ENGG2851 – Chapter 3

Data Analytics for Time Management

- The objectives of time management are:
  - Ensure that project objectives are achieved according to the timeframe defined in the business case.
  - Manage any changes to the project timeframe.
  - Ensure the changes to the project timeframe are aligned with other aspects of the project.
- The tool most commonly used to manage the project timeframe is the **project schedule**.
- The most commonly used graphical representation of the project schedule is the **Gantt Chart**.

Time Management Using the PMBoK

Sequence Activities

Sequence Activities:	The process of identifying and documenting the relationships between project activities.

- Produces a set of **Schedule Network Diagrams** defining the sequence of activities based on their dependencies.
- Schedule Network Diagrams are produced using the **Precedence Diagramming Method**, which shows activities as rectangles and dependencies as connecting arrows (known as the **Activity on Node Method**).
- **Activity on Node (AON)** schedule network diagrams allow the inclusion of *leads* and *lags* in the definitions of activity dependencies.

Lead:	Allows a successor activity to begin before predecessor activities complete.
Lag:	Introduces an additional delay to the start of a successor activity.

Types of Dependencies

Mandatory Dependencies:	Inherent to the sequence of work (e.g. foundations must be laid before construction of walls begin) or required contractually (also known as *hard dependencies*).
Discretionary Dependencies:	Introduced as a discretionary measure to control the sequence of work (also known as *soft dependencies*).
External Dependencies:	Define the relationship between in-scope activities and out-of-scope activities (e.g. council approval before the start of construction).

Dependency Relationships

Finish-to-Start (FS):	Start of successor activity depends on the completion of the predecessor activity.
Finish-to-Finish (FF):	Completion of successor activity depends on the completion of the predecessor activity.
Start-to-Start (SS):	Start of successor activity depends on the start of the predecessor activity.
Start-to-Finish (SF):	Completion of successor activity depends on the start of the predecessor activity.

Estimate Activity Resources

- This process is concerned with determining the types of resources needed to complete the project (both human and material).
- Availability of the resources also needs to be considered.
- Produces the resource requirements for each activity and the **Resource Breakdown Structure**.

Estimate Activity Durations

- The process of estimating the number of work periods required to complete the project activities using the available resources.
- Requires an estimate of **work** for each of the activities.
- Activity durations are then derived based on the capacity of available resources to complete the estimated amount of work.

The Process of Estimation

Estimation:	The process of developing predictions.

- All predictions are associated with a certain *probability*.
- Estimates can be given as a *range* or a single number with a *confidence interval*.

Confidence Intervals

- Confidence Intervals are expressed in terms of the **standard deviation**.
- For a **Normal (Gaussian) Distribution**, the confidence intervals are given as:
  - $1\sigma = 68.26\%$
  - $2\ \sigma = 95.46\%$
  - $3\ \sigma = 99.73\%$
  - $6\ \sigma = 99.99\%$

Estimation Methods

Expert Judgement

- Estimates are based on individual or group assessment.
- Based on intuition, past experience, and human case-based reasoning.
- Methods include **Delphi** and **Wideband Delphi**:
  - Designed to arrive at consensus among a group of experts through comparison of estimates and examination of reasoning.
  - Participants in the Delphi Method do not interact directly.
  - Wideband Delphi requires facilitated direct discussion between the participants.
- Additional Considerations:
  - Better accuracy in predictable environments.
  - Feedback is important – especially with respect to how task characteristics relate to actual effort.
  - Expert judgement outperforms model-based approaches only in the case of short-term forecasting.

Analogous Estimation

- Estimates are derived based on historical data from similar projects.
- Can be implemented as a form of expert judgement or as a computer model.
- **Case-Based Reasoning**:
    - Designed to deal with situations where historical data does not exist or is incomplete, and where casual rules are difficult to establish.
    - Involves identification of and comparison with past cases, based on specific features.
    - Can incorporate expert judgement and learning based on addition of new cases.
- Additional Considerations:
    - Choice of case attributes strongly the ability to find similar cases.
    - Evaluating the degree of similarity and adapting historical data to arrive at a new estimate can be complicated, computationally intensive and sensitive to the values of model parameters.

Parametric Estimation

- Estimates derived using causal methods defined by parametric equations.
- **COCOMO II** and **Function Point Analysis**:
    - Basic COCOMO II effort formula:

$$Effort = a \times (size)^b$$

where a and b are parameters determined based on cost and scale drivers reflecting project characteristics

- Additional Considerations:
    - Many sets of historical data for projects with carious characteristics are required.
    - Model calibration may introduce subjective bias.

Regression Analysis

- Mathematical process of determining the relationship between a *dependent variable* and a number of *independent variables*.
- Commonly used to develop parametric estimation models.
- Involves determination of a curve that best fits a set of data points.
- Examples:

Least-Squares Method:	Involves derivation of equation parameters from the data and aims to produce a *global* best-fit curve.
Regression Trees:	Effective in the presence of non-linear effects and involve partitioning the data into regions to determine *local* relationships between variables.

- Additional Considerations:
    - Vulnerable to distortions as a result of outliers in historical data.
    - Limited effectiveness when applied in less predictable environments.

Probabilistic Estimation

- Utilises **Bayesian Networks** to create a probabilistic model to forecast effort.
- Enables integration of risk, historical data, and expert judgement.
- Possible to derive model structure (causal relationships) and parameters (probabilities) through *machine learning*.
- Enables ‘what-if’ analysis to determine the impact of varying model parameters on the estimate.
- Especially useful for situations where historical data is partial or incomplete.

Artificial Intelligence Methods

- Fuzzy Logic:
  - Deals with situations where historical data is vague or imprecise.
  - Commonly used to improve accuracy of other methods (e.g. analogous or parametric).
- Genetic Algorithms:
  - Involves optimisation of parametric estimation models by searching for a set of parameter values that minimise the estimation error.
- Artificial Neural Networks:
  - Estimates derived using a model developed through *machine learning*.
  - Unlike preceding methods, model parameters do not have to be explicitly defined.
  - Quality of historical data determines model effectiveness.
  - Addition of new historical data requires retraining.

Develop Schedule

- The process of analysing activity sequences, durations, and resource requirements and applying constraints to create the project schedule.
- Schedule constraints define hard dates impacting the start and finish of activities.
- The methods and techniques used to construct the schedule include:
  - Critical Path Method
  - Critical Chain Method
  - Resource Levelling
  - Applying leads and lags
  - Schedule Compression
  - Monte Carlo Analysis

Schedule Compression

- Reduces project duration to fit within the constraints without changing the scope.

Crashing:	Reduces activity duration by increasing the capacity of resources to do the work.
Fast-Tracking:	Revising the schedule to perform initially sequential activities in parallel.

- Both methods may introduce additional cost and risk to the project, which must be balanced against the reduced duration.

Monte Carlo Analysis

- A simulation method that uses random sampling to determine the impact of risk on the likelihood of a particular outcome – in case of scheduling, project completion by the planned date.
- The Method:
  - The duration of each activity is defined in terms of a probability distribution function.
  - The simulation is run multiple times, each time randomly choosing activity durations based on their probability distribution functions and calculating the project completion date.
  - The results are statistically analysed to determine the likelihood of the project completing by the planned date.