CVEN30008 Engineering Risk Analysis

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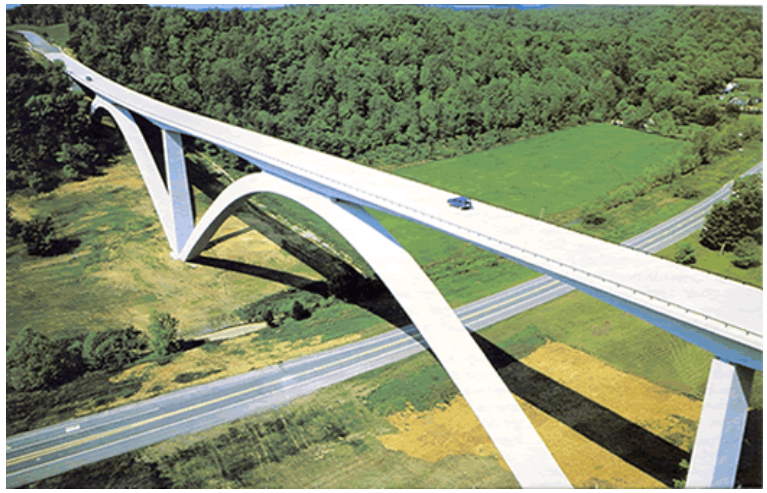


Research interests

The development of rapid bridge assessment tools will allow to increase general safety and optimize operational and maintenance activities for bridges.

vicroads

Roads & Maritime

Research Interests

Why Engineers always have an affinity to the mechanics of biological materials and structure?

Nature Object

Building

Lessons from Nature - Learn how nature has solved complex structural problem and to transfer the basic ideas of these solutions to man-made structures.

Outline of talk

- Subject Introduction
- Risk Management Standard

  - Australian/New Zealand Risk Management Standard (AS/NZS ISO 31000:2009)

Subject Introduction

Bachelor of Science - Civil Systems

First year			
Engineering Systems Design 1	Calculus 2^	Physics 1	Breadth
Engineering Systems Design 2	Linear Algebra	Physics 2: Physical Science & Technology	Breadth
Second year			
Engineering Mechanics	Engineering Mathematics	Quantum Mechanics & Special Relativity	Breadth
Engineering Materials	Earth Processes for Engineering	Real Analysis	Breadth
Third year			
Fluid Mechanics	Risk Analysis	Graph Theory	Breadth
Systems Modelling & Design	Structural Theory & Design	Complex Analysis	Breadth

Subject Introduction

Bachelor of Science - Spatial Systems

Year 1 Semester 1	Foundations of Computing	Science subject	Calculus 1 [1]	Breadth
Year 1 Semester 2	Foundations of Algorithms	Science subject	Linear Algebra [1]	Breadth
Year 2 Semester 1	Applications of GIS	Science subject	Science subject	Breadth
Year 2 Semester 2	Surveying and Mapping	Engineering Computation	Science subject	Breadth
Year 3 Semester 1	Risk Analysis	Imaging the Environment	Science elective	Breadth
Year 3 Semester 2	Integrated Spatial Systems	Land Administration Systems	Science subject	Breadth

Subject Introduction

Bachelor of Environment - Engineering Systems

Year 1	Semester 1	**Reshaping Environments**	Environments Elective	Environments Elective	Calculus 1
	Semester 2	Natural Environments	Environments Elective	Structural Environments[3]	Calculus 2
Year 2	Semester 1	Engineering Mathematics	Engineering Mechanics	Environments Elective	Linear Algebra
	Semester 2	Engineering Materials	Earth Processes for Engineering	Environments Elective	Breadth Subject
Year 3	Semester 1	Risk Analysis	Fluid Mechanics	Environments Elective	Breadth or Environments Elective
	Semester 2	Systems Modelling and Design	Structural Theory and Design	Major Selective	Breadth or Environments Elective

Subject Introduction

Bachelor of Environment – Spatial Systems

Year 1	Semester 1	**Reshaping Environments**	Mapping Environments (recommended)	Calculus 1[2]	Breadth Subject
	Semester 2	Natural OR Urban Environments	Environments Elective	Environments Elective	Breadth Subject
Year 2	Semester 1	Applications of GIS	Database Systems	Linear Algebra	Breadth Subject
	Semester 2	Surveying and Mapping	Engineering Computation	Environments Elective	Breadth Subject
Year 3	Semester 1	Risk Analysis	Imaging the Environment	Environments Elective	Breadth or Environments Elective
	Semester 2	Integrated Spatial Systems	Land Administration Systems	Environments Elective	Breadth or Environments Elective

Subject Introduction

- Lecture Program
  - Monday, 4:15pm-5:15pm (MSD-B117)
  - Wednesday, 4:15pm-5:15pm (MSD-B117)
- One hour Tutorial Program (No tutorial in week 1)
  - Monday - Friday (Student Portal)
- Consultation (Attendance is not compulsory)
  - Thursday, 2:00pm-3:00pm (Engineering D207)

Subject Introduction

- Lecture Program
  - Risk Management Standard (AS/NZS ISO 31000:2009)
  - Qualitative Risk Analysis
  - Quantitative Risk Analysis
  - Risk Management in Engineering Projects
- Teaching Staff
  - University of Melbourne
    - Dr Lihai Zhang (University of Melbourne)
  - Guest Lecturers
    - Mr Peter Bishop (Senior Project Manager, Melbourne Water)
    - Dr Ferenc Birloni (Director, MW Engineers)
    - Mr Mathew Jonston (Risk Manager, John Holland)
    - Dr Yew-Chin Koay (Bridge Manager, VicRoads)
    - Dr Jane Lai (Project Manager, Norman Disney & Young)

Assessment

- Assignment Submissions (30%)
  - Assignment 1: Qualitative risk analysis (15%)
  - Assignment 2: Quantitative risk analysis (15%)
  - Group assignment submission:
    - Turnitin: Academic honesty & plagiarism
    - PRAZE: Peer Review
- Final Exam (60%)
  - The examination will assess the knowledge and the skills that you have gained through lectures, tutorial materials and assignments.
- Attendance and contribution to discussion in tutorials (10%)

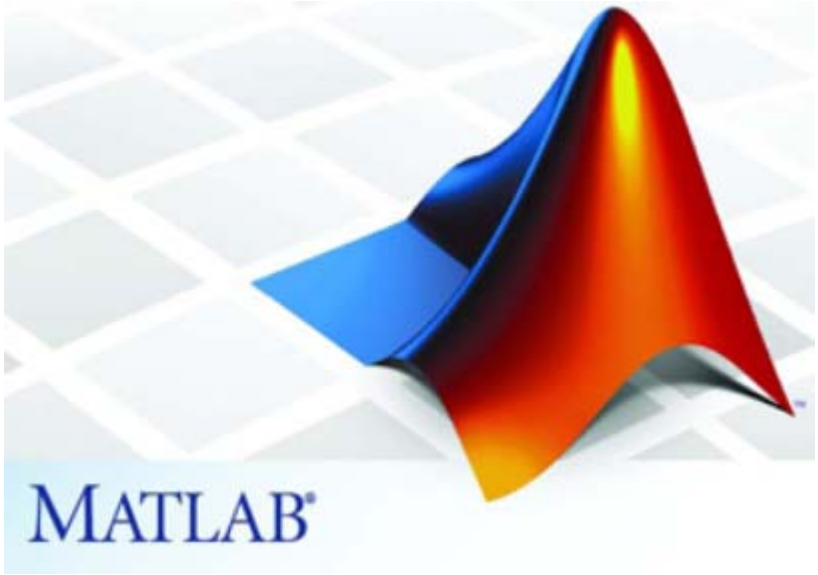
No tutorial in Week 1 !

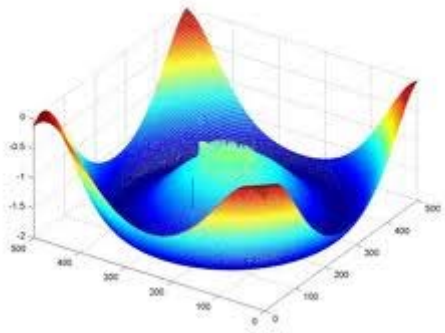
Subject Feedback

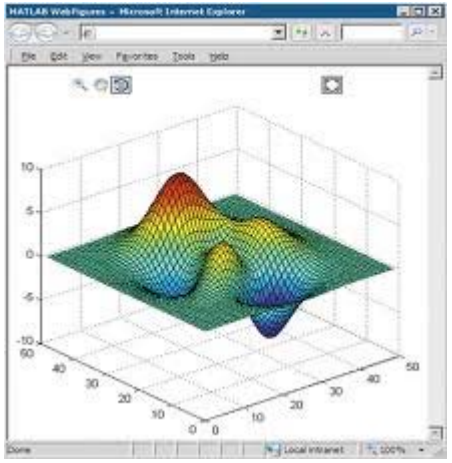
- LMS Discussion Board and FAQ
- Consultation session every week (D207)
- 3 class representatives
  - To represent the interests of the students
  - To collect feedback from students
  - To periodically meet up with the subject coordinator
  - To attend department focus group meeting

Did I receive valuable feedback on my progress ?

Computational Tools



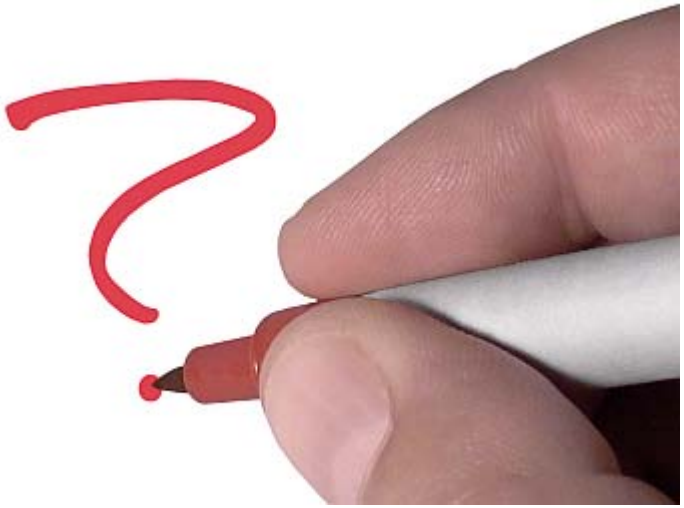




- **Probability distributions**
- **Confidence intervals**
- **Hypothesis testing**
- **Monte Carlo simulation**

Risk analysis

Which Australian region contains the greatest risk with respect to bush fire damage?



Codified Design – How safe is safe enough?

- This judgement must be made by code writers when
  - Identifying those natural and artificial forces that must be considered to ensure adequate safety and serviceability.
  - Providing criteria for achieving minimum required levels of structural resistance to these forces.

What has this judgement been based on?

Risk Definition

- Uncertainty
  - A state of having limited knowledge where it is impossible to exactly describe existing state or future outcome, more than one possible outcome.

- Risk
  - The effect of uncertainty on objectives (AS/NZS ISO 31000:2009)

Without uncertainty, there is no risk !

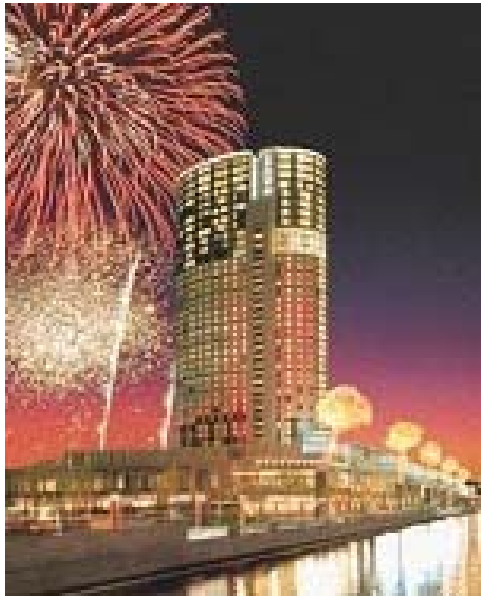
The objective of Risk Analysis in engineering

Improve the predictability of a project !

What is a project?

The word "**project**" is defined as *"an organised undertaking"* or *"a special unit of work"* (Webster's New World Dictionary).

In industry, a project is a specific work scope (consisting of inter-related activities) that is expected to be completed within a finite **timescale** and **budget**; and to a nominated standard of **quality.**



Bridges in Melbourne

West Gate Bridge

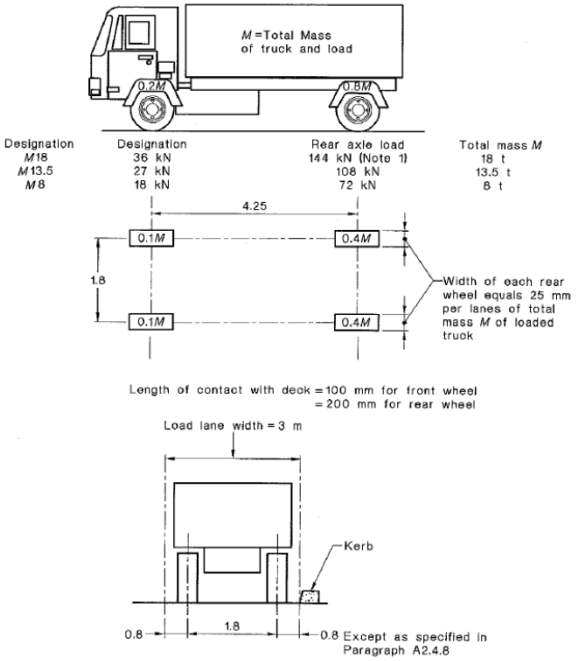
Webb Bridge Yarra River

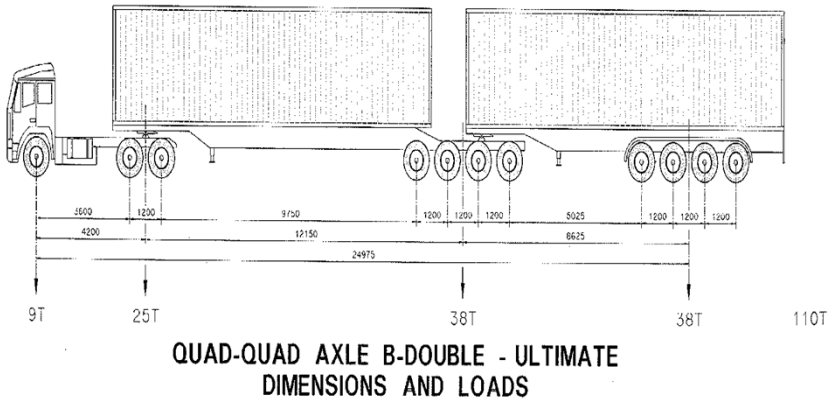
West Gate Bridge Strengthening

- Current West Gate Bridge – the risks …
- Residual design deficiencies
- Loading has increased significantly
- Non compliance with modern day bridge design and assessment standards
- Traffic capacity constraints causing congestion

West Gate Bridge Strengthening

Redesign - NAASRA





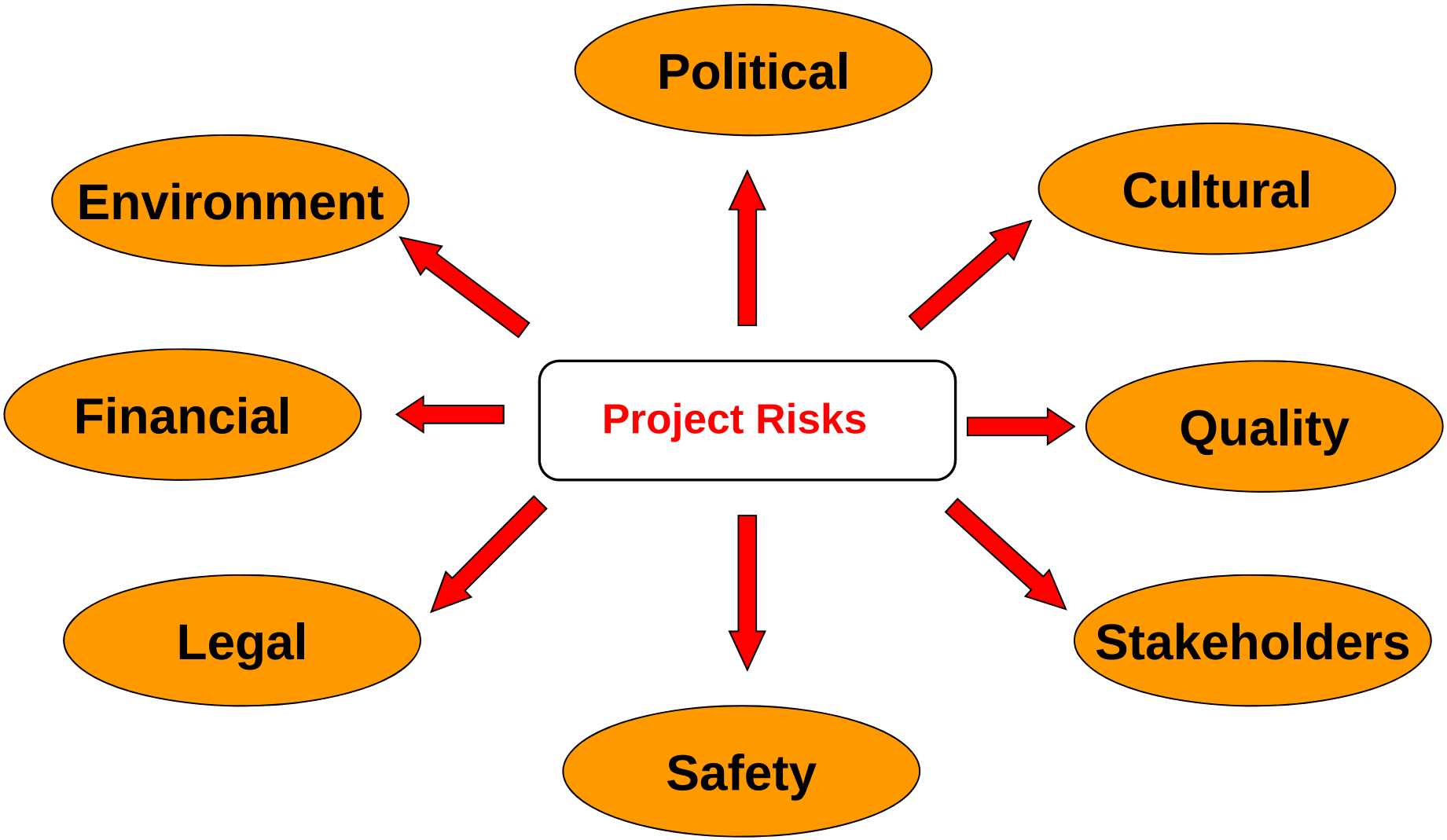
QUAD-QUAD AXLE B-DOUBLE - ULTIMATE DIMENSIONS AND LOADS

Future 110T Truck

West Gate Bridge Strengthening

STAGE	DETAILS	TIME FRAME
1	Structural Analysis / Modeling	Nov 07 to Jul 08
2	Scope & Cost Development (prepare Business Case)	July 08 to Dec 08
3	Detailed Design	Jan 09 to Aug 09
4	Construction –Operation of 5 lanes in peak direction and no further impact on traffic throughput –Total Project Completion	May 09 to Jun 11 Oct 2010 Jun 2011

Risk Management



Environmental Risks – EastLink

- EastLink
  - 39km motorway in Melbourne's east, connecting the Eastern, Monash, Frankston and Peninsula Link freeways.
  - Opened to traffic on Sunday 29 June 2008.
  - The final project cost was A$2.5 billion.
  - The safest motorway in Melbourne, and planted around 4 million native plants, shrubs and trees in the EastLink landscape.

Environmental Risks – EastLink

- Environmental risk management covered in the project
  - Air quality, noise and vibration management
  - Archaeological and cultural heritage management
  - Erosion and sediment control
  - Flora and fauna management
  - Soil and water management
  - Weed and waste management

Wetlands and Waterways

- The EastLink Wetland System
  - The EastLink road project is unique in Australia in that it has been designed for 100% capture and treatment of road surface water run-off throughout the 39 km corridor. This is being achieved through the provision of a series of constructed wetlands that are designed to handle all of this water before it is released to the waterways adjacent to the project.

Natural Resource Management

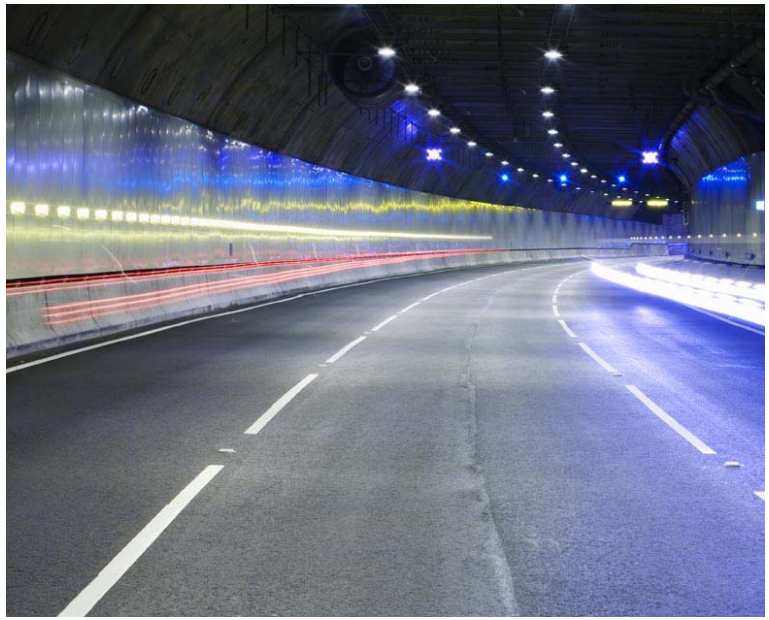
- The newly-built shared use path located alongside the roadway enables the public to better enjoy the reinstated creek sections, as well as the other landscape and wetland features of EastLink.

Types of Noise Barriers

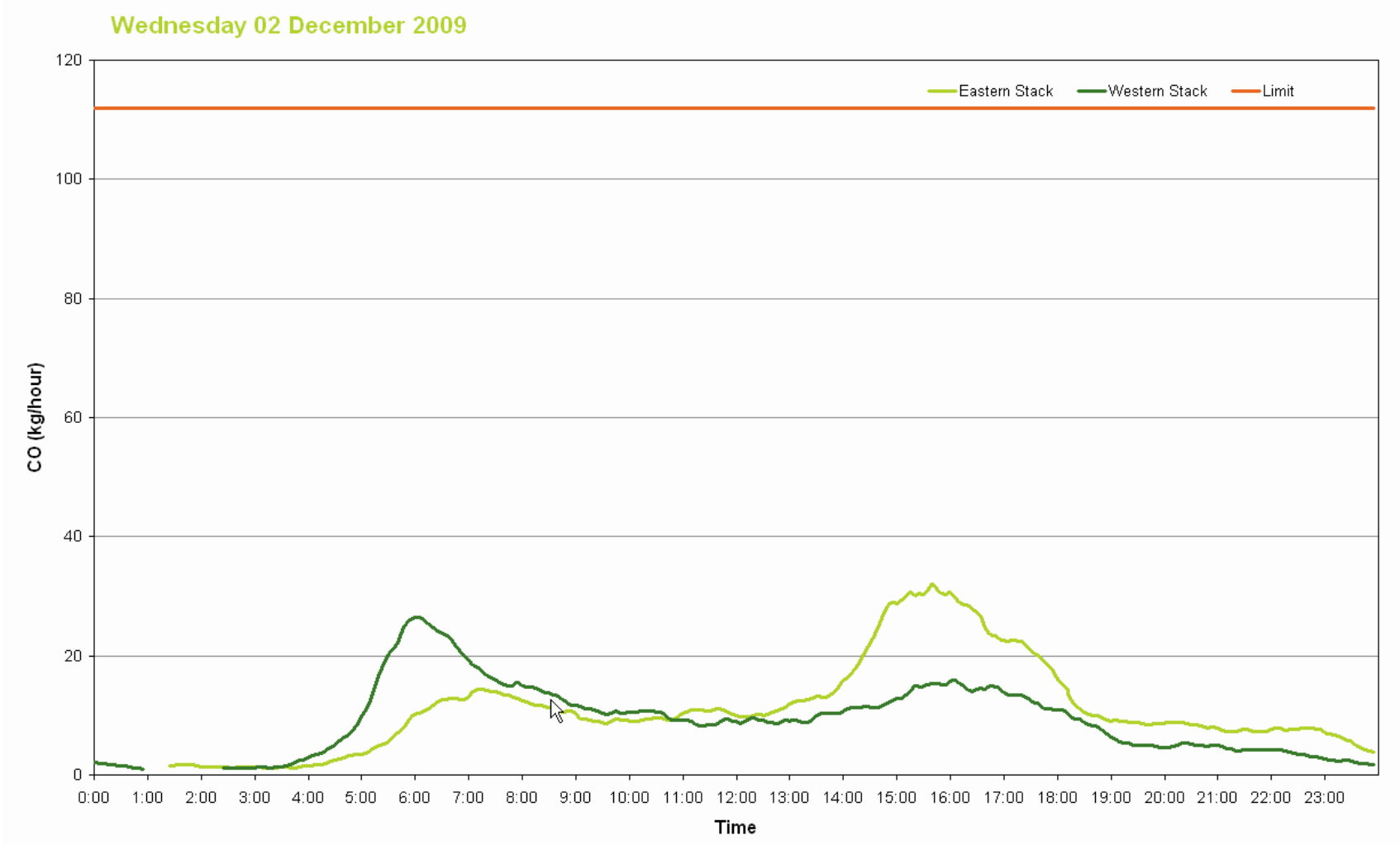
- Pre-cast concrete panels
  - The concrete panels comprise two type
    - a fractured pattern and a rock textured pattern
    - a charcoal-pigmented concrete or off-white pigmented concrete.
- Acrylic
  - Transparent acrylic panels have been installed on bridges with smaller sheets of acrylic installed in concrete and acrylic composite noise walls. Orange and green acrylic panels have been used on bridges and interchanges.

Air Quality

- Air quality monitoring on EastLink is conducted to ensure the quality of air within the tunnels emitted through the tunnel stacks and the air at ground level locations around the tunnels meets the standards mandated by the Victorian Environmental Protection Authority (EPA).
- ConnectEast has been issued a licence from the EPA for the operation of the EastLink tunnels in accordance with standards for in-tunnel air quality and for emissions from the ventilation stacks.



Ambient Air Quality



Natural Resource Management

- The removal of vegetation at the start of land clearing operations involved careful investigation of habitat values and the surrounding flora and fauna.

Natural Resource Management

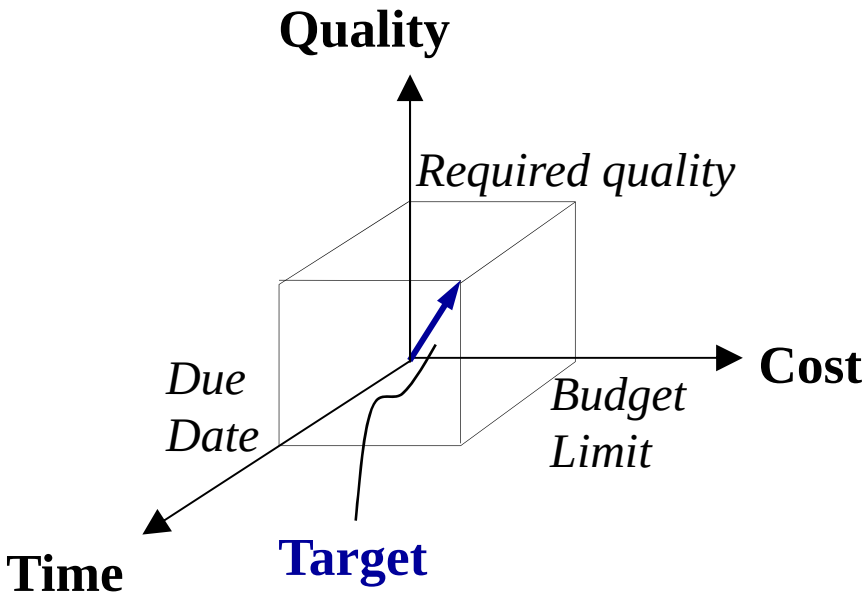
- The trees removed from project land have been replaced over time with over 3.5 million native species trees and shrubs, as well as grassed areas. Records have been kept of any high ecological-value trees and shrubs removed under State Government permit. Any disturbed fauna have been successfully rescued and re-introduced into other suitable habitats off-site.

Political risks

- Possibility of an unexpected politically-motivated event affecting the outcome of an investment
  - Investment restrictions (e.g. capital controls)
  - Operating restrictions (e.g. restrictions on local market access)
  - Political stability
  - Terrorism

Engineering Risks

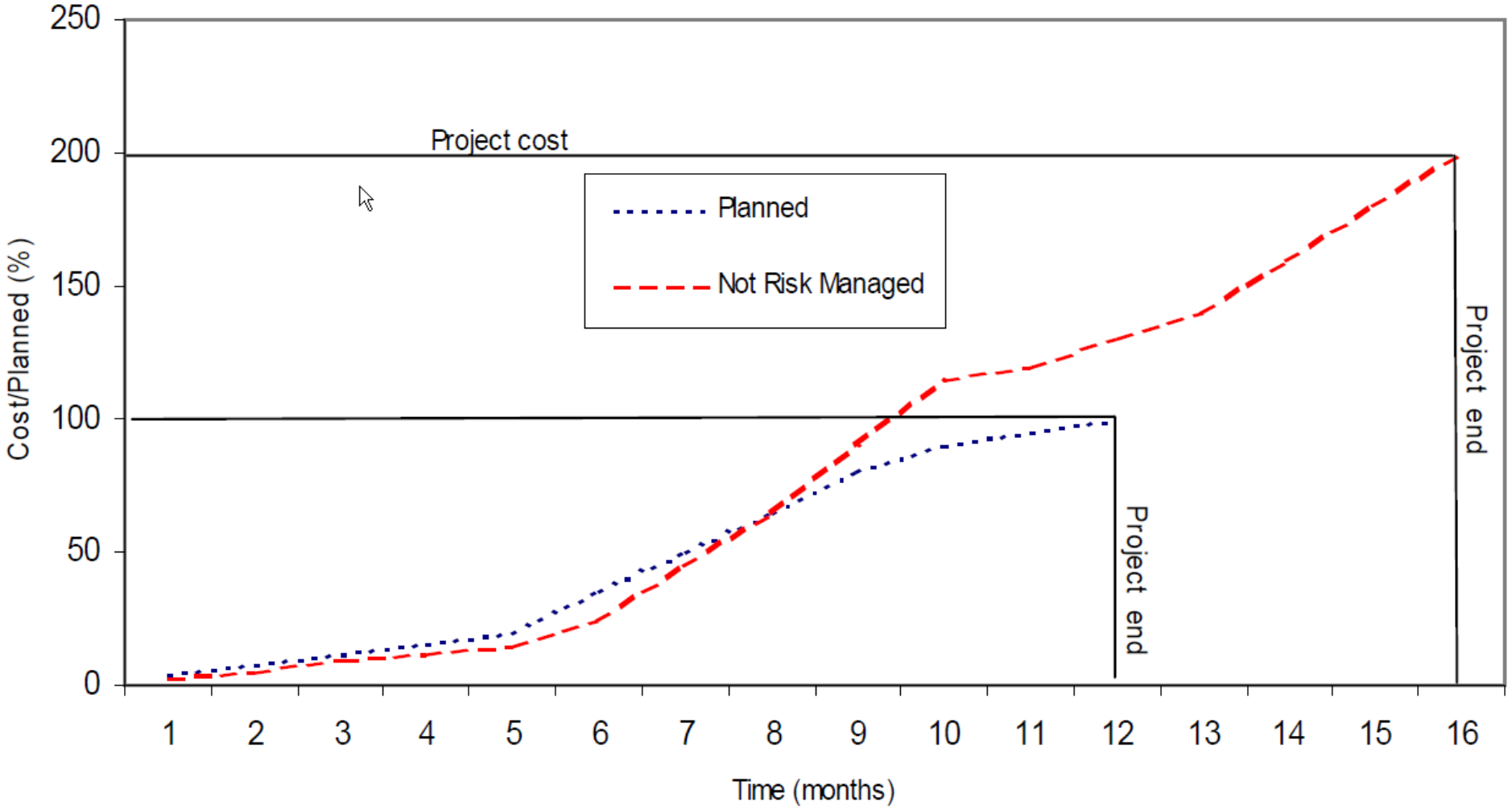
- Project Success
  - The project is completed within a finite **timescale** and **budget**; and to a nominated standard of **quality.**



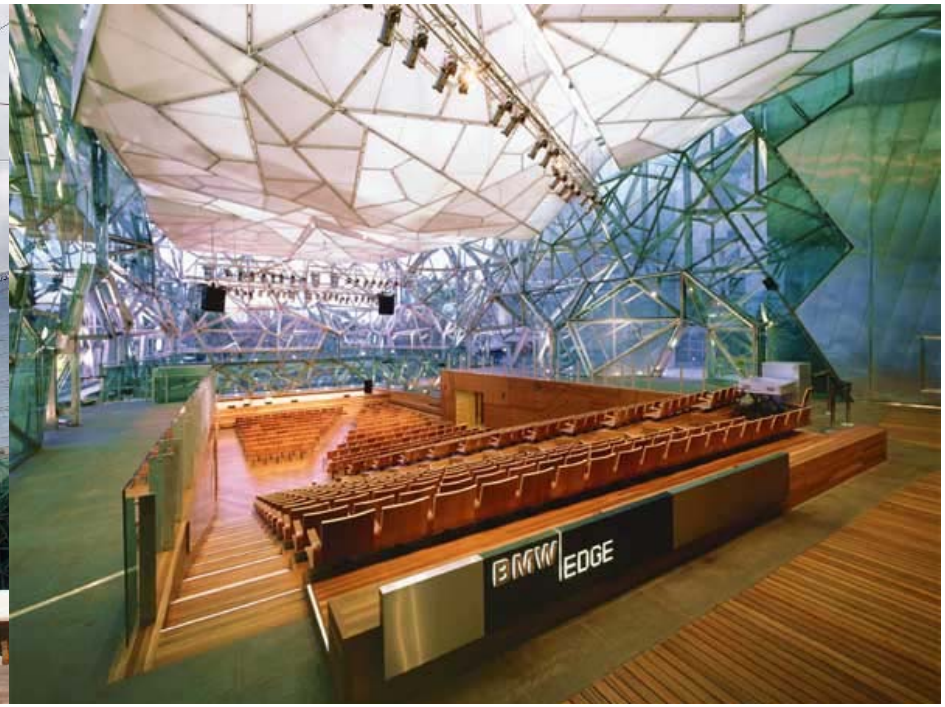
Engineering Risks

- Project dynamics
  - Time
    - Baseline schedule, expected, actual time
  - Cost
    - Base cost, delay, adjustment, overrun
  - Quality
    - Scope, technical standards, benefits

Engineering Risks



Federation Square



Federation Square

- Time
  - Architectural design competition awarded in 1997
  - Construction began in 1998
  - The square is expected to open in Spring 2001
  - Officially opened on October 26th 2002

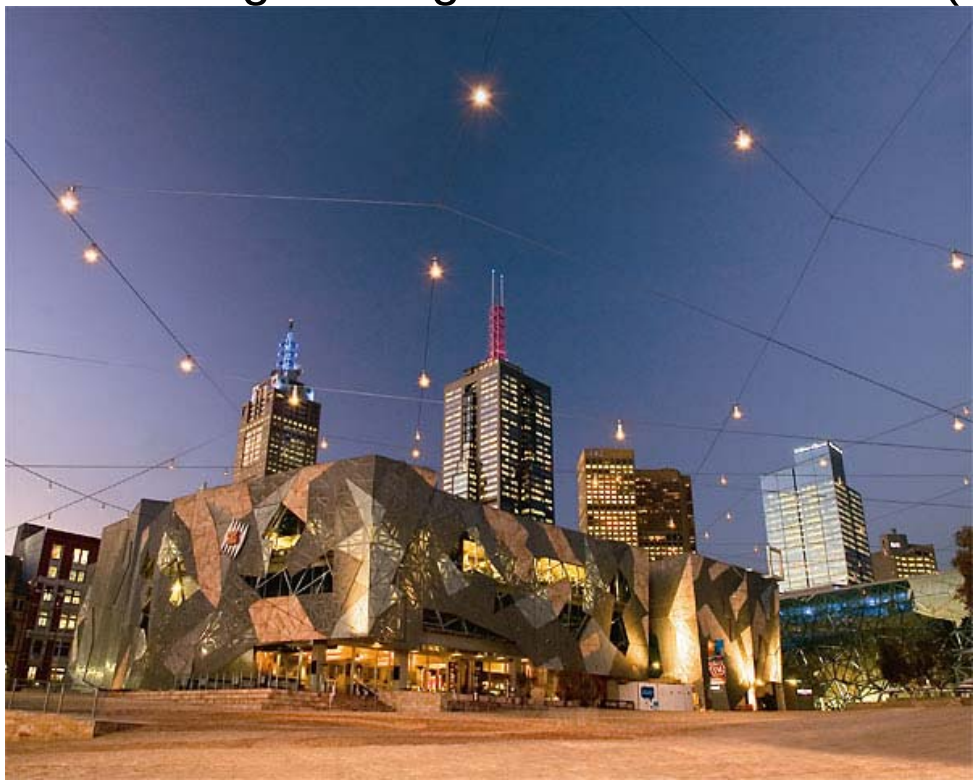
Risk Management

- Cost
  - Original estimate - AU$110m (1998)
  - AU$100m over its original budget in 2000
  - Actual cost around AU$470m in 2002

LAB architecture studio + Bates Smart federation square at night- photography john gollings

Risk Management

- Quality
  - Urban Land Institute – International Awards (2005)
  - The Australian Construction Achievement Awards (2004)
  - Victorian Tourism Awards (2004)
  - The Australian Engineering Excellence Awards (2003)

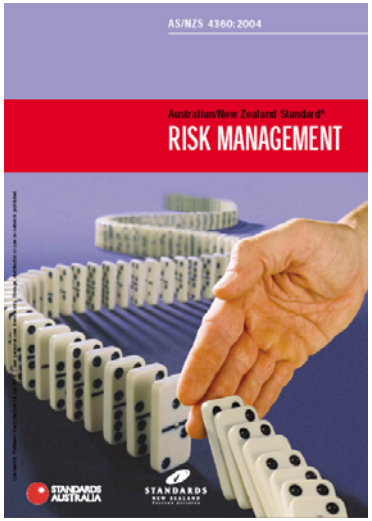


So, was the project a success…?

- Unconscious observation of risks
- Reactive response to emerging issues.
- Sustained cost and time escalation.
- Cash flow issues – not enough cash at stages to pay contractors
- Budget moved from $110M to $471M, and time overruns.
- Reputation

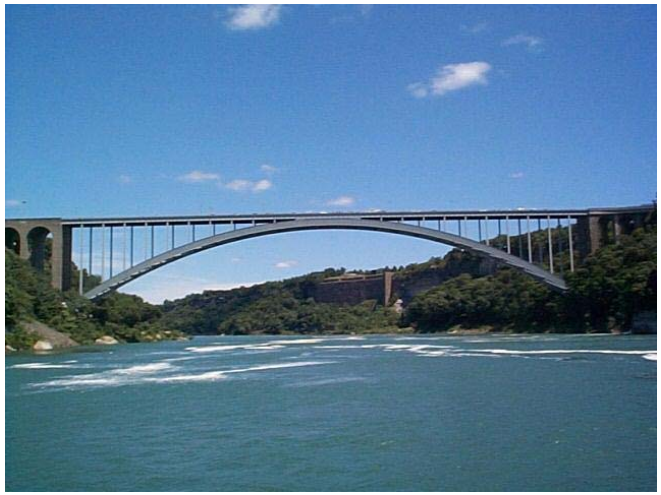
Risk Management

- Australian/New Zealand Risk Management Standard
  - AS/NZS/ISO 31000:2009 as a revision of AS/NZS 43600: 2004
  - It provides principles and generic guidelines on risk management
  - It can be applied to any type of risk, whatever its nature, whether having positive or negative consequences
  - Universal application across all organisations –International



Risk Management

- Risk management process
  - Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk



Establish the context

Identify the risks

Analyse the risks

Evaluate the risks

Treat the risks

Monitoring and review

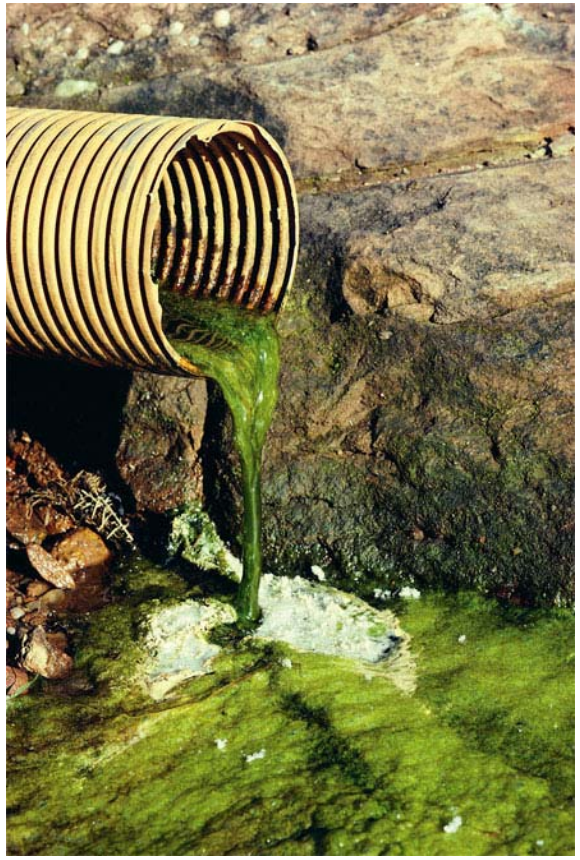
Principles of Risk Management Standard (AS/NZS ISO 31000:2009)

Risk Management Principles

- Establish the context
  - Define the basic parameters
  - Set the purpose and scope for the risk management
  - The context includes the organization's external and internal environment and the purpose of the risk management activity
    - External context – business, social, regulatory, cultural, competitive, financial, political environment, external stakeholders …
    - Internal context – internal stakeholders, capabilities, resources (e.g. people, capital) …

Risk Management Principles

- Identify risks
  - What can happen?
  - When and where?
  - How and why?
  - Who is involved or affected?
- Historic information, expert option



Risk Management Principles

- Risk analysis
  - Develop an understanding of risk
    - Whether risks need to be treated?
    - What is the cost of the treatment?
  - Consequences and likelihood
    - Source of information – past records, relevant experience, experiments, expert judgements …
    - Techniques – structured interviews with experts, use models and simulations

Risk Management Principles

- Risk analysis - Qualitative analysis
  - Use words to describe the magnitude of potential risk likelihood and consequences
  - Often used first to obtain a general indication
  - Later it may be necessary to undertake quantitative analysis on the major risk issues

Risk Management Principles

- Risk analysis - Qualitative analysis
  - Likelihood

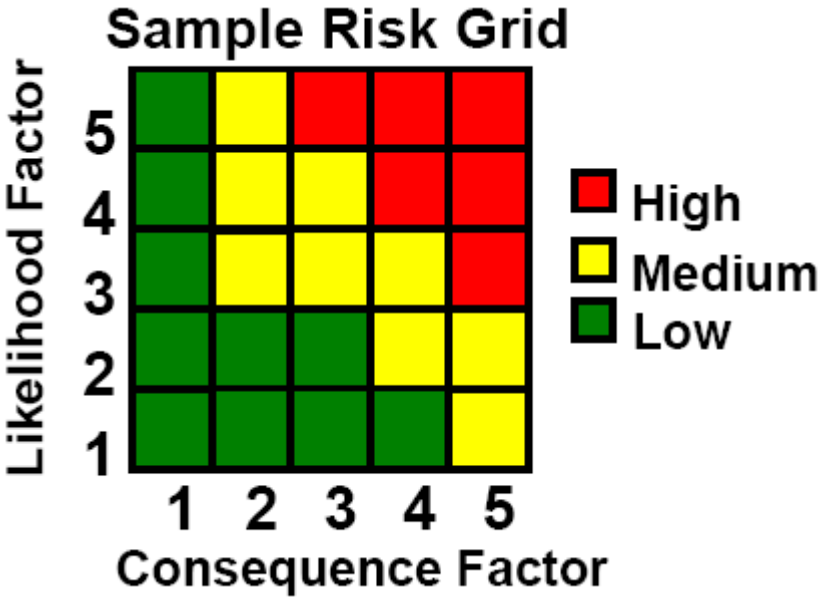
Level	Descriptor	Description
1	Low	The event may occur only in exceptional circumstances
2	Minor	The event could occur at some time
3	Moderate	The event should occur at some time
4	Significant	The event will probably occur in most circumstances
5	High	The event is expected to occur in most circumstances

  - Consequence

Level	Descriptor	Description
1	Low	No injuries, low financial loss
2	Minor	First aid treatment, medium financial loss
3	Moderate	Medical treatment required, high financial loss
4	Significant	Extensive injuries, loss of production capability, major financial loss
5	High	Death, huge financial loss

Risk Management Principles

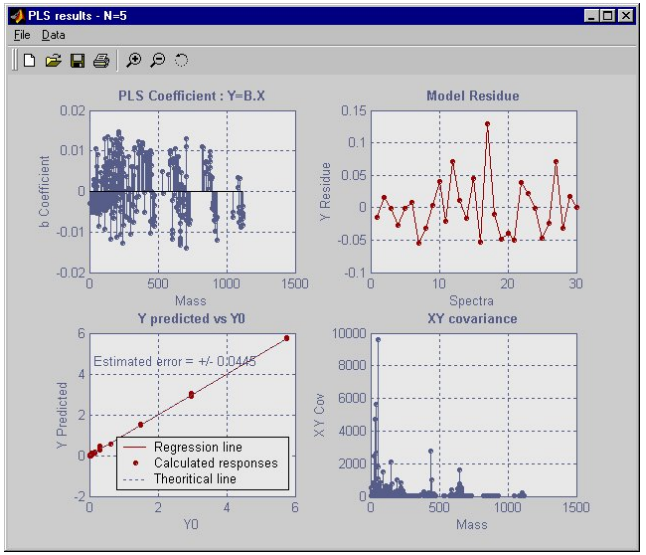
- Risk analysis - Qualitative analysis



1 – Low
2 – Minor
3 – Moderate
4 – Significant
5 - High

Risk Management Principles

- Risk analysis - Quantitative analysis
  - Use numerical values for both consequences and likelihood analysis using a variety of sources
  - Statistical theory
    - Sampling
    - Probability
    - Commonly used distributions
    - Confidence intervals
    - Hypothesis testing
    - Correlation and linear regression
    - Monte-Carlo simulation



Risk analysis - Quantitative analysis

Consider a machine that makes steel bars for use in building construction. The specification for the diameter of the bars is 2.0+/- 0.1 cm. During the last hour, the machine has made 1000 rods.

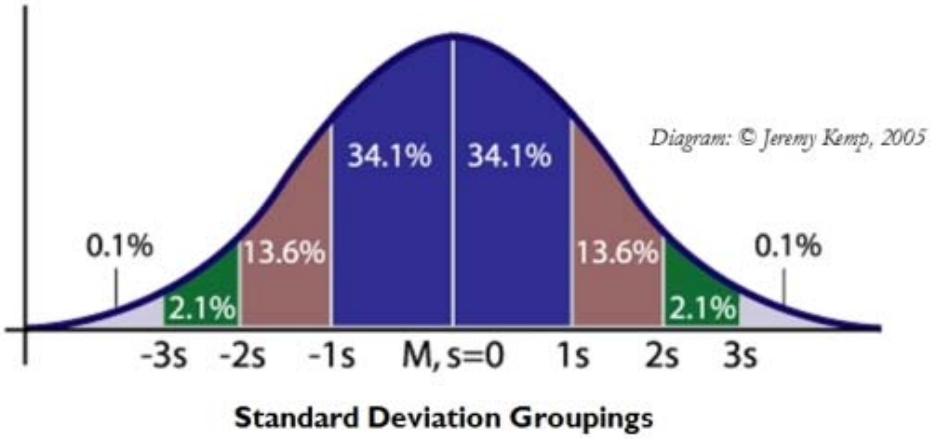
The quality engineer draws a random sample of 50 rods, measures them, and finds that 46 of them (92%) meet the diameter specification.

It is unlikely that the sample of 50 bars represents the population of 1000 perfectly !

Questions

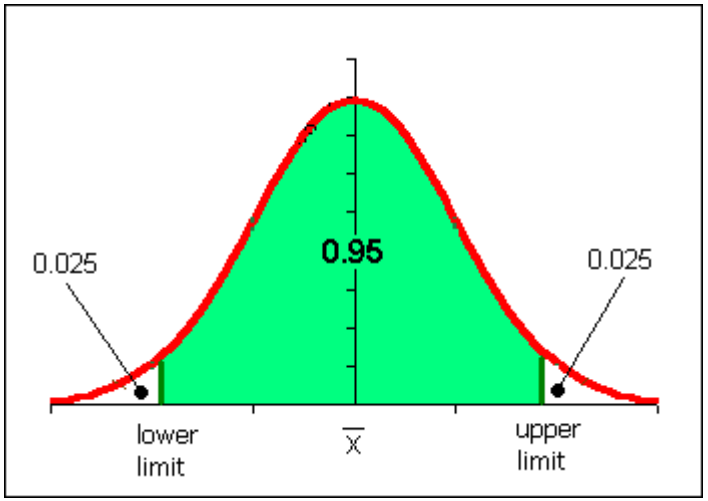
- The likely size of the difference between the sample mean and the population mean. How large is a typical difference for this kind of sample?
  - Requires the computation of a **Standard Deviation**

$$\sigma = \sqrt{\frac{\sum (x_i - m)^2}{n-1}}$$



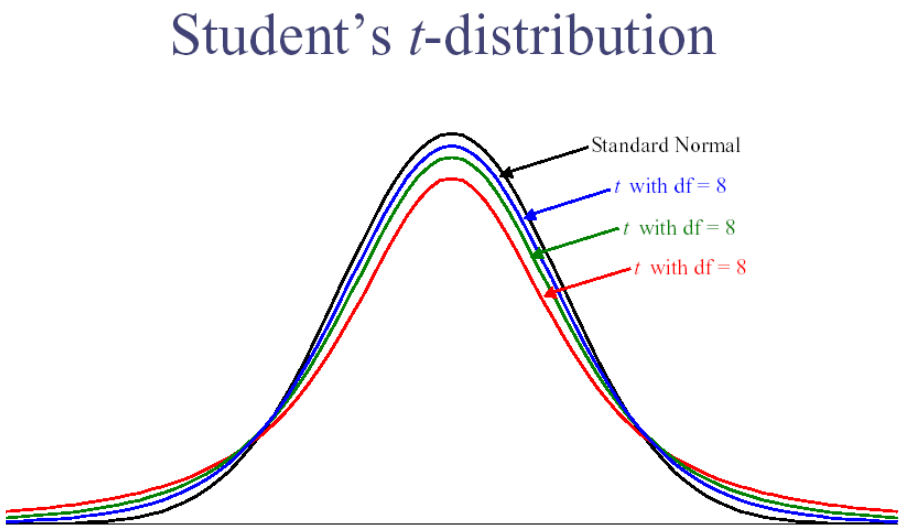
Questions

- Having observed that 92% of the sample bars were good, it indicates that the percentage of acceptable bars in the population as an interval of the form 92% +/ x%. How should x be calculated?
  - Requires the construction of a **Confidence Interval**



Questions

- The engineer wants to be fairly certain that the good steel bars >= 90%; otherwise the machine will be shut down for recalibration. How certain can he be that at least 90% of the 1000 bars are good?
  - Requires a Hypothesis Test



Risk Management Principles

- Risk evaluation
  - Make decisions based on the outcomes of risk analysis
  - Rank the risks by likelihood, possible cost and consequence. Determine
    - Which risks need treatment
    - Treatment priorities

Treat risks

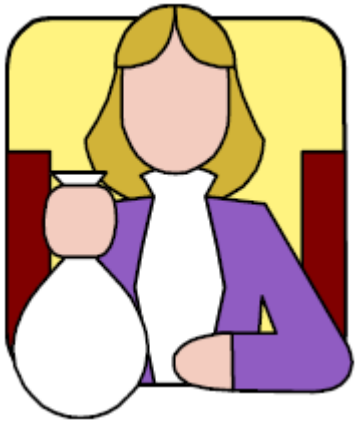
- Treat risks
  - Assessing risk treatment options (e.g. balancing the costs against the benefits)
  - Preparing and implementing treatment plans with consideration of priorities, resource, responsibilities and etc.
  - Documentation

Monitor and review

- Monitor and review
  - Monitor activities and processes to determine the accuracy of planning assumptions and the effectiveness of the measures taken to treat the risk
  - Method can include data evaluation, audit, compliance measurement

Risk Management Principles

- Communicate and consult
  - Dialogue with stakeholders
    - Values, needs, concerns and etc.
  - A consultative team
    - Help ensure risks are identified effectively
    - Bring different areas of expertise together in analysing risks.



Risk Management Principles