Project Planning and Control Methods

Lecture #10

# Project Control

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# Outline

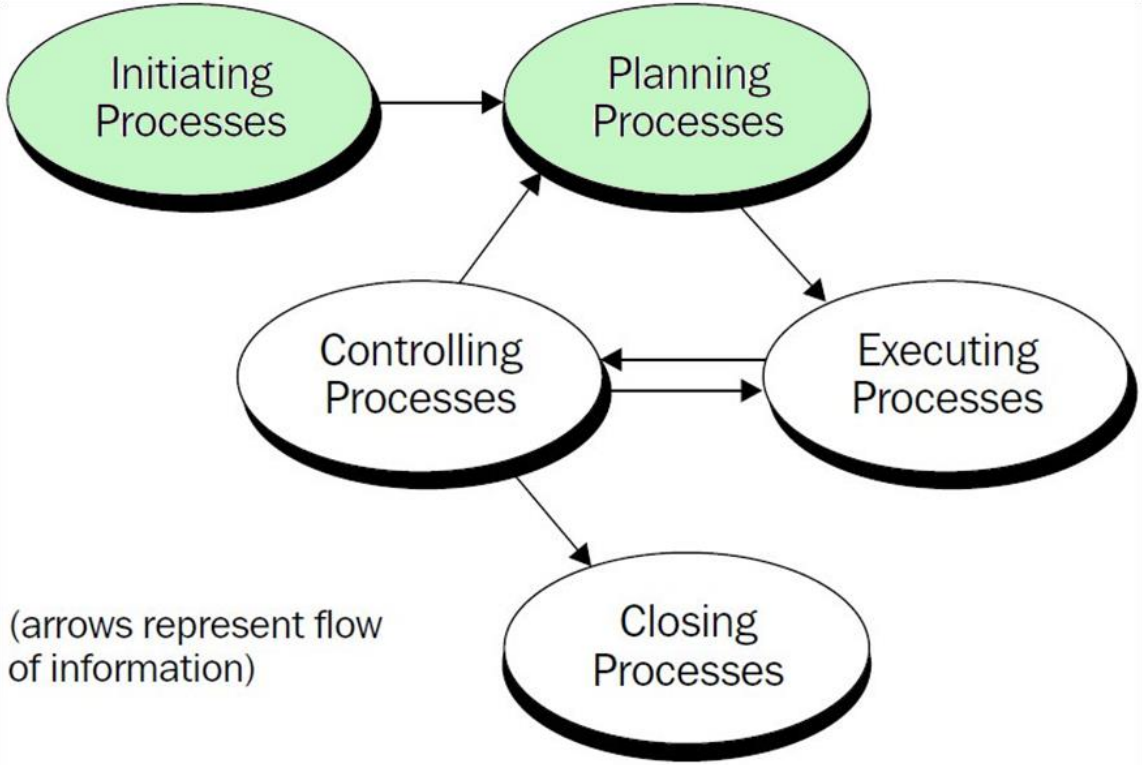


- Introduction
- Scope control
- Time/ cost control

# Introduction



- After development of project plan and creating baselines we now need to monitor and control the project's execution.

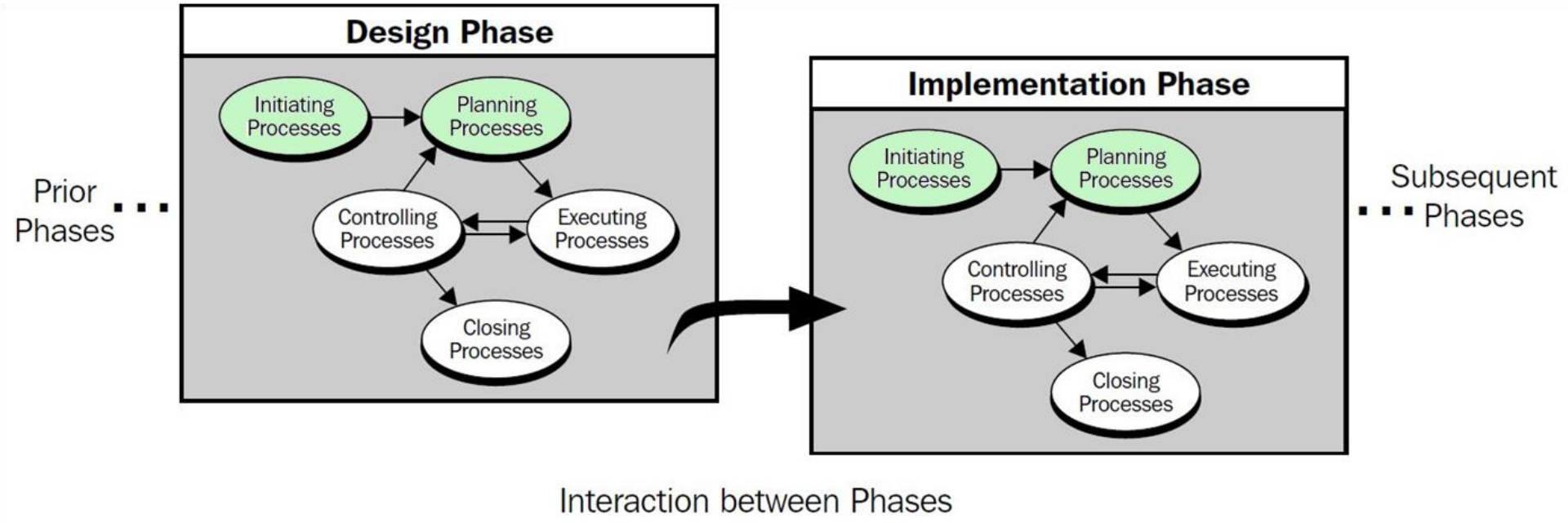



Links among Process Groups in a Phase

# Introduction



- Remember that in addition to the initial project's planning with a holistic view, planning and controlling processes are repeated in each project phase!

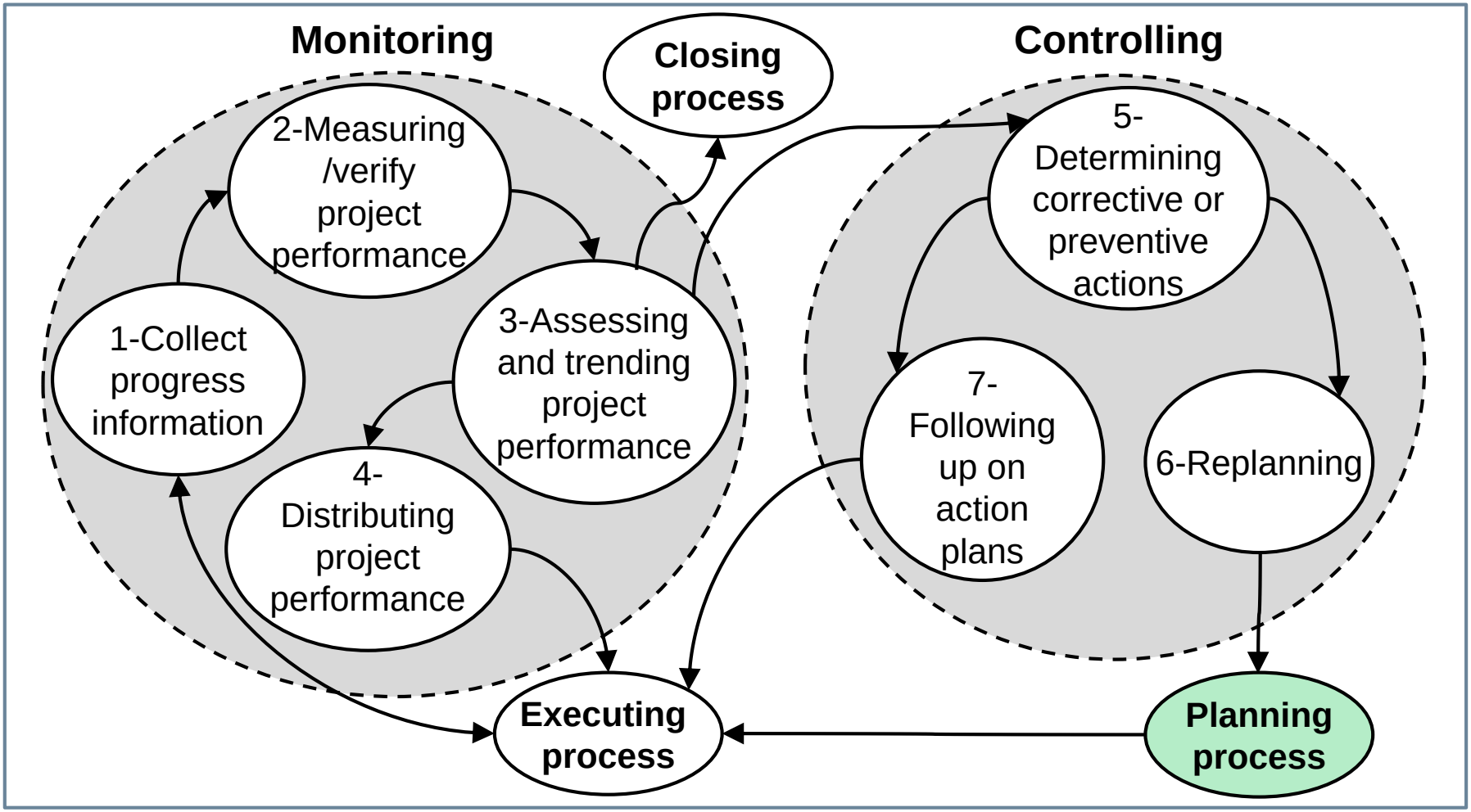



Interaction between Phases

# Introduction



**Project control sub-processes interactions** **(arrows represent data flow direction)**



# Scope control – collect prog. info.



- Scope control is one of the most challenging areas in many projects including construction projects. It is very important that all related processes to the scope control being documented and seen before start controlling the scope.
- When you are collecting scope progress information look for *objective evidence* on delivering project deliverables to the client i.e. *Client acceptance*.
- It is recommended that a documented procedure/ form is prepared and agreed on for delivering completed *project deliverables* (example).
- To accept project deliverables, usually project deliverable is supported by a set of quality inspections (determined in inspection test plan and/or quality control procedure). In this perspective project acceptance procedure/ process is a complementary procedure to the quality control procedures (example)!
- Every deliverable claimed to be completed from different parts of the project need to be measured and verified (using scope plan) and then being delivered to the client!
- For example when earth moving crew of our 10-storey building project claim completion of their excavation Job, we need to have inspection crew to verify and document completion of their job before delivering it to the client. Excavation delivery form will be supported by this inspection report!

# Scope control- scope change

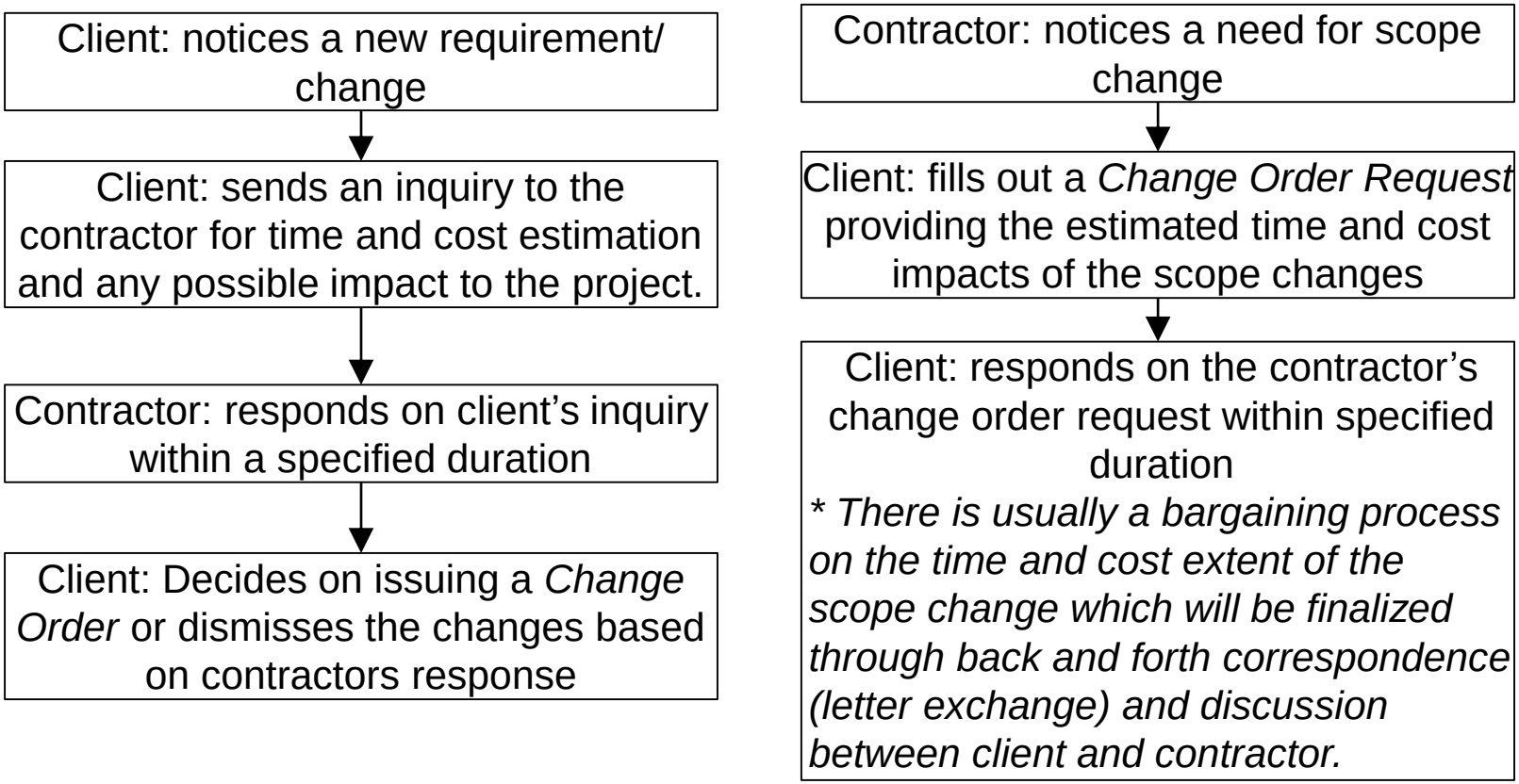


- Scope changes (also known as extra work order) are inevitable (expected) during the course of the project. Handling project *scope changes* in an efficient manner requires a well defined procedure with all related stakeholders agreed on it!
- Tracking the effects of scope changes on different aspects of project is very important which should be seen in the scope change handling procedure!
- Scope changes might appear as results of:
  - Client request: Client notices new requirements that had not seen before (e.g., a new rest area for the road, a balcony for the master bed room, a wider side-walk on the bridge, etc)
  - Contractor request: Contractor faces different conditions than what was indicated on the scope or expected (e.g., different soil condition than what is mentioned in the tunneling contract, higher inflation rate that what is seen on the contract and specially in expansion projects when specifications of the already built parts not meet the specifications provided by client, etc.)
  - Scope verification: When completion of a project is being verified, changes to the project scope might be caught (e.g., more volume of concrete poured for the foundation; area of the surface painted is larger than the area mentioned on the scope).

# Scope control- scope change



- Normally client needs to approve any changes to the scope prior to executing the changes. Unless it is pre-seen in the project's contract (e.g., in a unit-price contract an estimated scope is determined; a range of acceptable changes to the scope is indicated)!
- A typical scope change procedure can have following structure:



# Scope control- scope change



What if scope change (or extra work order) is caught after doing the job (e.g., during scope verification)?

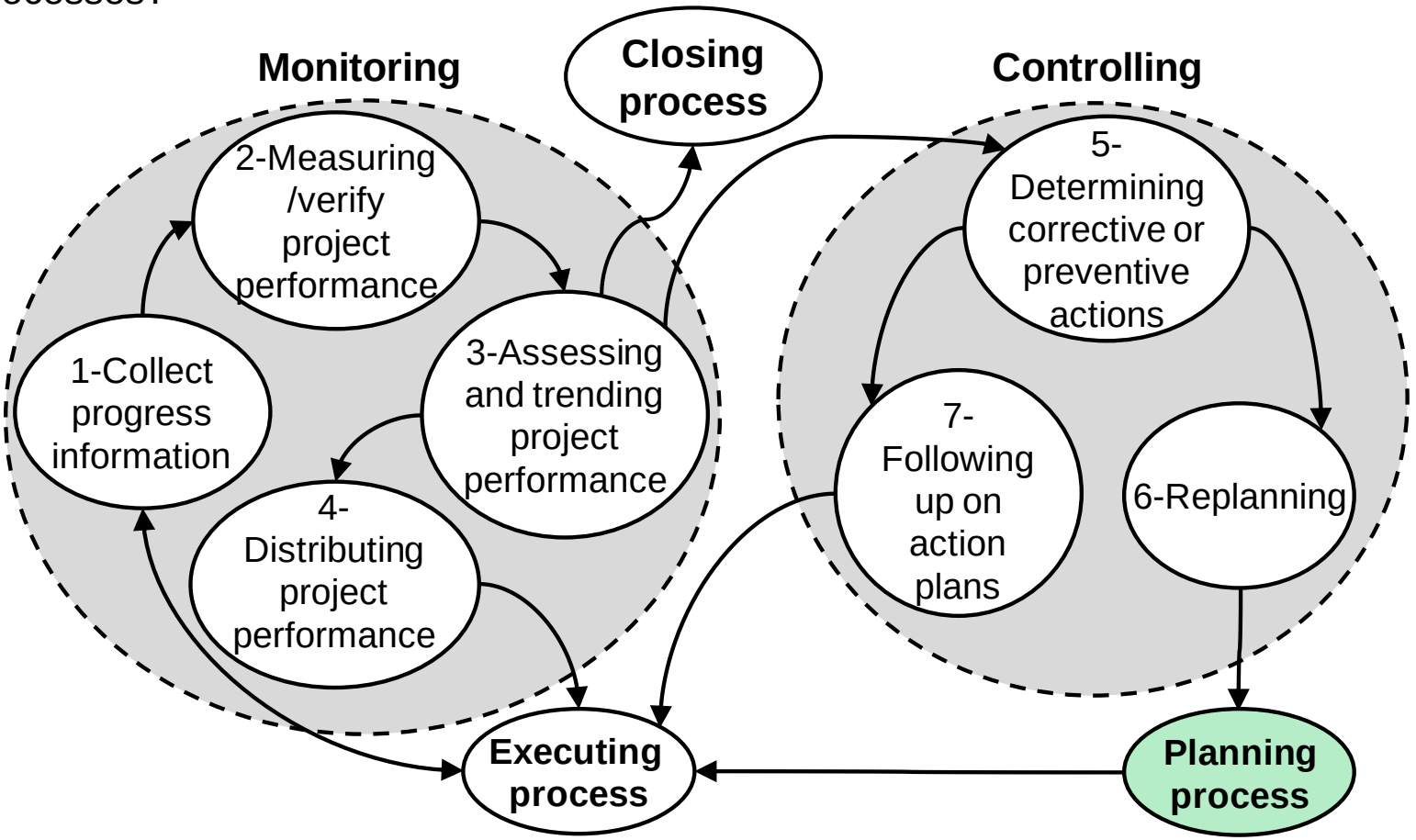
Titles “Scope change”, “Change Order”, “Change Order Request”, “Extra Work Order” and “Extra Work Order Request” are exchangeably used as the form titles for scope change control. No matter what the title of the forms are, for controlling scope changes we normally need two form types: One originated from the client (as approval) and the other one originated from contractor (as request for approval).

- Sample Scope change procedure; Change Order 1, 2; and Change Order request 1, 2.
- Although scope change is a common practice in projects (including construction projects), too much changes on the scope also can be a sign of poor project planning.
- Compared to including project requirements within the original scope, scope change is usually more expensive. So, it is quite recommended that project management team does its best to capture all project requirements within the original scope!
- Sometimes too much changes on the project scope, deforms the project from its original nature. It such cases defining a new project and project re-grouping might be the best choice.

# Scope control



How can you relate our Generic Project control sub-processes to the scope control sub-processes?



# Time/ cost control-collecting prog. info



- There are two main types of time/ cost progress information to be collected in a project:
  - Activity progress achieved
  - Actual time/ cost spent on different parts of project
- **Collecting activity progress achieved:**
  - Activity progress information include *actual start date*, *actual finish date* and *activity % progress* (or *% complete)*.
  - Activity progress in projects can be collected by:
    - Project control team members communicating different parts of projects and collect progress information on regular basis.
    - Project control sorts lists of activities related to different parts of projects within prepared formats and sends them to the project parts to collect the progress information on regular basis.
    - Project team members (or project crew supervisors) are responsible on reporting their progress to the project planning and control on regular basis.

# Time/ cost control-collecting prog. info

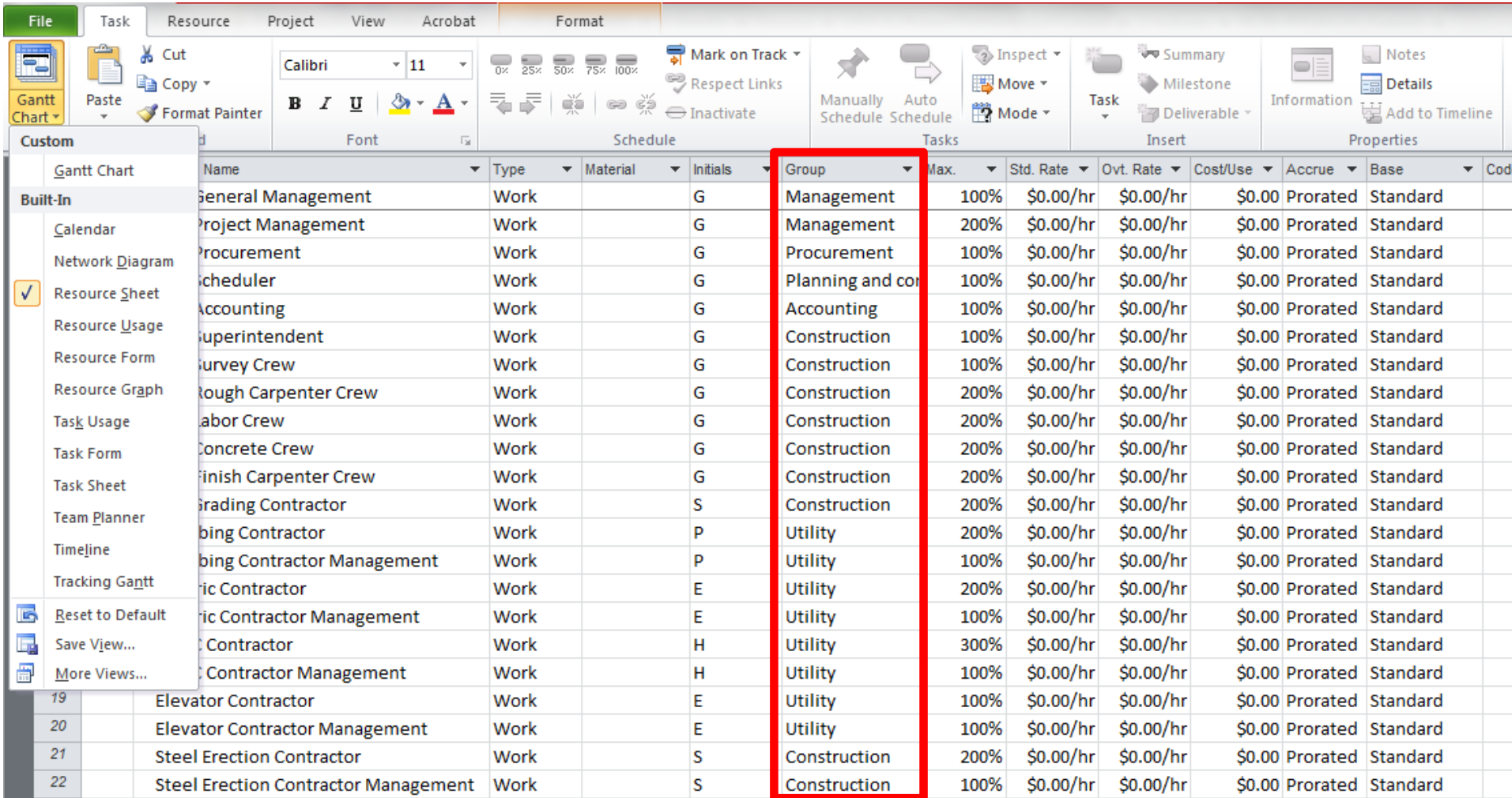


- It is common that project crew in different parts of projects (intentionally or even unintentionally) tend to inflate their work progress.
- Regardless of the type of collecting activity progress, it is very important to write down activity progress based on objective evidences:
  - Physical measurement (e.g., volume of concrete poured, length of the wall completed, area of floor finishing done, etc)
  - Supporting documents (e.g., material ordered documentations, material received documentation, permit paper, drawings prepared, meeting minutes, etc.)
  - Predetermined progress consideration format (specially for the sub-contracted / bought-out activities or project parts) (e.g., in window making and installing activities, 20% for material, 40% for producing windows and 40% for installation)
- Activity progress is collected at the *activity level* and is the base for every project performance indicator!!!

# Time/ cost control-collecting prog. info



- Using MSP: 1-Assign related organizational groups to the resources!



# Time/ cost control-collecting prog. info



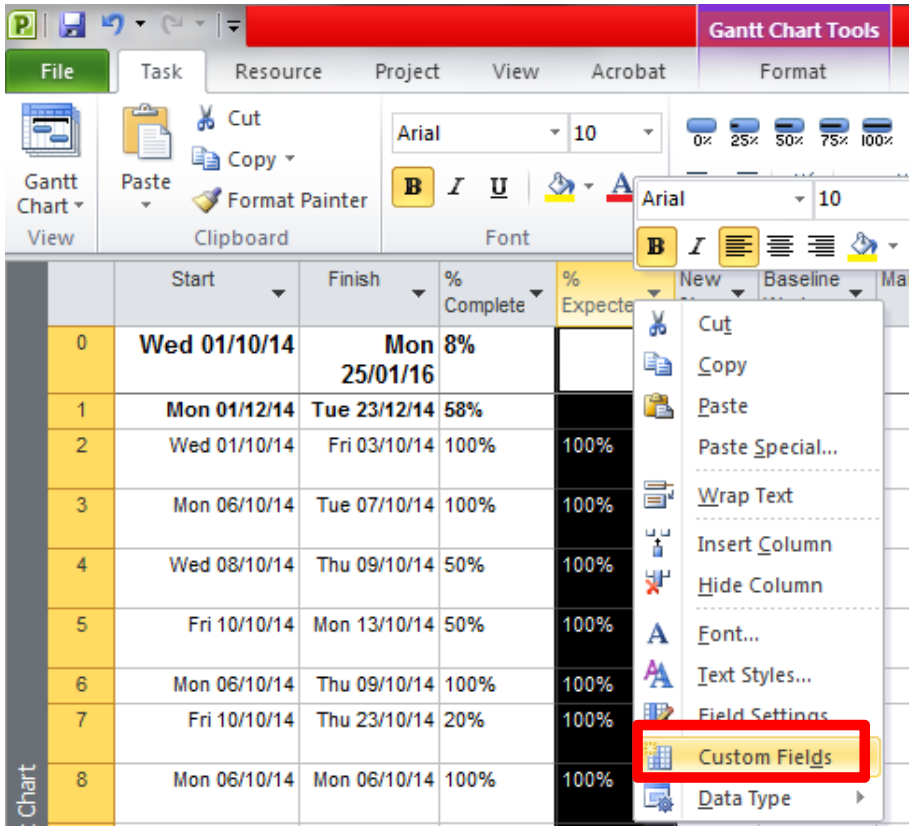
Expected *activity % progress*=

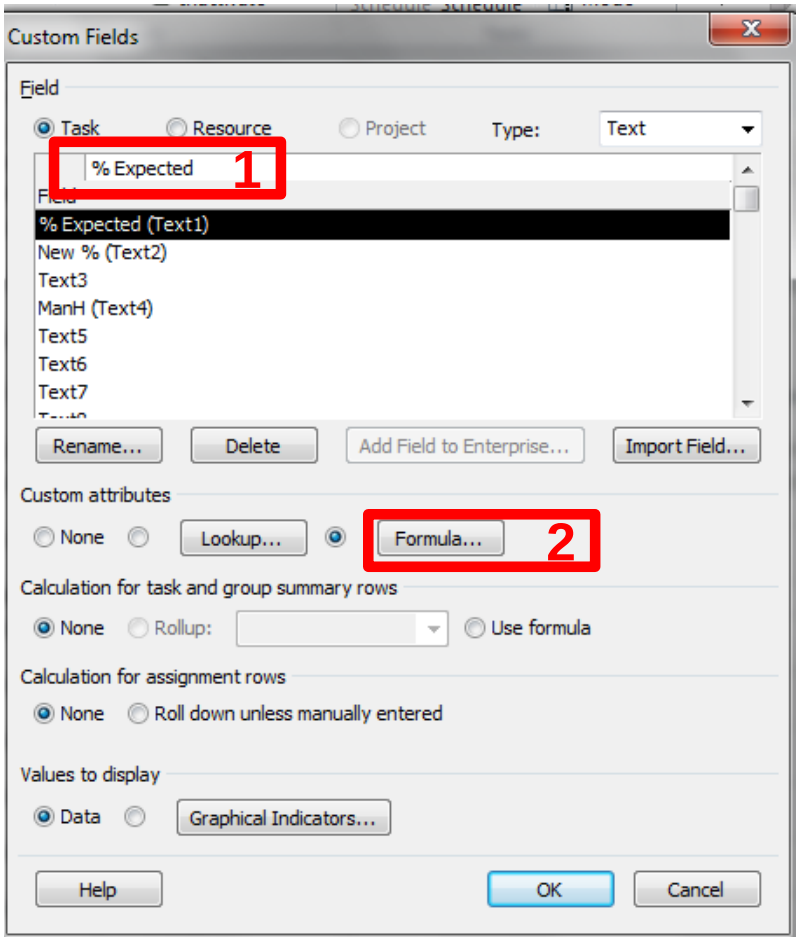
$$\begin{cases} 0\%; \text{ if } \textit{assessment date} < \textit{Start date} \\ \dfrac{\textit{Assessment date - Start date}}{\textit{Finish date - Start date}}\%; & \textit{Start date} \le \textit{assessment date} \le \textit{Finish date} \\ 100\%; \text{ if } \textit{assessment date} > \textit{Finish date} \end{cases}$$

# Time/ cost control-collecting prog. info



- Using MSP: 2- Set up required custom fields (e.g., % expected)!

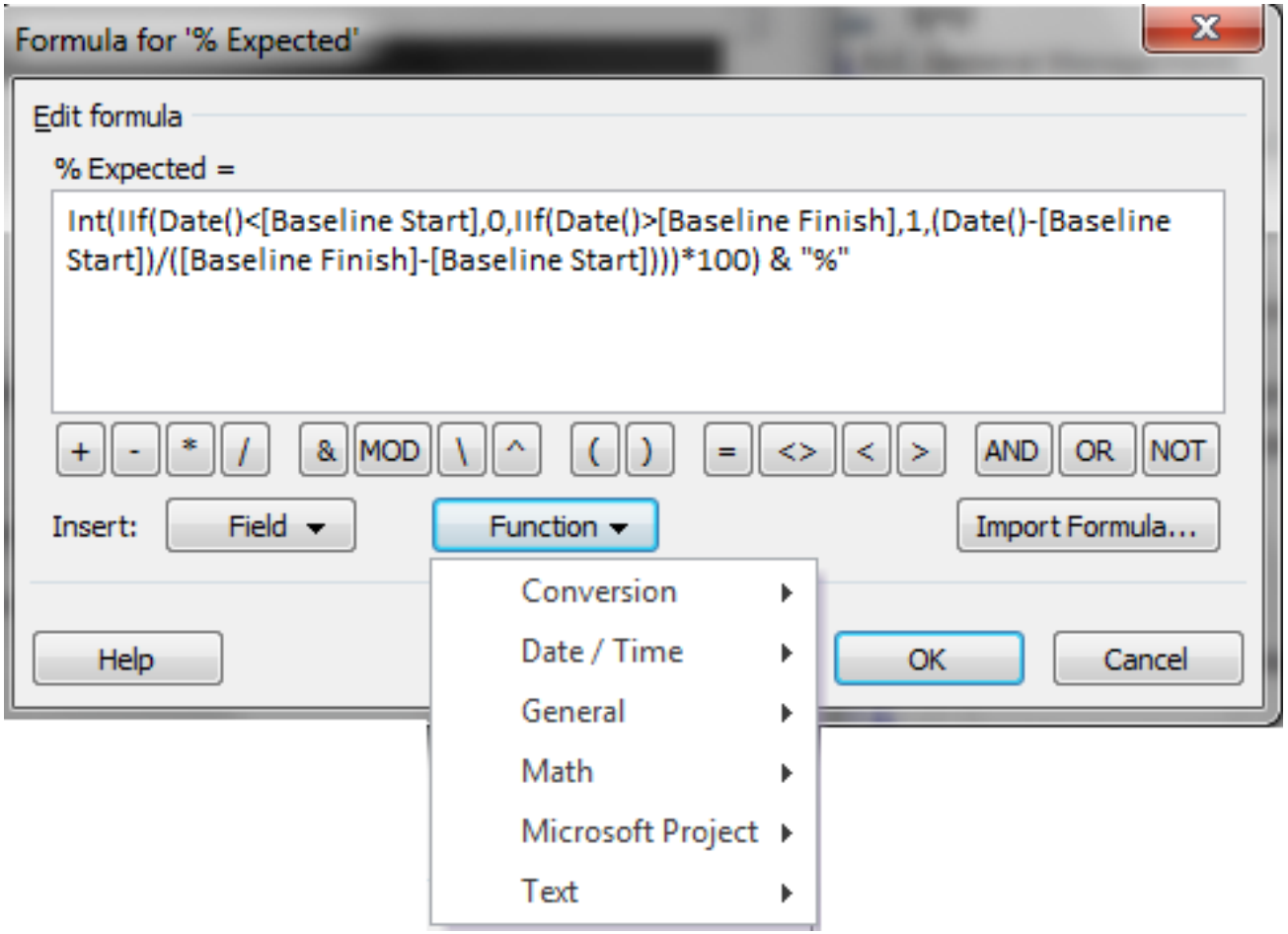


# Time/ cost control-collecting prog. info



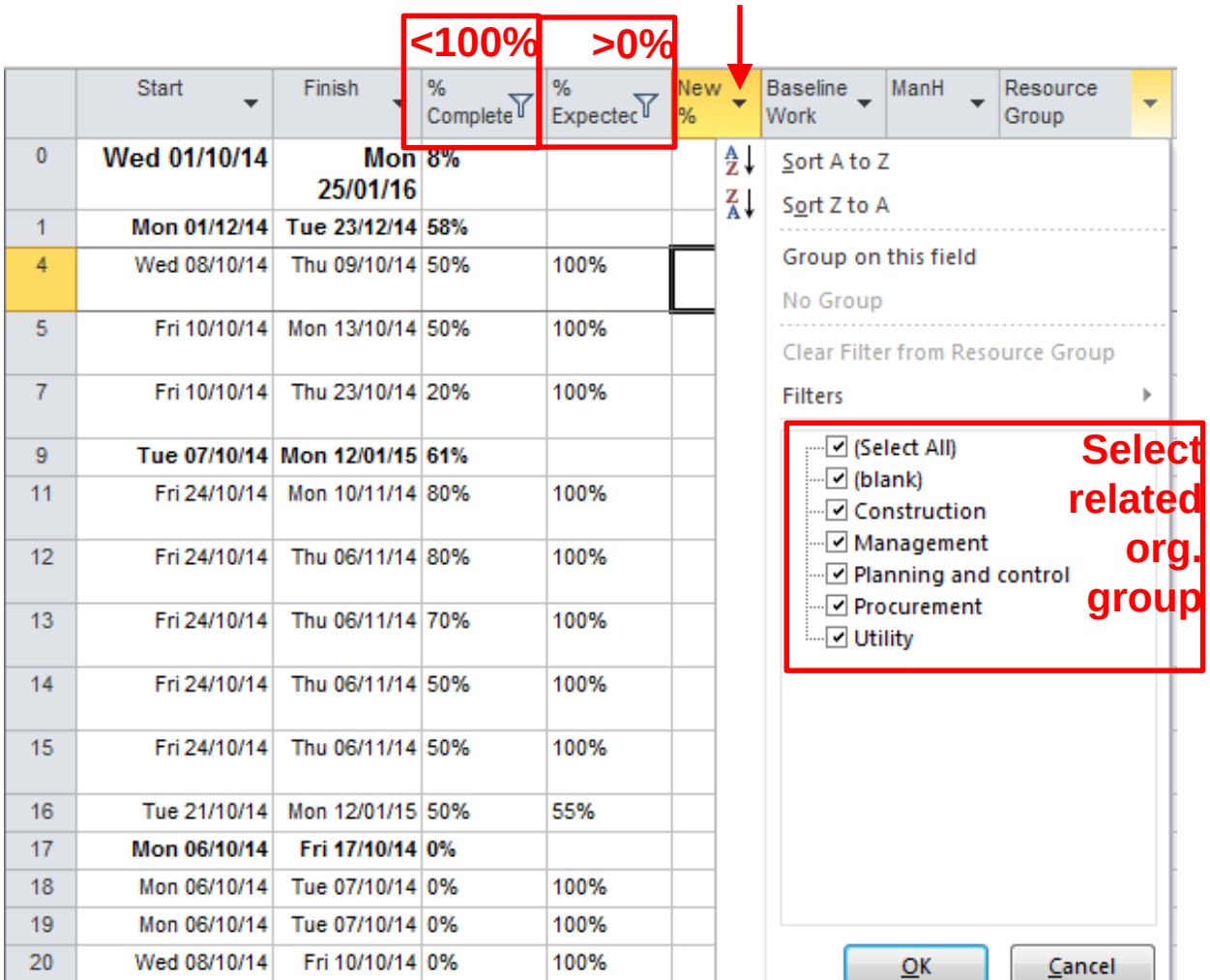
- Using MSP: 2- Set up required custom fields (e.g., % expected)!



# Time/ cost control-collecting prog. info



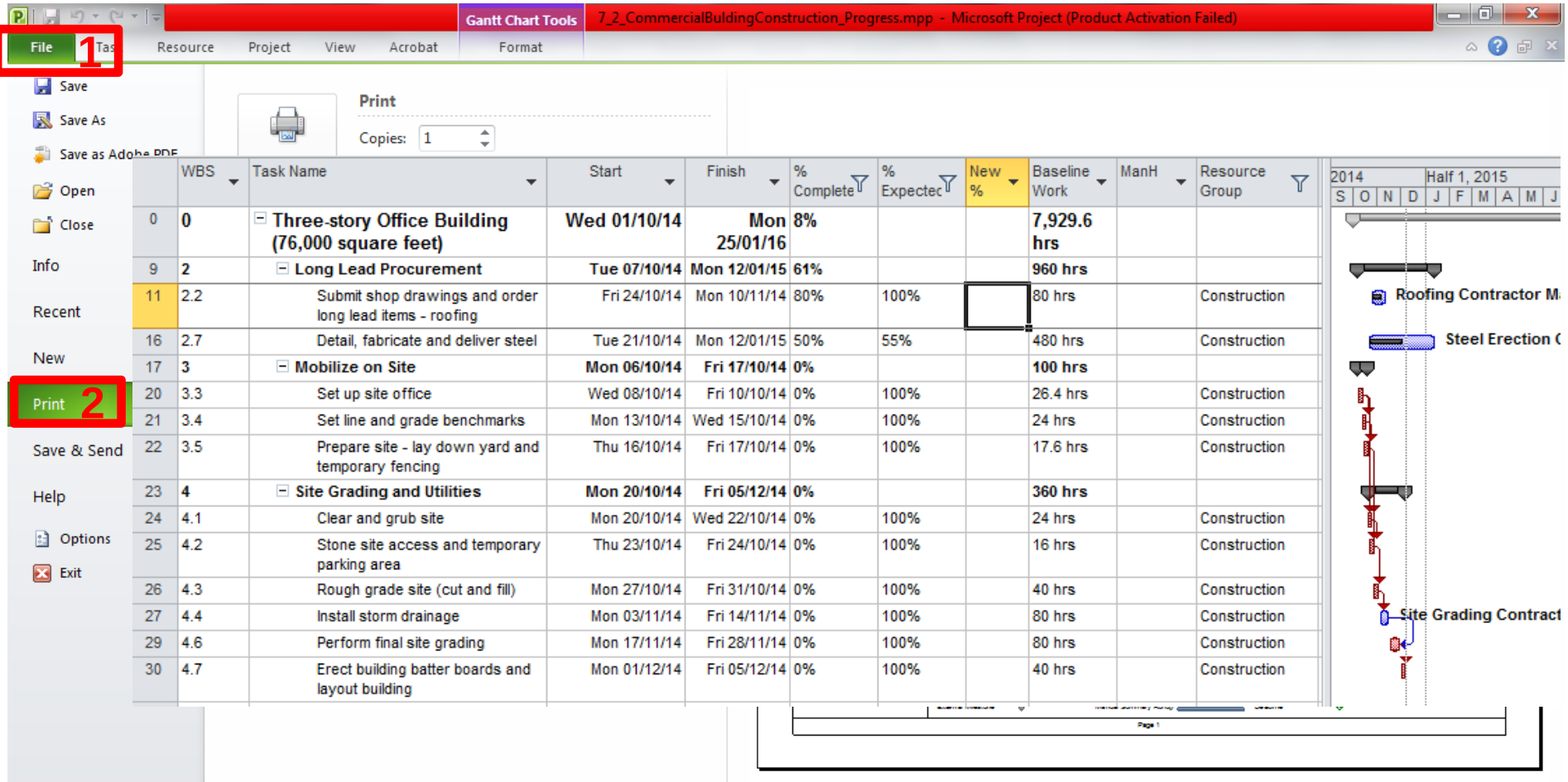
- Using MSP: 3- Filter started/ to be started tasks for each organizational group!



# Time/ cost control-collecting prog. info



- Using MSP: 4- Print data collection form for related organizational group!



# Time/ cost control-collecting prog. info



Hands on MSP!

# Time/ cost control-collecting prog. info



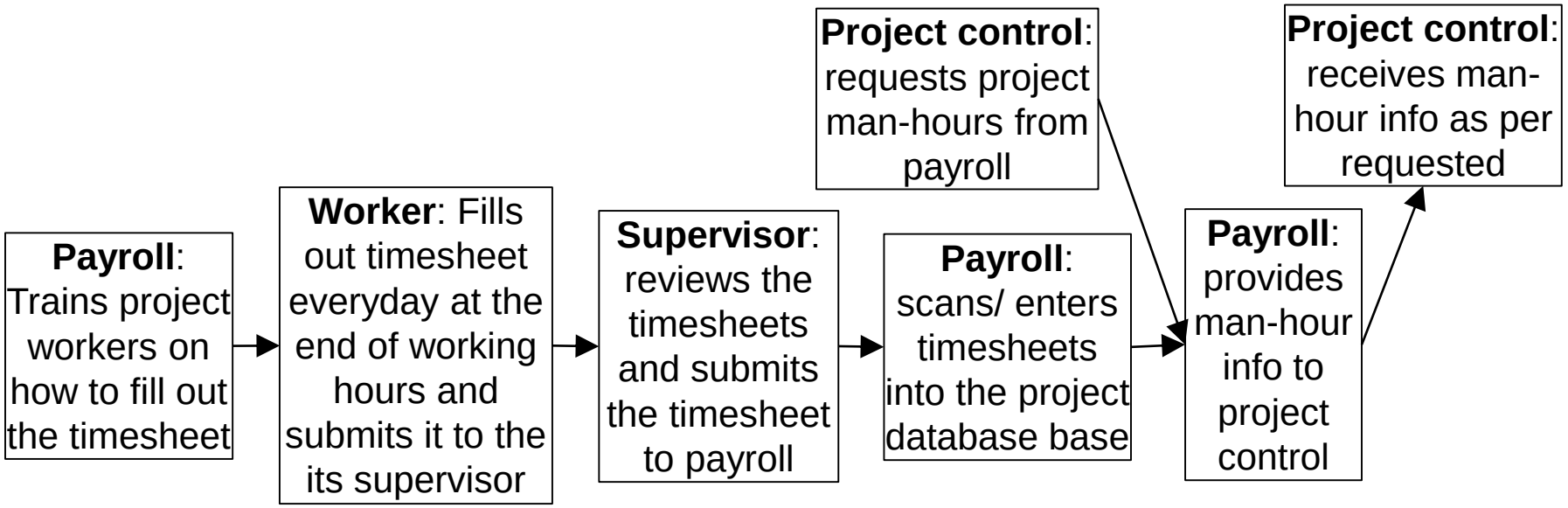
- **Collecting actual time/ cost spent on different parts of project:**
  - **Man-hours spent:**
    - To be able to collect man-hours spent on different parts of the project there should be a mechanism seen in the project to collect actual time/ cost spent on different parts of a project.
    - Time spent on different parts of project usually is captured by setting up daily timesheets for the project crew.

      Construction crew (e.g., welder, painter, mason, plumber, etc.) usually fill out paper base timesheets (via their direct supervisors); however, it is quite recommended that timesheets be in computer readable format. Office crew (engineer, drafter, purchaser, etc.) usually fill out computer base timesheets.

# Time/ cost control-collecting prog. info



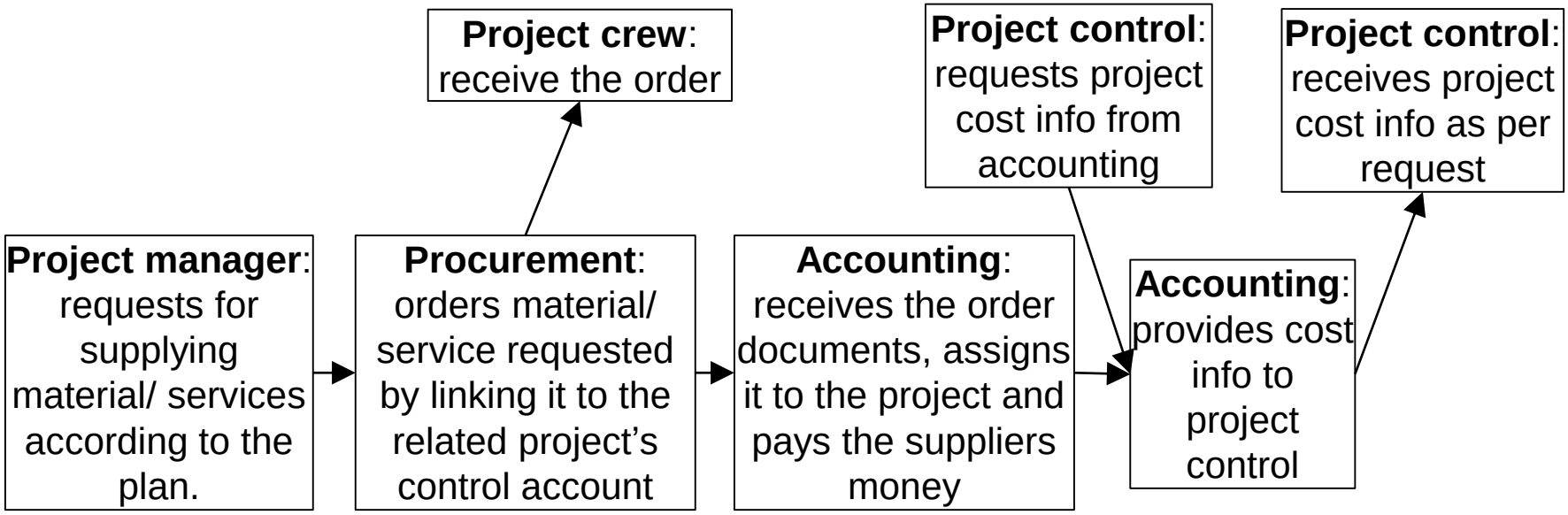
- Timesheet collects man-hour data at the level that can later on we can calculate project performance (which is usually set at the *control account* level).
- Man-hour data collected by timesheets can be used for calculating actual *time* spent on different parts of projects as well as calculating the worker's salary *cost* spent on different parts of projects.
- Work flow of project timesheet data collection can be presented as in below:



# Time/ cost control-collecting prog. info



- **Money paid to the project suppliers:**
  - During the project execution a considerable amount of project costs is spent on the project suppliers (for receiving materials and services). This workflow can be drawn as in below:



# Time/ cost control-collecting prog. info



- Use control project software (e.g., MS Project, Primavera P6) to accumulate project time/ cost progress info at the activity level.

| | WBS | Task Name | Start | Finish | % Complete | Actual Start | Actual Finish | Actual Cost |
|---|---|---|---|---|---|---|---|---|
| 0 | **0** | **Three-story Office Building (76,000 square feet)** | **Wed 01/10/14** | **Mon 25/01/16** | **8%** | **Wed 01/10/14** | **NA** | **$0.00** |
| 1 | **1** | **General Conditions** | **Mon 01/12/14** | **Tue 23/12/14** | **58%** | **Wed 01/10/14** | **NA** | **$0.00** |
| 2 | 1.1 | Receive notice to proceed and sign contract | Wed 01/10/14 | Fri 03/10/14 | 100% | Wed 01/10/14 | Fri 03/10/14 | $0.00 |
| 3 | 1.2 | Submit bond and insurance documents | Mon 06/10/14 | Tue 07/10/14 | 100% | Mon 06/10/14 | Tue 07/10/14 | $0.00 |
| 4 | 1.3 | Prepare and submit project schedule | Wed 08/10/14 | Thu 09/10/14 | 50% | Wed 08/10/14 | NA | $0.00 |
| 5 | 1.4 | Prepare and submit schedule of values | Fri 10/10/14 | Mon 13/10/14 | 50% | Fri 10/10/14 | NA | $0.00 |
| 6 | 1.5 | Obtain building permits | Mon 06/10/14 | Thu 09/10/14 | 100% | Mon 06/10/14 | Thu 09/10/14 | $0.00 |
| 7 | 1.6 | Submit preliminary shop drawings | Fri 10/10/14 | Thu 23/10/14 | 20% | Fri 10/10/14 | NA | $0.00 |
| 8 | 1.7 | Submit monthly requests for payment | Mon 06/10/14 | Mon 06/10/14 | 100% | Mon 06/10/14 | Mon 06/10/14 | $0.00 |
| 9 | **2** | **Long Lead Procurement** | **Tue 07/10/14** | **Mon 12/01/15** | **61%** | **Tue 07/10/14** | **NA** | **$0.00** |
| 10 | 2.1 | Submit shop drawings and order long lead items - steel | Tue 07/10/14 | Mon 20/10/14 | 100% | Tue 07/10/14 | Mon 20/10/14 | $0.00 |

# Time/ cost control-collecting prog. info

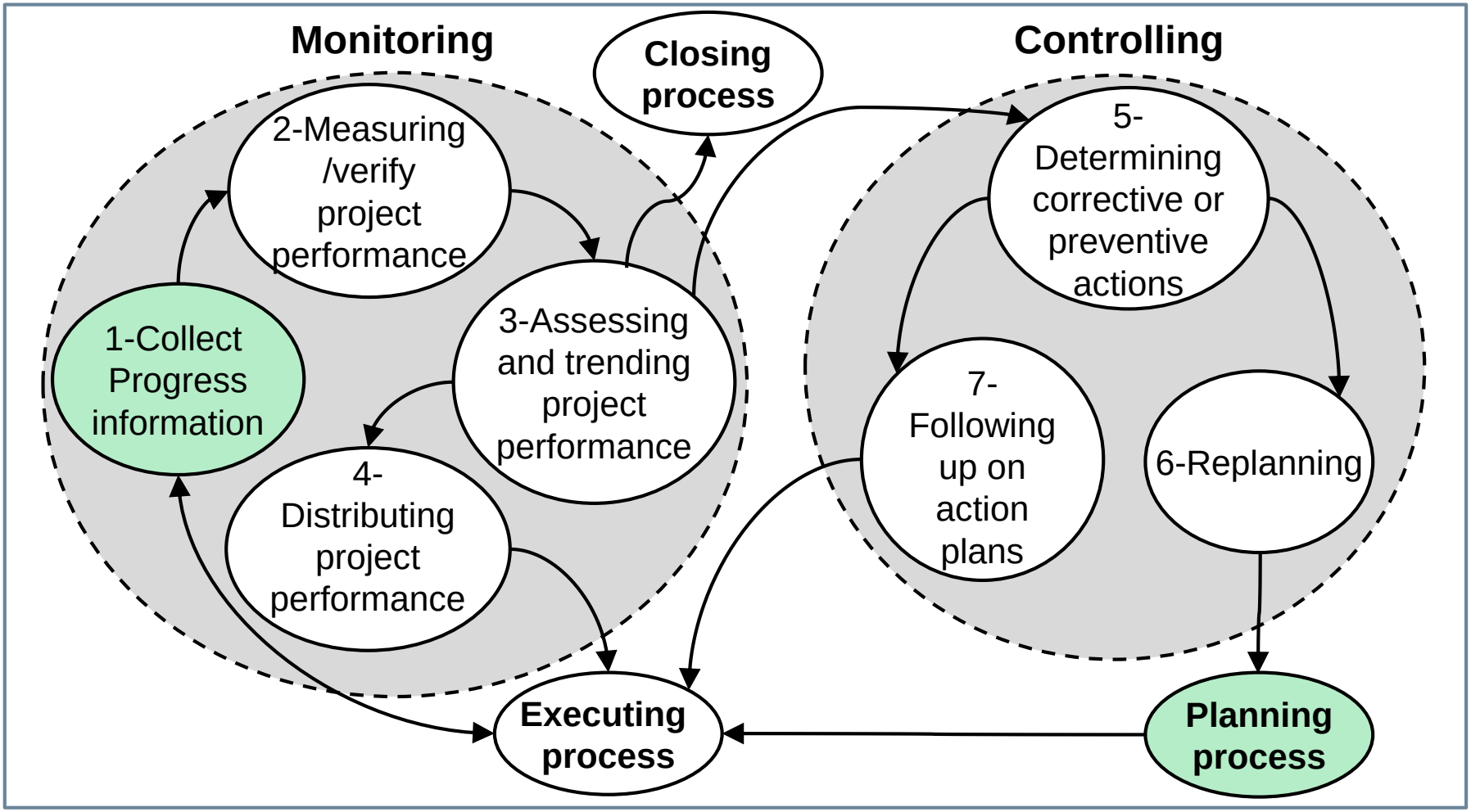


- Ideally it is preferred that you (as a project control) maintain two separate project control files for time control and cost control. **Why?** 
- However, in practice usually it is very difficult to maintain two separate time and cost control files one based on WBS and the other one based on CBS!
- You need to base your progress on objective/ documented evidence. In project you need to support your WBS/ CBS with binders of progress evidence documents.
- It is very important to have binders organized and progress evidence is traceable! One organizing method can be binders organized base on CBS structure!

# Time/ cost control-collecting prog. info



**Project control sub-processes interactions** **(arrows represent data flow direction)**



# In class practice 1



**What is project progress and what are ways of collecting project progress information?**

# Time/ cost control-measuring performance



**Question:** What does the project performance mean and how can we measure the project performance?

# Time/ cost control-measuring performance



**Question:** What does the project performance mean and how can we measure the project performance?

- Project performance is the evaluation of project standing. Project performance indicates how satisfactory or unsatisfactory project is run.
- To be able to evaluate project standing and determine its performance we compare the project progress outcomes with the project *baselines* prepared at the planning step.
- To simplify analysis of project performance, project *performance indicators* (PIs) are used for measuring project performance. These performance indicators (PIs) are calculated by measuring different aspects of projects and usually give us values that can easily be interpreted and represent project standing in different areas/ views.

**Question:** According to the planning steps we discussed in the course what kinds of project performance indicators do you expect during the control process?

# Time/ cost control-measuring performance



- Performance indicators (PIs) can be defined in almost all project knowledge areas. However, use of PIs in some areas are more highlighted than the others. Among four areas we discussed (integration, scope, time and cost) use of PIs in time and cost control are more common than the other two.
- Some main project PIs commonly used come as follows:
  - **Project % progress:**

    Project % progress is one of the most used PIs in the project control. There are two types of project % progresses to be calculated and compared to each other in the project; *actual % progress* and *scheduled % progress*.
    - **Actual project % progress:** is calculated by aggregating all activity % complete (collected from the project crew) to the project level. Example:

| | WB | Task Name | Baseline Start | Baseline Finish | % Complete |
|---|---|---|---|---|---|
| 1 | | **Prepare foundation form-work** | Sat 06/04/13 | Sat 20/04/13 | **61%** |
| 2 | 3.1.1 | Extract foundation sizes from drawin | Sat 06/04/13 | Sat 06/04/13 | 100% |
| 3 | 3.1.2 | Order form sheets required | Sun 07/04/13 | Sun 07/04/13 | 100% |
| 4 | 3.1.3 | Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | 100% |
| 5 | 3.1.4 | Size the form-sheets | Wed 10/04/13 | Sat 13/04/13 | 49% |
| 6 | 3.1.5 | Install form-sheets in place | Mon 15/04/13 | Sat 20/04/13 | 9% |

# Time/ cost control-measuring performance



- **Actual project % progress (cont'd):**

For aggregating activity % complete to a higher WBS level, we need to consider the weight or importance of activities. For example MS project relates weight of activities to their duration or man-hours required for activities. Example:

**% Complete** calculated in proportion to the activity duration

**% Complete** calculated in proportion to the activity work (MH)

| Task Name | Start | Finish | Duration | % Complete | Work | % Work Complete |
|---|---|---|---|---|---|---|
| **Prepare foundation form-work** | **Sat 06/04/13** | **Mon 15/04/13** | **7 days** | **61%** | **72 hrs** | **48%** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | 1 day | 100% | 8 hrs | 100% |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | 1 day | 100% | 8 hrs | 100% |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | 1 day | 100% | 8 hrs | 100% |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | 1 day | 49% | 16 hrs | 49% |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | 2 days | 9% | 32 hrs | 9% |

As it is presented in the example above, adopting different methods of activity weighting will result in different % progresses calculated for the project. Before start controlling the project you need to set your weighting method.

# Time/ cost control-measuring performance



- **Scheduled project % progress**

Scheduled or planned project progress determines the project progress according the project time baseline at the specific *assessment date* (usually current or actual date).

For calculating scheduled progress we need first to calculate scheduled progress of every activity in the project. Activity progress can be calculated by using following conditional formula:

$$\text{Scheduled } \textit{activity \% progress} = \begin{cases} 0\%; \text{ if } \textit{assessment date} < \textit{Start date} \\ \dfrac{\textit{Assessment date - Start date}}{\textit{Finish date - Start date}}\%; \textit{Start date} \le \textit{assessment date} \le \textit{Finish date} \\ 100\%; \text{ if } \textit{assessment date} > \textit{Finish date} \end{cases}$$

For calculating project scheduled % progress from scheduled activity % progress, similar method to actual project % progress is taken.

Calculation of *project scheduled % progress* might be included or not included in scheduling programs; however, in either case we can easily insert the calculation formula in the program or use Excel sheets for this purpose.

# Time/ cost control-measuring performance



- **Scheduled project % progress (cont'd)**

  **Example**: Scheduled progress for our "Prepare foundation formwork " project at the assessment date of Apr 12, 2013 will be:

| Task Name | Baseline Start | Baseline Finish | Baseline Work | Scheduled Progress (Apr 12, 2013) |
|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | **72 hrs** | **56%** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | 8 hrs | **100%** |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | 8 hrs | **100%** |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | 8 hrs | **100%** |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | 16 hrs | **100%** |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | 32 hrs | **0%** |

It is very important to use similar activity weighting method for both *actual* and *scheduled* project % progress calculation. Since we are going to compare them to each other!

# Time/ cost control-measuring performance



- **Comparing actual and scheduled project % progress**

  By comparing Actual and Scheduled Project % Progress we can determine whether our project is ahead or behind the schedule:

  actual progress<scheduled progress => project is behind the schedule

  actual progress=scheduled progress => project is on schedule

  actual progress>scheduled progress => project is ahead of schedule

Actual and scheduled % progress can be calculated not only for entire project but also for different parts of the project (e.g., phases and work packages) with following the same approach as we did for the project progress. In this case we can see how much ahead or behind the progress is at different parts of the project and focus on the parts which require more attention.

# Time/ cost control-measuring performance



- **Earned Value Management (EVM)**

  EVM emerged (started) as a project performance analysis tool in United States Government programs in the 1960s and it has since become an essential part of every project tracking.

  EVM originated from this concern that the amount of money and time we have spent on the project does not mean that we have earned that much money and time in the project.

  - **EVM basic elements**

    There are 3 basic elements in the EVM:

    **Planned Value (PV):** This is also referred to as Budgeted Cost of Work Scheduled (BCWS). Planned Value (PV) or BCWS is the total cost of the work scheduled /Planned in the baseline as of a reporting date.

    **Example 1:** The PV in the following project as of Sun Apr 12, 2013 is:

# Time/ cost control-measuring performance



**Example 1 (cont'd):**

| Task Name | Baseline Start | Baseline Finish | Baseline Cost | Baseline Work |
|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | $1,440 | **72 hrs** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | $160 | 8 hrs |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | $480 | 8 hrs |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 | 8 hrs |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | $240 | 16 hrs |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | $480 | 32 hrs |

PV of the project as of Apr 12, 2013 will be:

# Time/ cost control-measuring performance



**Example 1 (cont'd):**

| Task Name | Baseline Start | Baseline Finish | Baseline Cost | Baseline Work |
|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | $1,440 | **72 hrs** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | $160 | 8 hrs |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | $480 | 8 hrs |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 | 8 hrs |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | $240 | 16 hrs |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | $480 | 32 hrs |

PV of the project as of Apr 12, 2013 will be:

| Task Name | Baseline Start | Baseline Finish | Baseline Cost | Baseline Work | Scheduled Progress (Apr 12, 2013) | PV |
|---|---|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | $1,440 | **72 hrs** | **56%** | **$960** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | $160 | 8 hrs | **100%** | **$160** |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | $480 | 8 hrs | **100%** | **$480** |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 | 8 hrs | **100%** | **$80** |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | $240 | 16 hrs | **100%** | **$240** |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | $480 | 32 hrs | **0%** | **0** |

$$PV \text{ (or BCWS)} = \sum \text{Scheduled Progress}_i * \text{Budgeted Cost}_i$$

# Time/ cost control-measuring performance



- **EVM basic elements (cont'd)**

**Actual Cost (AC):** Actual cost (AC) or actual cost of work performed (ACWP) comes directly from project information collected.

**Earned Value (EV):** EV is also referred to as Budgeted Cost of actual Work Performed (BCWP). EV or BCWP is the total cost of the work completed/performed as of a reporting date.

**Example:** The EV in the following project as of Sun Apr 12, 2013 is:

| Task Name | Baseline Start | Baseline Finish | Baseline Cost | Baseline Work | Scheduled Progress (Apr 12, 2013) | PV | Actual Progress (Apr 12, 2013) | EV |
|---|---|---|---|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | $1,440 | **72 hrs** | **56%** | $960 | **58%** | **$992** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | $160 | 8 hrs | 100% | $160 | 100% | $160 |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | $480 | 8 hrs | 100% | $480 | 100% | $480 |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 | 8 hrs | 100% | $80 | 80% | $64 |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | $240 | 16 hrs | 100% | $240 | 60% | $144 |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | $480 | 32 hrs | 0% | 0 | 30% | $144 |

$$EV \text{ (or } BCWP) = \sum \text{Actual Progress}_i * \text{Budgeted Cost}_i$$

# Time/ cost control-measuring performance



- **EVM performance indicators**

  **Schedule performance index (SPI):** SPI is an index comparing the value of the work is performed (EV) with the amount of work which should have been done according to the schedule (PV). SPI shows the efficiency of the time utilized on the project. SPI can be calculated using the following formula:

  SPI = Earned Value (EV) /Planned Value (PV)

  **Example**: SPI at the previous example with EV of 992$ and PV of 960$ is calculated:

  SPI = 992 / 960 = 1.03

SPI value above 1 indicates the amount of work performed in the project is ahead of schedule and project team is more efficient than the baseline in utilizing the time allocated to the project.

SPI value below 1 indicates the amount of work performed in the project is behind the schedule and project team is less efficient in utilizing the time allocated to the project.

**Question**: What does SPI=1 mean?????

# Time/ cost control-measuring performance



**Cost performance index (CPI):** CPI is an index comparing the value of the work is performed (EV) with the actual cost spent (AC). CPI shows the efficiency of the utilization of the resources (or money) on the project. cost performance index can be calculated using the following formula:

CPI = Earned Value (EV) /Actual Cost (AC)

**Example**: CPI at the following project with EV of 992$ and AC of 1070$ is calculated:

CPI = 992 / 1070 = 0.927

| Task Name | Baseline Start | Baseline Finish | Baseline Cost | Baseline Work | Actual Progress (Apr 12, 2013) | EV | Ac |
|---|---|---|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | $1,440 | **72 hrs** | **58%** | **$992** | **$1,070** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | $160 | 8 hrs | 100% | $160 | $200 |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | $480 | 8 hrs | 100% | $480 | $450 |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 | 8 hrs | 80% | $64 | $70 |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | $240 | 16 hrs | 60% | $144 | $200 |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | $480 | 32 hrs | 30% | $144 | $150 |

CPI value above 1 indicates project is run under cost budget and project team is more efficient than the baseline in utilizing the resources to the project.

CPI value below 1 indicates project has cost overrun and project team is less efficient than the baseline in utilizing the resources to the project.

# Time/ cost control-measuring performance



CPI and SPI can be calculated for different project parts (e.g., phase, work package or even activity) by following the similar method as project CPI and SPI calculation. In this case we can see how efficient different project parts are managed (regarding the time and cost perspective) so that we can focus on the parts which require more attention.

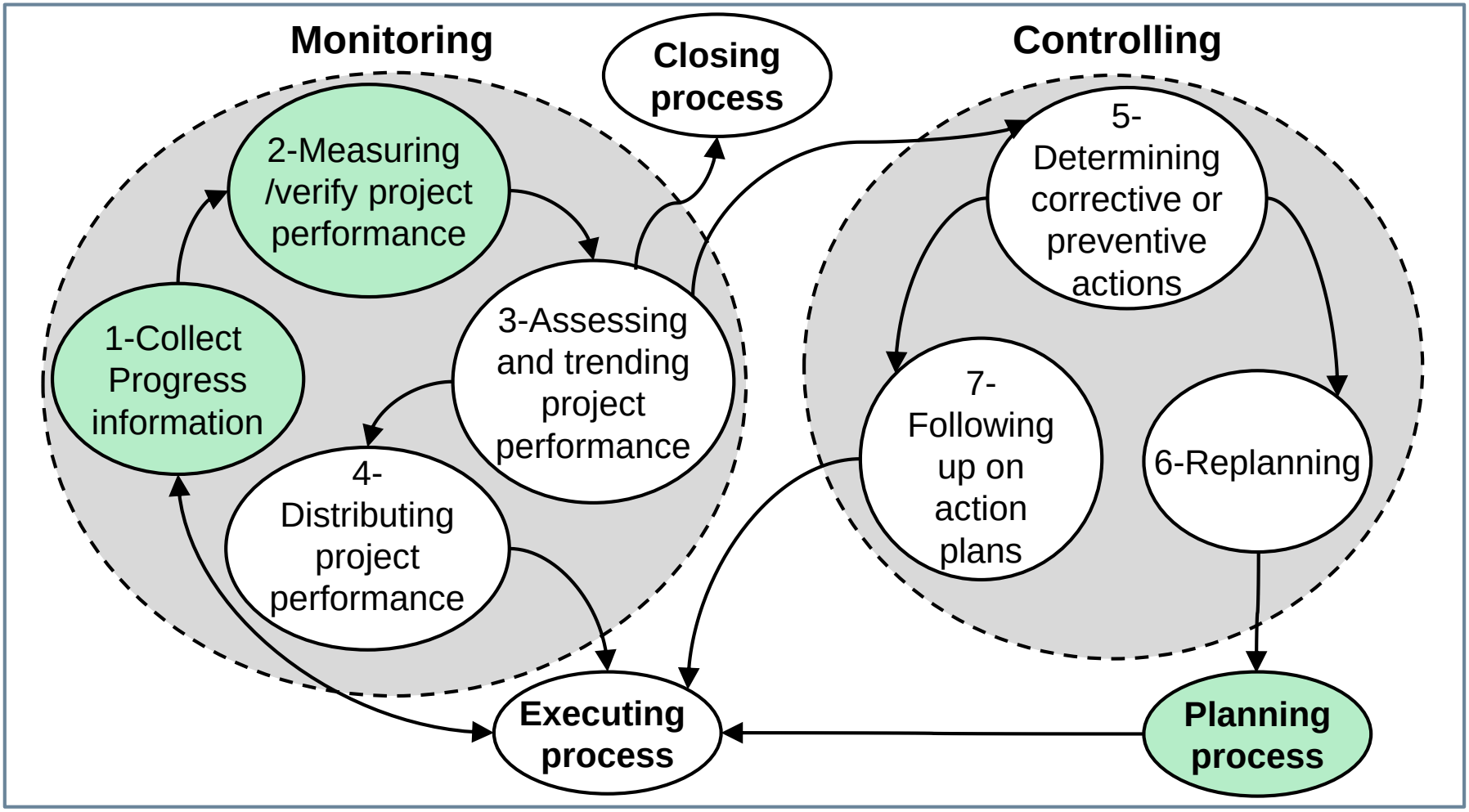
Performance indicator for different parts of the project on April 12, 2013

| Task Name | Baseline Start | Baseline Finish | Baseline Cost | Baseline Work | Scheduled Progress | Actual Progress | PV | EV | Ac | SPI (EV/PV) | CPI (EV/AC) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Prepare foundation form-work** | Sat 06/04/13 | Tue 16/04/13 | $1,440 | **72 hrs** | **56%** | **58%** | $960 | **$992** | **$1,070** | **1.03** | **0.93** |
| Extract foundation sizes from drawings | Sat 06/04/13 | Sat 06/04/13 | $160 | 8 hrs | 100% | 100% | $160 | $160 | $200 | 1.00 | 0.80 |
| Order form sheets required | Sun 07/04/13 | Mon 08/04/13 | $480 | 8 hrs | 100% | 100% | $480 | $480 | $450 | 1.00 | 1.07 |
| Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 | 8 hrs | 100% | 80% | $80 | $64 | $70 | 0.80 | 0.91 |
| Size the form-sheets | Wed 10/04/13 | Wed 10/04/13 | $240 | 16 hrs | 100% | 60% | $240 | $144 | $200 | 0.60 | 0.72 |
| Install form-sheets in place | Sat 13/04/13 | Mon 15/04/13 | $480 | 32 hrs | 0% | 30% | $0 | $144 | $150 | NA | 0.96 |

# Time/ cost control-measuring performance



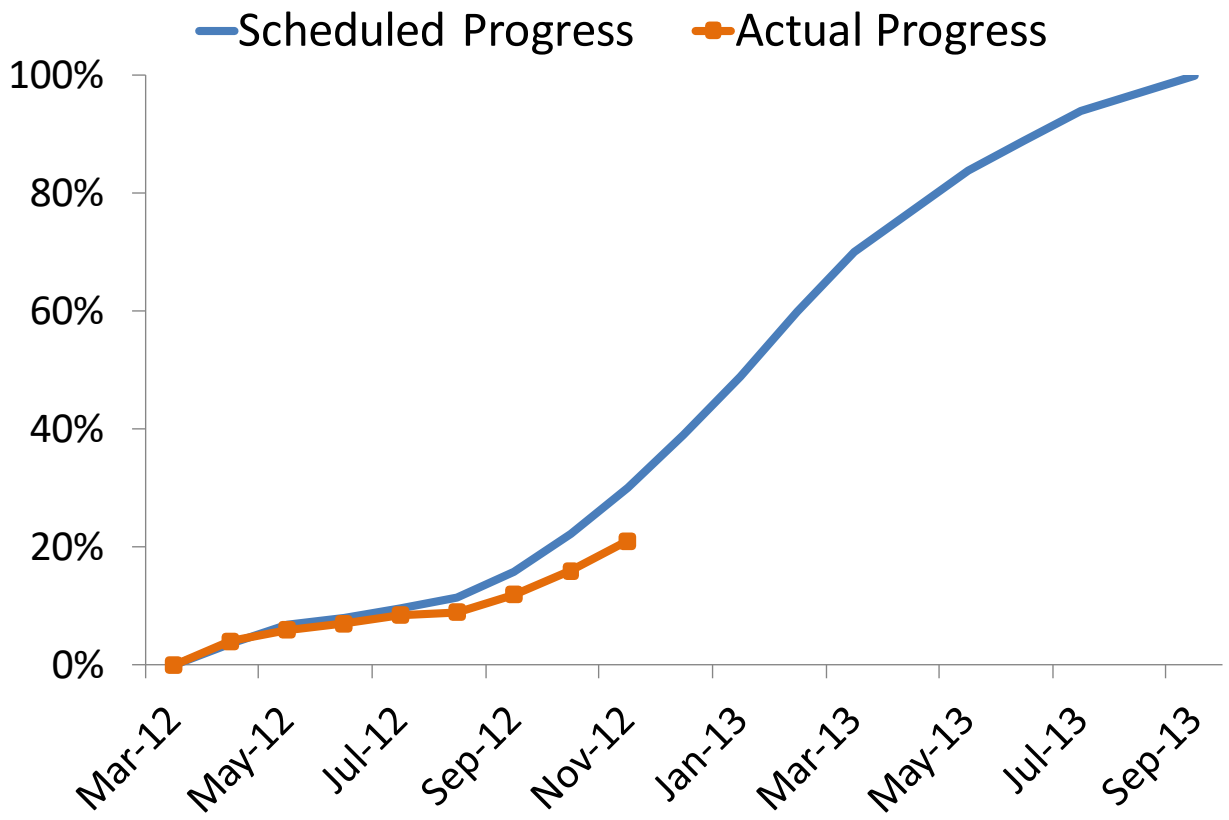
**Project control sub-processes interactions** **(arrows represent data flow direction)**



# Time/ cost control-assessing performance



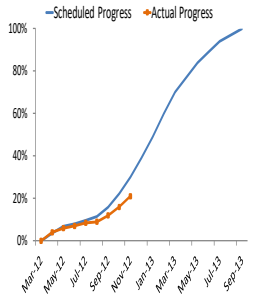
- % Progress trending
  - Cumulative project % progress trending and presenting it on the curve is one of the most prevalent project performance trending.



# Time/ cost control-assessing performance



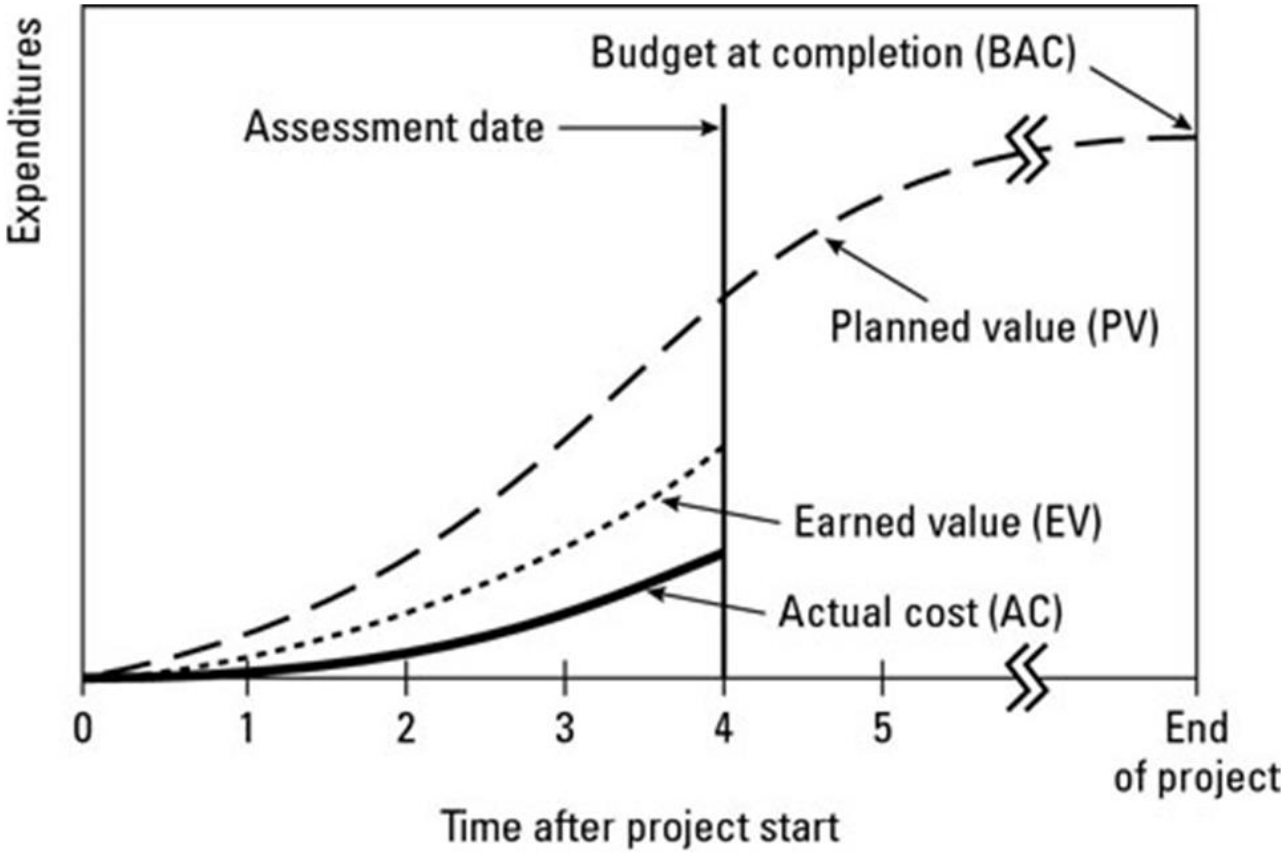
- % Progress trending (cont'd)
  - Trend of *scheduled % progress* can be calculated as soon as schedule baseline is finalized by calculating scheduled activity % progresses and scheduled project % progress on different assessment dates ranged from project start date to the project finish date.
  - Some project scheduling programs have this curve as an output; this curve can also be drawn by using spreadsheets (e.g., Excel sheets)
  - Trend of *actual % progress* is formed as project goes on and historical project % progress are collected.
  - Because of its usual shape structure, the cumulative % progress curve is also called *S-Curve*!!!!



# Time/ cost control-assessing performance



- EVM basic elements trending and assessment
  - Trend of *Planned Value (PV)* can be calculated as soon as schedule baseline is finalized by ranging assessment dates from the project start date to the project finish date.
  - Trends of *Earned Value (EV)* and *Actual Cost (AC)* are formed as project goes on and historical EV and AC are calculated and maintained.



# Time/ cost control-assessing performance



- EVM basic elements trending and assessment (cont'd)
  - Schedule variance (SV): The difference between the amount of budgeted cost of actual work performed (EV) and budgeted cost of work scheduled to be done (PV). The SV shows whether and by how much (in $) your work is ahead of or behind your approved schedule.

    SV = EV – PV

    SV>0 => project is ahead of schedule ;  SV<0 => project is behind the schedule
  - Cost variance (CV): The difference between the amount of budgeted cost of work performed (EV) and the amount of actual cost of the work performed (AC). The CV shows whether and by how much you're under or over your approved budget.

    CV = EV – AC

    CV>0 =>  Project is run under cost budget ;  CV<0 => Project is run over cost budget
  - Earned schedule duration (ES): is the project duration in which the value of the trend of planned values (PV trend) becomes equal to the earned value (EV) at the assessment date (usually current date)

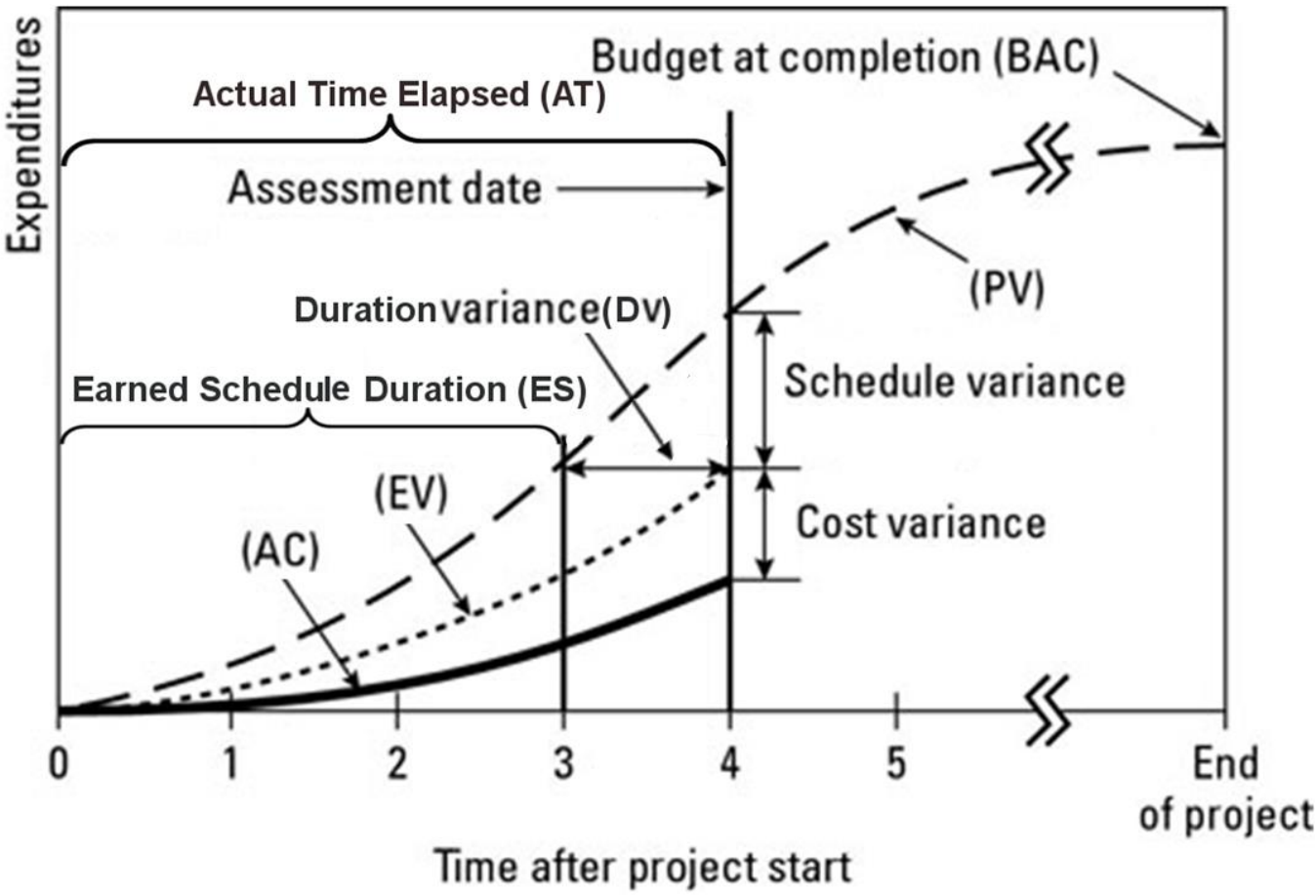
# Time/ cost control-assessing performance



- EVM basic elements trending and assessment (cont'd)
  - Duration variance (DV): is calculated as the different between earned schedule duration (ES) and the actual time elapsed (AT) at the assessment date.

    DV = ES – AT

    DV determines the amount of time periods project is ahead (if DV>0) or behind (if DV<0) the schedule.



# Time/ cost control-assessing performance



- EVM basic elements trending and assessment (cont'd)
  - **Example**: Baseline information of the prepare form-work project is as in below:

| WBS | Task Name | Baseline Start | Baseline Finish | Baseline Cost |
|---|---|---|---|---|
| 1 | **Prepare foundation form-work** | **06/04/2013** | **20/04/2013** | **$1,440** |
| 1.1 | Extract foundation sizes from drawings | 06/04/2013 | Sat 06/04/13 | $160 |
| 1.2 | Order form sheets required | 07/04/2013 | Sun 07/04/13 | $480 |
| 1.3 | Hire two form-workers for the job | Sat 06/04/13 | Sat 06/04/13 | $80 |
| 1.4 | Size the form-sheets | Wed 10/04/13 | Sat 13/04/13 | $240 |
| 1.5 | Install form-sheets in place | Mon 15/04/13 | Sat 20/04/13 | $480 |

The trend of weekly PV (planned value) for the project can be calculated as:

| | At the end of week 1 on Apr 12 | | At the end of week 2 on Apr 19 | | At the end of week 3 on Apr 26 | |
|---|---|---|---|---|---|---|
| WBS | Scheduled Progress | PV | Scheduled Progress | PV | Scheduled Progress | PV |
| 1 | | **$900** | | **$1,360** | | **$1,440** |
| 1.1 | 100% | $160 | 100% | $160 | 100% | $160 |
| 1.2 | 100% | $480 | 100% | $480 | 100% | $480 |
| 1.3 | 100% | $80 | 100% | $80 | 100% | $80 |
| 1.4 | 75% | $180 | 100% | $240 | 100% | $240 |
| 1.5 | 0% | $0 | 83% | $400 | 100% | $480 |

# Time/ cost control-assessing performance



- **Example (cont'd)**:

  If EV (earned value) at the ***end of week 2*** is 900$ and AC is 850$ we have:

  SV (schedule variance) = 900 – 1360 = - 460$ (equal to 460$ value of work we are behind the schedule)

  CV (cost variance) = 900 – 850= 50$ (equal to 50$ we have saved for the work is performed)

  Looking into the trend of PV, we are noticed that the earned schedule duration (ES) is 1 week and duration variance (DV) is -1 week (1 week behind the schedule).

  ***EV at week 2 is equal to PV at week 1. This indicates ES=1week.***

| At the end of week 1 on Apr 12 | | At the end of week 2 on Apr 19 | | | |
|---|---|---|---|---|---|
| **Scheduled Progress** | **PV** | **Scheduled Progress** | **PV** | **EV** | **AC** |
| | **$900** | | **$1,360** | **$900** | **$850** |
| 100% | $160 | 100% | $160 | | |
| 100% | $480 | 100% | $480 | | |
| 100% | $80 | 100% | $80 | | |
| 75% | $180 | 100% | $240 | | |
| 0% | $0 | 83% | $400 | | |

# In class practice 2 - EVM



Calculate monthly PV for a project with the following information. Actual progress achieved at the end of June 2013 (30/6/2013) is 57% and total actual cost is 12500$. Calculate CV and SV of the project. Is project behind or ahead of schedule and for how long? Does project have cost over-run or is under budget and for how much?

| Task Name | Baseline Start | Baseline Finish | Baseline Cost |
|---|---|---|---|
| **Project** | **01/04/2013** | **31/07/2013** | **$15,000** |
| A | 01/04/2013 | 23/04/2013 | $2,000 |
| B | 15/04/2013 | 30/04/13 | $3,000 |
| C | 01/05/2013 | 30/06/2013 | $7,000 |
| D | 01/07/2013 | 15/07/2013 | $2,000 |
| E | 15/07/2013 | 31/07/2013 | $1,000 |

# In class practice 2 - EVM



***EV at the end of June (assessment date) is almost equal to PV at the end of May. This indicates ES=2 months and DV is -1 month or project is one month behind the schedule***

| | | PV | | | | June | | |
|---|---|---|---|---|---|---|---|---|
| Task Name | Baseline Cost | April | May | June | July | % Complete | EV | AC |
| **Project** | **$15,000** | **$5,000** | **$8,500** | **$12,000** | **$15,000** | **57%** | **$8,550** | **$12,500** |
| A | $2,000 | $2,000 | $2,000 | $2,000 | $2,000 | | SV =EV-PV | CV =EV-CV |
| B | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | | | |
| C | $7,000 | $0 | $3,500 | $7,000 | $7,000 | | **-$3,450** | **-$3,950** |
| D | $2,000 | $0 | $0 | $0 | $2,000 | | | |
| E | $1,000 | $0 | $0 | $0 | $1,000 | | | |

# Time/ cost control-assessing performance



- EVM project completion assessment:
  - Cost estimate at completion (EAC) can be estimated by supposing the same cost efficiency or CPI to be applied to the project:

    EAC = Budget at completion (BAC) / CPI

  - One way of estimating project duration (EPD) is by simply using SPI as the schedule indicator and simply divide the planned duration (PD) by SPI.

    $EPD_{(TSPI)} = PD / SPI_{(Total\ Project)}$

    However, final project duration is related to the completion of activities on the Critical Path(s) not all project activities. Another method for estimating project duration is using SPI of activities on the critical path. $EPD_{(CPSPI)} = PD / SPI_{(Critical\ Path)}$

    Another way of estimating project duration is by using earned schedule duration (ES) and actual time elapsed (AT). $EPD_{(ES)} = PD * AT / ES$

    Use of last estimation has shown more accurate estimations compared to the other methods.

# Time/ cost control-assessing performance



**To complete performance index (TCPI):** TCPI computes the future cost efficiency required to achieve a target cost estimate at completion (Target EAC). TCPI can be calculated using the following formula:

$$TCPI = (BAC - EV) / (Target\ EAC - AC)$$

The target EAC is assumed reasonable if *TCPI* is within plus or minus 0.05 of the *CPI*. Otherwise the target EAC needs to be adjusted!

**Example**: The planned and target budget at completion (BAC) of a project is 2M$. At the current stage, the project has earned the EV of 992T$ while the AC spent is 1.07M$.

The CPI becomes:

$$CPI = EV / AC = 992 / 1070 = 0.927$$

The TCPI becomes:

$$TCPI = (BAC - EV) / (EAC - AC) = (2000 – 992) / (2000 – 1070) = 1.084$$

$TCPI – CPI = 1.084 – 0.927 = 0.157 > 0.05$ is not reasonable 

# Time/ cost control-assessing performance



**To complete schedule performance index (TSPI):** TSPI is a performance indicator that shows how congested the remaining project duration should be utilized to the project team to complete the project on time.

TSPI can be calculated using the following formula:

$$TSPI = (BAC - EV) / (BAC - PV)$$

*TSPI* > 1 determines congested workload compared to normal pace.

*TSPI* < 1 determines lenient workload compared to normal pace.

**Example**: The planned and target budget at completion (BAC) of a project is 2M$. At the current stage, the project has earned the EV of 992T$ while the PV is 1M$.

The CPI becomes:

$$SPI = EV / PV = 992 / 1000 = 0.992$$

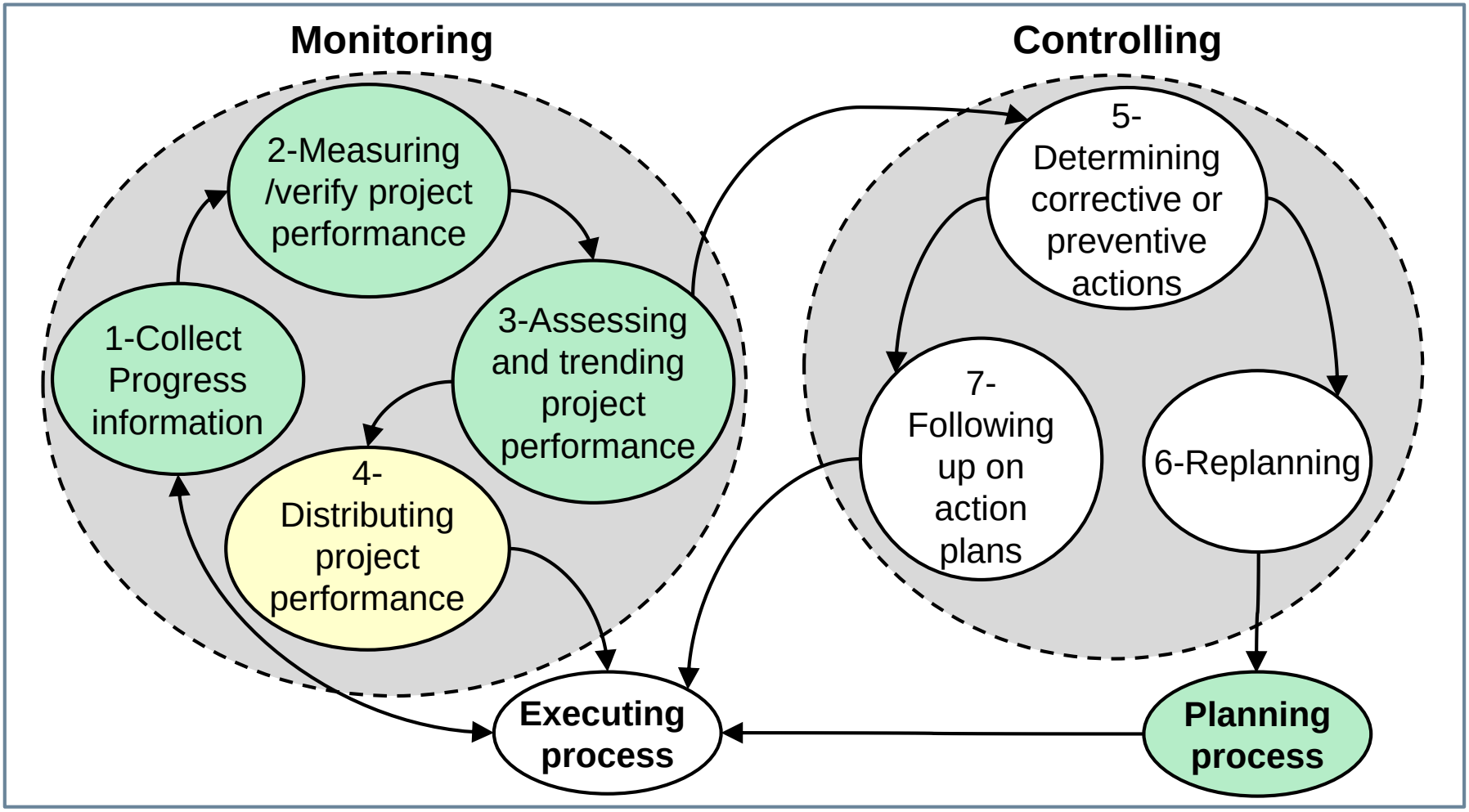
The TSPI becomes:

$$TCPI = (BAC - EV) / (BAC- PV) = (2000 – 992) / (2000 – 1000) = 1.008 > 1$$

# Time/ cost control-assessing performance



**Project control sub-processes interactions** **(arrows represent data flow direction)**



# Time/ cost control-corrective actions



- Deviations from the project plan are results of issues occurred in the project it is very important in the project to set a mechanism through which we can systematically identify, analysis and correct issues happened in the project.
- Corrective actions are created and followed (usually in a form format) in the project to:
    1) Fix the issues happened and caused deviations in the project
    2) Remove the root cause of the issue to avoid issue happening in future
- A robust project monitoring process can help the project control team on finding the root causes in a more efficient manner.
- Root cause analysis is a very important part of the project control to prevent the issue from repeating again in future. There are different techniques for root cause analysis 5-Whys is one of the simplest and most effective techniques to be used in project control process.
- In 5 Whys we try to explore the cause-and-effect relationship of the problem by repeatedly questioning the cause of the issue starting from more apparent and general causes and then narrowing down to the less obvious and more specific root causes.
- According to 5 Whys technique, after *maximum of 5 times* following cause-and-effect relationships, for most issues we are going to reach the root cause. However, you are supposed to follow the root cause as many times as required (even more than 5 times)

# Time/ cost control-corrective actions



- **Example:** the performance indicators show that “Prepare foundation form-work” work-package is behind the schedule which will result on delaying other dependent parts of the project. Following 5 Whys method we could find the root cause of the issue as in below:
  1) Why “Prepare foundation form-work” is behind the schedule?
     Because HR person delayed the hiring form-workers.
  2) Why HR person delayed the hiring form-workers?
     Because HR person was in vacation for three days and no other person was filling in for him.
  3) Why No body was filling in for the HR person?
     Because when project manager accepted his vacation, HR person thought PM is aware of the project schedule and will assign another person for the activity however PM was so busy to get that detail in the activity.

  **Corrective action**: To fix the delay problem set the weekend as overtime for the form-workers. To resolve the issue from happening in future, all project employees are mandated to highlight their related activities in the project schedule for the PM when requesting for vacation days!

# Time/ cost control-corrective actions



- The main difference between corrective and preventive action is that in the determining preventive actions project control teams can identify potential issues causing problem in future, usually by trending and assessing the project performance, and will try to avoid the issue from happening in future by removing the root cause of the issue; no fixing is required since the issue has not happened yet.
- **Example**: The trend of the % progress of the masons indicate that their progress rate is getting decreased, although it is still on time. The root cause analysis indicated that the main reason is the continual overtime that masons are working which has made them tired and their productivity has been decreased. PM decided to hire new masons and remove the overtime to reduce the fatigue among the masons and increase their productivity.
- **Corrective/ preventive actions in a push/ pull systems:**
  - **Push method:** The traditional way of approaching corrective actions was based on the push method. In the push method project control team will do not do any changes within the project as long as the project performance indicators are fine. As soon project indicators showed decline in the project the control group will start acting!

# Time/ cost control-corrective actions



- **Pull method:** The new approach to the project control is based on the pull method. This the approach used as the base for the *continual improvement*. In the pull method any non-conformity (or breach of procedures) is documented (through NCR forms), sent to the project control team and fixed and the root cause analysis is run for it to avoid any future in the project performance.

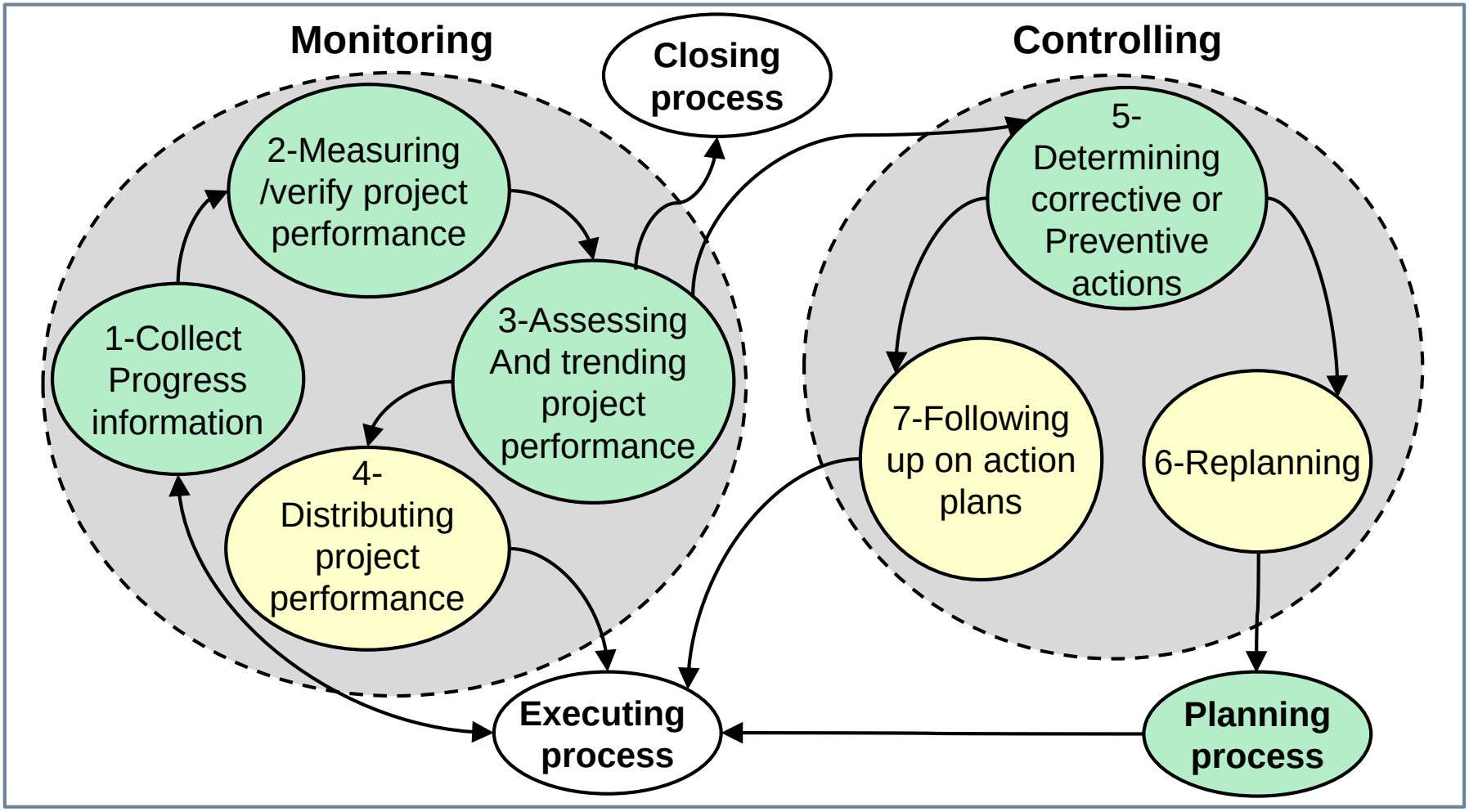
  In the pull method all project ream members actively participate in reporting issues happened and contribute to the problem solving process. In addition to the project performance monitoring and analysis (which is seen in the push method), project control group also monitors, trends and assesses non-conformities for any corrective and preventive actions required.

- Corrective and preventive actions are seen as improvement tools in ISO 9001 standard and have been mentioned in item 8.5.1 and 8.5.2!

# Time/ cost control-corrective actions



**Project control sub-processes interactions** **(arrows represent data flow direction)**



# Thank you!