Project Execution, Monitoring, and Control
Goals of the Unit

• Plans have little value if not executed and, during execution, monitored and updated to reflect the current situation

• This unit introduces:
  – The activities to put a plan into practice
  – The techniques for monitoring and controlling your plans (progress and costs against schedule and budget)
  – Earned Value Analysis, a technique which allows the project manager to monitor a project in an integrated way
Project Execution
Project Execution

• Project execution is where work is performed

• There are three main management activities:
  – Kicking activities off
  – Collecting the output of activities
  – Collecting information about the project health
Kicking Activities Off

• Goal:
  – Ensure there is a formal start for a significant portion of a project
  – Ensure the team is aligned on the goals and modalities of the activities being started

• The main mean is a kick-off meeting

• In general, any communication mean can be used (but it risks being less effective than a kick-off meeting)

• Choose an adequate level of granularity
Collecting the Output of Activities

• Goal:
  – Systematic collection of project outputs (deliverables)
  – Occasion to assess the lesson learned

• For software projects the main mean to collect project outputs is a repository + tagging/versioning

• A meeting to assess the lesson learned can also be used to “formalize” the collection of outputs
Collecting Information about the Project Status

• Goal:
  – Systematic collection of data to assess the project status

• It can be performed on a regular basis (in which case the frequency has to be chosen according to the project size)

• It can be performed on a need basis (for exceptional events, e.g., risks)

• Quantitative data can be collected based on the monitoring means

• Qualitative data (e.g., team morale, “feeling” about the status or difficulty of a given task) must also be collected
Project Monitoring and Control
Introduction

• Goals:
  – **For the project**: assessing project status (scope, time, cost, quality, ...), analyzing deviations, and taking corrective actions, if necessary
  – **For the organization**: collecting data helps building a better and more accurate plans for future projects

• Process (on a regular basis):
  – **Collect.** Get the data about the current status of your project.
  – **Measure and Compare.** Compare with baseline plan, highlight any deviation, make a projection based on current data.
  – **Assess and Re-plan.** Decide whether corrective actions are necessary. If so, plan, document, and take the corrective actions.
Plan P1
Actual World describes A1
Monitoring and controlling cycle
compare deviations & assessment replan P2
(new baseline)
... and the cycle repeats ...

work captured by A1 (actual plan)

P1 (baseline)
Approaches

• **Focus:**
  – Here we focus on schedule, costs, and progress

• **Non-integrated approach:**
  – Monitor schedule: understand whether we are late or early
  – Monitor costs: understand whether we over or under budget
  – Simple, but partial views

• **Integrated approach:**
  – Earned Value Analysis: measure schedule, costs, and progress together
  – More complex, but a more comprehensive view
Monitoring Schedule
Basic Concepts

• Baseline (planned values):
  – A snapshot of the plan at a given time (plan at t1, plan at t2, …)
  – Many baselines can be taken

• Actual Values
  – Actual status of the schedule
  – Actual start, actual end, actual effort/actual progress
The Process

1. Build the plan
2. Save a baseline
3. On a regular basis, assess the plan:
   1. Actual start and end of an activity
   2. Actual effort spent on the activity
   3. Technical progress (may be difficult to assess)
4. Re-plan:
   1. Estimate effort and duration to end
   2. Technique 1: efficiency with which actual effort has been expressed w.r.t. planned effort
   3. Technique 2: efficiency with which technical progress is expressed w.r.t. planned progress
   4. Share the new plan, and GOTO 2
Collecting Effort Data

• Depending on the level of formality... people may be required to provide data about effort spent on activities

• Usually best on a weekly basis

• Need to reference activities of the plan

• It will contain “noise”

<table>
<thead>
<tr>
<th></th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements M1</td>
<td>30</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Requirements M2</td>
<td></td>
<td>30</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Meeting</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Research</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Indirect activities</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Monitoring Costs
Cost control, the simple approach

- The budget table defines your baseline
- Actual costs define your current status
- It can be split over years (or reporting periods)

<table>
<thead>
<tr>
<th>CBS Item</th>
<th>Budgeted</th>
<th>Actual</th>
<th>Status</th>
<th>New Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td>€10,000.00</td>
<td>€5,000.00</td>
<td>€5,000.00</td>
<td>€5,000.00</td>
</tr>
<tr>
<td>Software</td>
<td>€4,000.00</td>
<td>€2,000.00</td>
<td>€2,000.00</td>
<td>€2,000.00</td>
</tr>
<tr>
<td>Travel</td>
<td>€5,000.00</td>
<td>€6,000.00</td>
<td>-€1,000.00</td>
<td>€1,000.00</td>
</tr>
<tr>
<td>Project Bfr</td>
<td>€3,000.00</td>
<td>€3,000.00</td>
<td>€3,000.00</td>
<td>€1,000.00</td>
</tr>
<tr>
<td>Total</td>
<td>€22,000.00</td>
<td>€13,000.00</td>
<td>€9,000.00</td>
<td>€9,000.00</td>
</tr>
</tbody>
</table>

Overruns drawn from other funds (e.g. project buffer, a different CES item) or from other projects
Remarks

• **Advantages:**
  
  – Relatively simple (however, delays between commitment of expenditures and cash flow)
  
  – For various CES items probably the best way of monitoring (e.g. hardware, software, ...)

• **Disadvantages:**
  
  – Not sufficient to have an idea on the overall status of the project (will we make it with the remaining money?)
Earned Value Analysis
Earned Value Analysis

- **Earned Value Analysis** provides an integrated view of the project by measuring **planned effort (costs)**, **actual progress (earned value)**, and **effort (actual costs)** in terms of **monetary values**.

- Measuring plan, work, and progress with the same unit makes them comparable.

- Useful because:
  - Progress becomes comparable with effort.
  - Budget and actual costs are put in context (being under budget is not necessarily good, if the technical progress is even lower).
Assumptions and Definitions

• Assumptions:
  – **Manpower = Cost**: plotting effort or cost is equivalent
  – Corollary: **Actual manpower = Actual Cost**
  – **Progress = Money**

• Definitions:
  – **Planned Value**: the cumulative costs planned for the project.
    Also called: **Budgeted Costs of Work Scheduled**
  – **Actual Costs**: the cumulative costs actually incurred into.
    Also called: **Actual Costs of Work Performed**
  – **Earned Value**: the actual progress, expressed as the quantity of planned value which has generated results
Planned Cost Computation

<table>
<thead>
<tr>
<th>Name</th>
<th>Planned Cost</th>
<th>Total Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1000</td>
<td>500</td>
</tr>
<tr>
<td>B</td>
<td>2000</td>
<td>1500</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>2000</td>
</tr>
</tbody>
</table>

- **Total Cumulative**:
  - M1: 500
  - M2: 2000
  - M3: 3100
  - M4: 3200
  - M5: 3300
  - M6: 3400

- **Planned Cost**:
  - A: 1000
  - B: 2000
  - C: 400

- **Time**:
  - A: 100
  - B: 100
  - C: 100

- **Cumulative**
  - M1: 500
  - M2: 2000
  - M3: 3100
  - M4: 3200
  - M5: 3300
  - M6: 3400
Earned Value Computation

- Rule 1.
  - Earned value should be determined by examining products

- Rule 2.
  - 50/50 Rule (50% of Planned Value at start and 50% at end)
  - 20/80 Rule (20% at start and 80% at end)
  - 0/100 Rule (0% at start and 100% at end)
Earned Value Analysis

Money

BAC = project budget

AC
(Actual Costs)

PV
(Planned Value)

EV
(Earned Value)

Cost Variance

Schedule Variance

monitoring date

planned end

Time
Some Interesting Points and Metrics

- **BAC** = Budget at Completion

- **SV**: Schedule Variance (BCWP-BCWS)
  - A comparison of amount of work performed during a given period of time to what was scheduled to be performed.
  - A negative variance means the project is behind schedule

- **CV**: Cost Variance (BCWP-ACWP)
  - A comparison of the budgeted cost of work performed with actual cost.
  - A negative variance means the project is over budget.
Cost Performance Index (CPI)

\[ CPI_t = \frac{EV_t}{AC_t} \]

- CPI (Cost Performance Index) compares work performed to actual costs.
- How much are we getting for each euro we spend?

<table>
<thead>
<tr>
<th>CPI &gt; 1</th>
<th>Project is efficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI &lt; 1</td>
<td>Project is inefficient</td>
</tr>
</tbody>
</table>
Schedule Performance Index (SPI)

$$SPI_t = \frac{EV_t}{PV_t}$$

- SPI (Schedule Performance Index) compares work performed to work planned
- How fast does the project progress w.r.t. how fast we expected it to be?

<table>
<thead>
<tr>
<th>SPI &gt; 1</th>
<th>Project is ahead of schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI &lt; 1</td>
<td>Project is behind schedule</td>
</tr>
</tbody>
</table>
Cost Schedule Index (CSI)

\[ CSI_t = CPI_t \times SPI_t \]

\[ CSI_t = \frac{EV_t}{AC_t} \times \frac{EV_t}{PV_t} \]

- CSI: Cost Schedule Index (CSI = CPI \times SPI)
- The further CSI is from 1.0, the less likely project recovery becomes
Measuring SPI and CPI

- early and under budget
- late and over budget
- early, but over budget
- late, but under budget
- exactly like scheduled and budgeted
Earned Value Analysis: Example
Example

• Remarks:
  – Lower part = baseline; upper part: actual & progress

• Questions:
  – Are we late?
  – Are we over budget?
Example

- Activity 1: as scheduled (time)
- Activity 2: started late; ahead of schedule
- Activity 3: started earlier; progress same as time elapsed
- Activity 4: not started yet
Example: BCWS (Planned Value)

<table>
<thead>
<tr>
<th>Task</th>
<th>Effort</th>
<th>Resources Cost</th>
<th>Task Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Paint Wall</td>
<td>4w</td>
<td>€3,200.00</td>
<td>€3,600.00</td>
</tr>
<tr>
<td>2) Paint Ceiling</td>
<td>4w</td>
<td>€3,200.00</td>
<td>€2,000.00</td>
</tr>
<tr>
<td>3) Refurnish</td>
<td>2w</td>
<td>€800.00</td>
<td>€400.00</td>
</tr>
<tr>
<td>4) Clean</td>
<td>1w</td>
<td>€400.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task</th>
<th>Budgeted Cost of Work Scheduled (BCWS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Wall</td>
<td>800 800 800 800</td>
</tr>
<tr>
<td>Paint Ceiling</td>
<td>800 800 800 800</td>
</tr>
<tr>
<td>Refurnish</td>
<td>400 400</td>
</tr>
<tr>
<td>Clean</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Budgeted Cost of Work Scheduled (BCWS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>800 1600 2400 4000 4800 5600 6800 7200 7600</td>
</tr>
</tbody>
</table>
Example: BCWP (Earned Value)

<table>
<thead>
<tr>
<th>Task</th>
<th>Budgeted Cost of Work Scheduled (BCWS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Wall</td>
<td>1600</td>
</tr>
<tr>
<td>Paint Ceiling</td>
<td>0</td>
</tr>
<tr>
<td>Refurnish</td>
<td>400</td>
</tr>
<tr>
<td>Clean</td>
<td>2,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- BCWS
- BCWP
Comments

• Ahead of schedule on week 1 because of the noise of the 50%-50% rule (analogously the delay on w2 and w3)

• w4: we are behind schedule (activity 2 did not start as expected)

• w5: we are again ahead of schedule, because of activity 3.

• Since the 50%-50% rule only counts start and end of activities, the fact that progress in activity 2 is better than expected is not taken into account in the EVA graph
Example: ACWP (Actual Costs)

<table>
<thead>
<tr>
<th>Task</th>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Wall</td>
<td>900</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>Paint Ceiling</td>
<td>0</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Refurnish</td>
<td></td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Clean</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Actual Cost of Work Performed (ACWP) | 900 | 1800 | 2700 | 3600 | 6000 |

Graph showing the comparison between BCWS, BCWP, and ACWP.
## Recap

<table>
<thead>
<tr>
<th></th>
<th>Paint Wall</th>
<th>Paint Ceiling</th>
<th>Refurnish</th>
<th>Clean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>€800.00</td>
<td>€800.00</td>
<td>€800.00</td>
<td>€800.00</td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Budgeted Cost of Work Scheduled (BCWS)</strong></td>
<td>€800</td>
<td>€1,600</td>
<td>€2,400</td>
<td>€4,000</td>
</tr>
<tr>
<td><strong>Budgeted Cost of Work Performed (BCWP)</strong></td>
<td>€1,600</td>
<td>€1,600</td>
<td>€1,600</td>
<td>€3,200</td>
</tr>
<tr>
<td><strong>Actual Cost of Work Performed (ACWS)</strong></td>
<td>€900</td>
<td>€1,800</td>
<td>€2,700</td>
<td>€3,600</td>
</tr>
<tr>
<td><strong>CPI (BCWP/ACWP)</strong></td>
<td>178%</td>
<td>89%</td>
<td>59%</td>
<td>89%</td>
</tr>
<tr>
<td><strong>SPI (BCWP/BCWS)</strong></td>
<td>200%</td>
<td>100%</td>
<td>67%</td>
<td>80%</td>
</tr>
<tr>
<td><strong>Cost Variance</strong></td>
<td>€700</td>
<td>-€200</td>
<td>-€1,100</td>
<td>-€400</td>
</tr>
<tr>
<td><strong>Schedule Variance</strong></td>
<td>€800</td>
<td>€0</td>
<td>-€800</td>
<td>-€800</td>
</tr>
</tbody>
</table>
Comments

• Various noise due to the 50%-50% rule (e.g. w1)

• Data shows that we are now a bit over budget, but early in schedule (last column).

• However:
  – Actual costs efficiency is due to the 50%-50% rule on activity 2 (we accrued 1600) ... the data will get more accurate when we finish activity 2 (expenditure will likely be 4000 euros and BCWS 3200)