. The processes of managing the terms of the innovation project were studied. We studied the best known and most effective methods of network planning, namely: the method of critical path, the method of evaluation and analysis of programs, the method of graphical evaluation and revision of plans, the method of evaluation and revision of risk-based plans and the method of analysis of work and deviations.

Conclusions

The important issues of calendar planning of the innovation project and the algorithm of the calendar planning process were considered. The issues of grid graph and their types were considered: arrow diagram method and predecessor diagram method. Schedule development tools are presented. The rules of construction of grid graphs are described. We came to the conclusion that the characteristic feature of innovative projects is their uniqueness, then it is often difficult to determine the exact duration of individual works, so it is necessary to take into account the uncertainty of the timing of certain types of project work.

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Thank you!