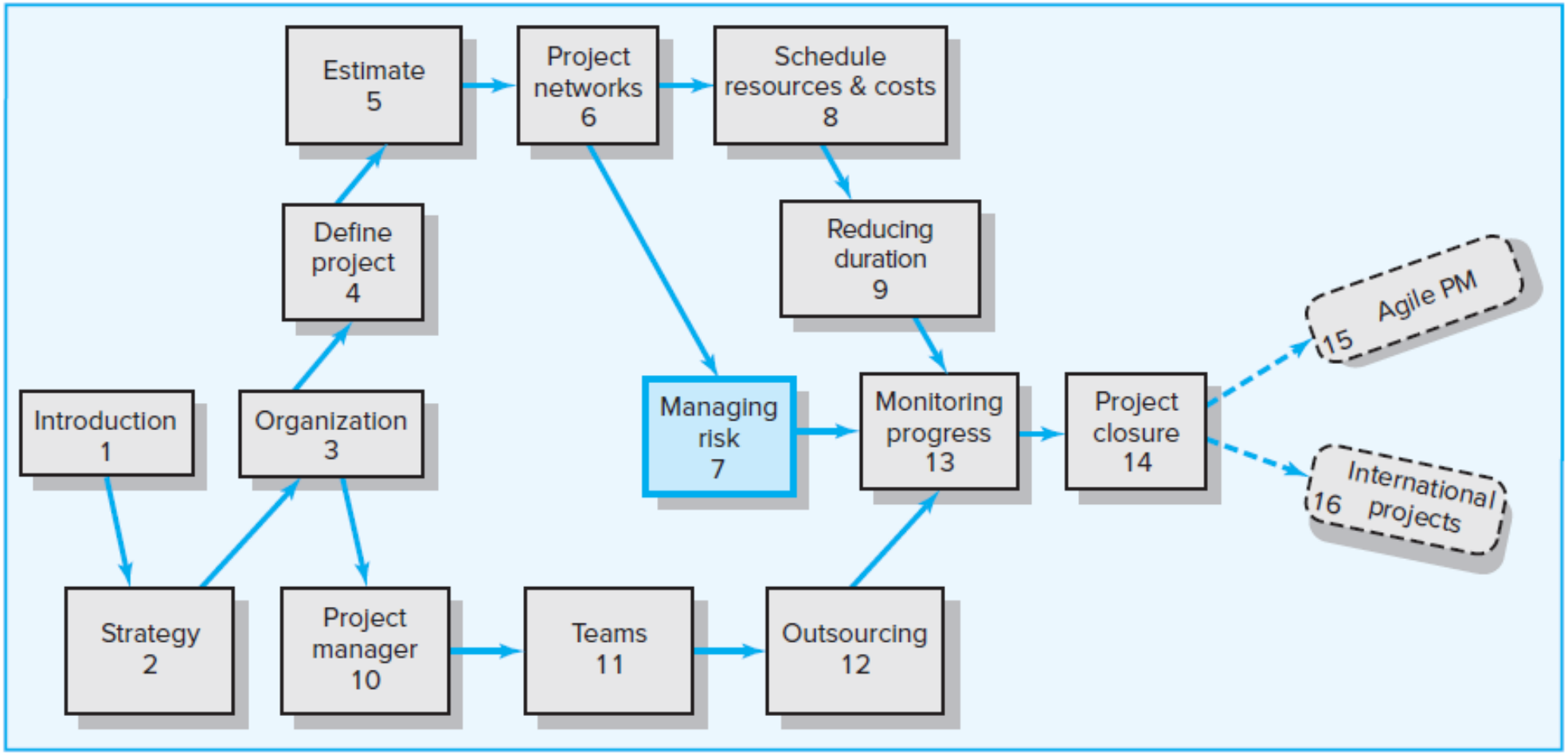
OntarioTech
Engineering
& Applied Science

Project Management for Engineers - ENGR 5410G
Fall 2024

Unit 6:
Managing Risk (ch 7)

Where We Are Now



Learning Objectives

07-01 Describe the risk management process.

07-02 Understand how to identify project risks.

07-03 Assess the significance of different project risks.

07-04 Describe the five responses to managing risks.

07-05 Understand the role contingency plans play in the risk management process.

07-06 Understand opportunity management and describe the five approaches to responding to opportunities in a project.

07-07 Understand how contingency funds and time buffers are used to manage risks on a project.

07-08 Recognize the need for risk management being an ongoing activity.

07-09 Describe the change control process.

Chapter Outline

7.1 Risk Management Process

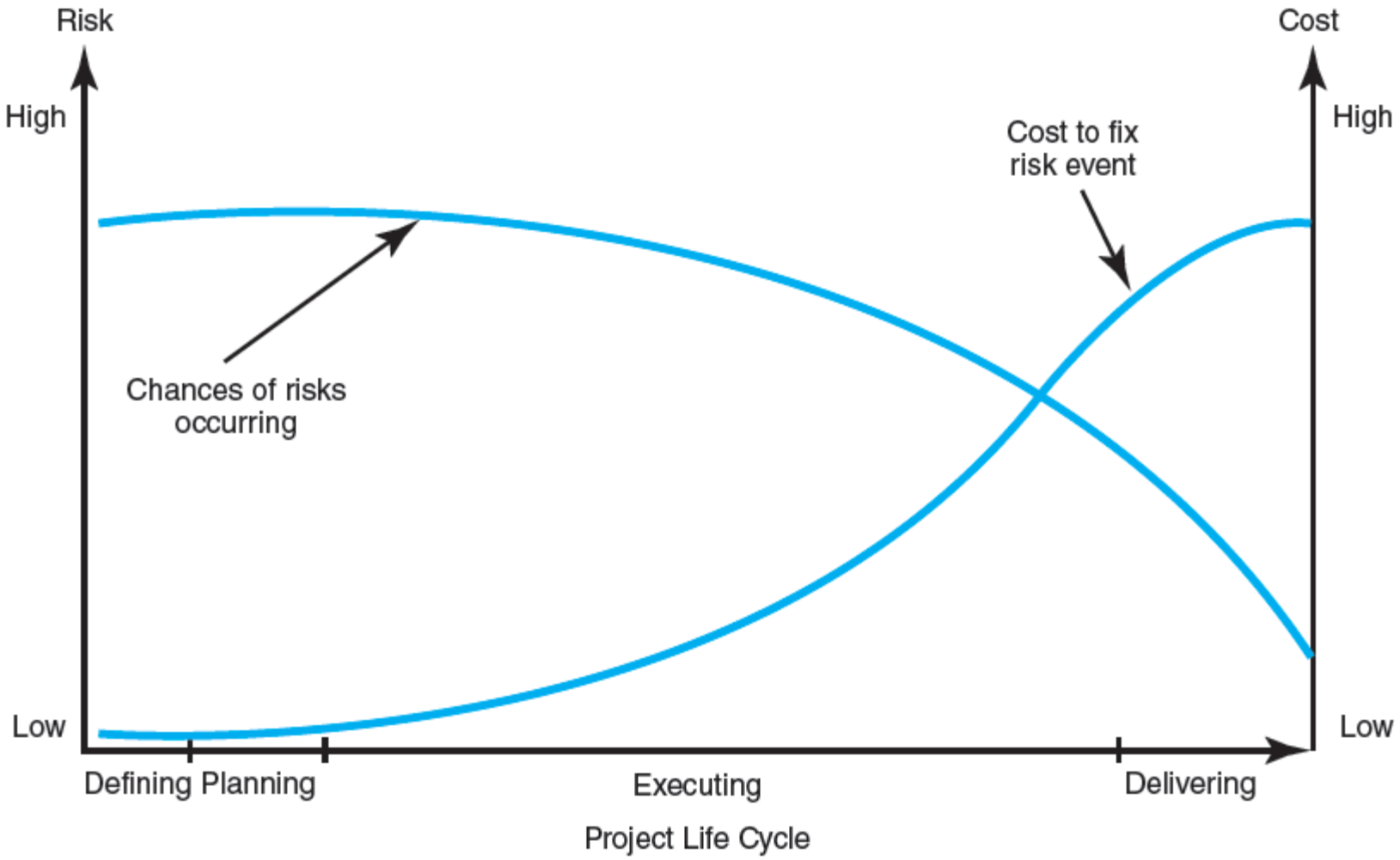
- **Risk Defined**

- An uncertain event or condition that if it occurs, has a positive or negative effect on project objectives.
- No amount of planning can overcome or control risk.

- **Risk Management Defined**

- An attempt to recognize and manage potential and unforeseen trouble spots that may occur when the project is implemented.
  - What can go wrong (risk event)
  - How to minimize the risk event's impact (consequences)
  - What can be done before an event occurs (anticipation)
  - What to do when an event occurs (contingency plans)

Risk Event Graph



- **FIGURE 7.1**

Benefits of Risk Management

- A proactive rather than reactive approach
- Reduces surprises and negative consequences
- Prepares the project manager to take appropriate action
- Provides better control over the future
- Improves chances of reaching project objectives on time, within budget, and of meeting required performance.

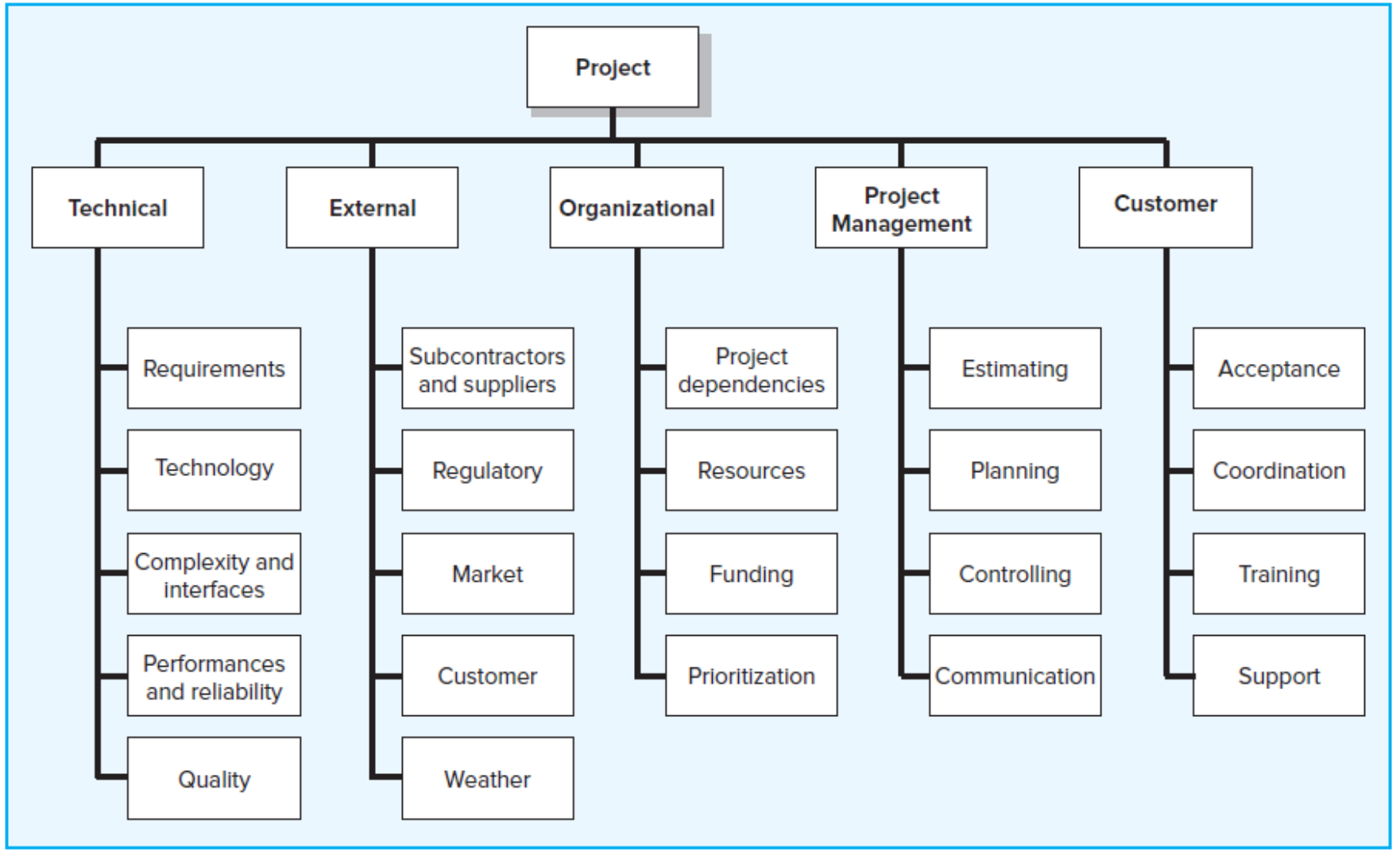
The Risk Management Process

- **FIGURE 7.2**

7.2 Step 1: Risk Identification

- Generate a list of all the possible risks that could affect the project through brainstorming and other problem identifying techniques.
- Focus on the events that could produce consequences, not on project objectives.
- Use risk breakdown structure (RBS) in conjunction with work breakdown structure (WBS) to identify and analyze risks.
- Identify the macro risks first then specific areas can be checked.
- Use risk profile (a list of questions) to address traditional areas of uncertainty on a project.

The Risk Breakdown Structure (RBS)



- **FIGURE 7.3**

Partial Risk Profile for Product Development Project

Technical Requirements

Are the requirements stable?

Design

Does the design depend on unrealistic or optimistic assumptions?

Testing

Will testing equipment be available when needed?

Development

Is the development process supported by a compatible set of procedures, methods, and tools?

Schedule

Is the schedule dependent upon the completion of other projects?

Budget

How reliable are the cost estimates?

Quality

Are quality considerations built into the design?

Management

Do people know who has authority for what?

Work Environment

Do people work cooperatively across functional boundaries?

Staffing

Is staff inexperienced or understaffed?

Customer

Does the customer understand what it will take to complete the project?

Contractors

Are there any ambiguities in contractor task definitions?

- FIGURE 7.4

7.3 Step 2: Risk Assessment

- **Scenario analysis** assesses the significance of each risk event in terms of probability and impact.
- **Risk assessment form** evaluates the severity, probability of risk events and its detection difficulty.
- **Risk severity matrix** prioritizes which risks to address.
  - **Failure Mode and Effects Analysis (FMEA)** extends the risk severity matrix by including ease of detection in the equation:

Risk Value = Impact x Probability x Detection

- **Probability analysis** uses statistical techniques in assessing project risk.
  - Decision trees, net present value (NPV), program evaluation and review technique (PERT), PERT simulation

Defined Conditions for Impact Scales of a Risk on Major Project Objectives (examples for negative impacts only)

	Relative or Numerical Scale				
Project Objective	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Cost	Insignificant cost increase	< 10% cost increase	10–20% cost increase	20–40% cost increase	> 40% cost increase
Time	Insignificant time increase	< 5% time increase	5–10% time increase	10–20% time increase	> 20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

- **FIGURE 7.5**

Risk Assessment Form

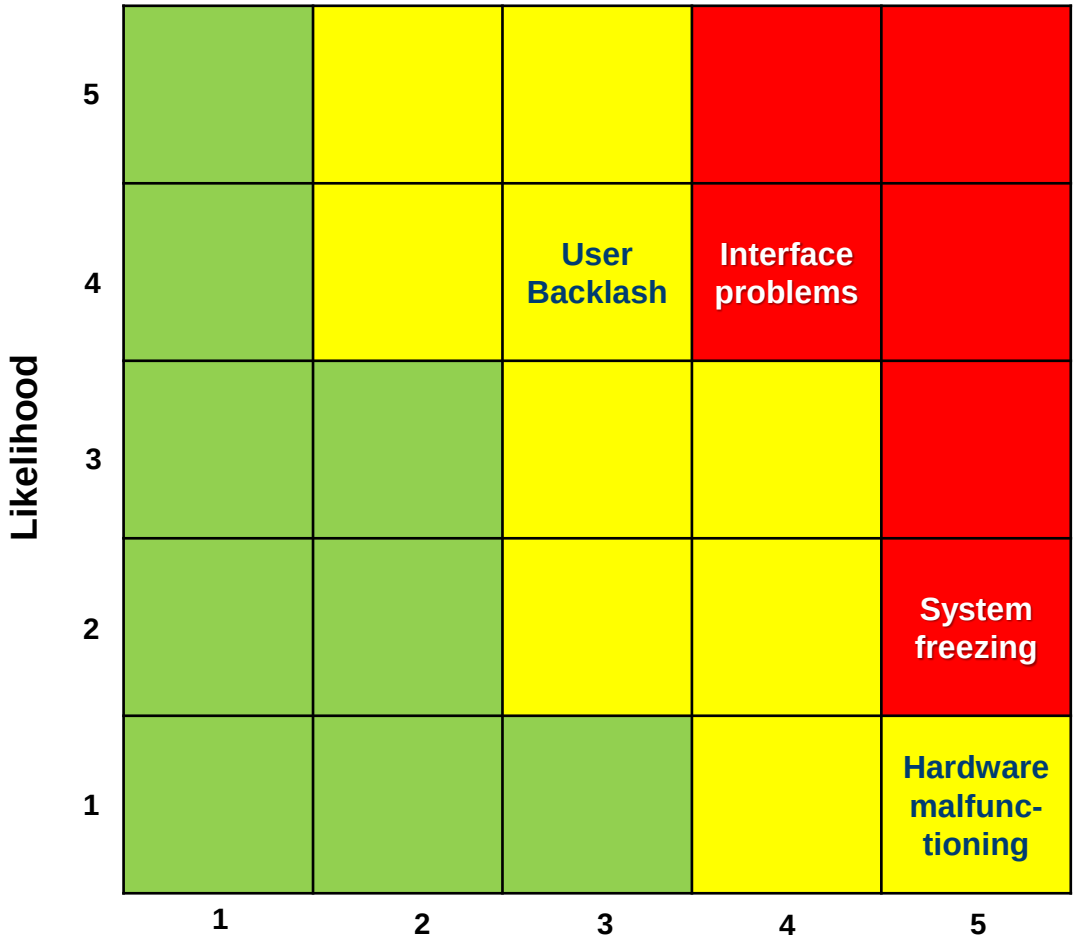
Risk Event	Likelihood	Impact	Detection Difficulty	When
Interface problems	4	4	4	Conversion
System freezing	2	5	5	Start-up
User backlash	4	3	3	Postinstallation
Hardware malfunctioning	1	5	5	Installation

FIGURE 7.6

Risk Severity Matrix

Failure Mode and Effects Analysis (FMEA)

Impact × Probability × Detection = Risk Value



- FIGURE 7.7

Red zone (major risk)
Yellow zone (moderate risk)
Green zone (minor risk)

7.4 Step 3: Risk Response Development

- **Mitigating Risk**
  - Reducing the likelihood that the event will occur
  - Reducing the impact that the adverse event would have on the project
- **Avoiding Risk**
  - Changing the project plan to eliminate the risk or condition
- **Transferring Risk**
  - Passing risk to another party
    - Examples: Fixed-price contracts, insurance, Build-Own-Operate-Transfer (BOOT) provisions
- **Escalating Risk**
  - Notifying the appropriate people within the organization of the threat
- **Retaining Risk**
  - Making a conscious decision to accept the risk of an event occurring

7.5 Contingency Planning

- **Contingency Plan Defined**

- Is an alternative plan that will be used if a possible foreseen risk event becomes a reality.
- Is a plan of action that will reduce or mitigate the negative impact of the risk event.
- Is not a part of the initial implementation plan and only goes into effect after the risk is recognized.

- **Risks of the absence of a contingency plan**

- Cause a manager to delay or postpone the decision to implement a remedy
- Lead to panic and acceptance of the first remedy suggested
- Make the decision making under pressure which can be dangerous and costly

Risk Response Matrix

- **FIGURE 7.8**

Risk Event	Response	Contingency Plan	Trigger	Who Is Responsible
Interface problems	Mitigate: Test prototype	Work around until help comes	Not solved within 24 hours	Nils
System freezing	Mitigate: Test prototype	Reinstall OS	Still frozen after one hour	Emmylou
User backlash	Mitigate: Prototype demonstration	Increase staff support	Call from top management	Eddie
Equipment malfunctions	Mitigate: Select reliable vendor Transfer: Warranty	Order replacement	Equipment fails	Jim

Risk and Contingency Planning

- **Technical Risks**
  - Backup strategies if chosen technology fails
  - Assess whether technical uncertainties can be resolved
- **Schedule Risks**
  - Expedite or “crash” the project to get it back on track
  - Schedule activities in parallel or use start-to-start lag relationships
  - Use the best people for high-risk tasks
- **Cost Risks**
  - Review price to avoid the trap of using one lump sum to cover price risks
- **Funding Risks**
  - Evaluate the risk of reductions in funding—a cut in the project

7.6 Opportunity Management

- An **opportunity** is an event that can have positive impact on project objectives.
- **Exploit**
  - Seek to eliminate the uncertainty associated with an opportunity to ensure that it definitely happens
- **Share**
  - Allocate some or all of the ownership of an opportunity to another party who is best able to capture the opportunity for the benefit of the project
- **Enhance**
  - Take action to increase the probability and/or the positive impact of an opportunity
- **Escalate**
  - Notify the appropriate people within the organization of the opportunity
- **Accept**
  - Be willing to take advantage of the opportunity if it occurs, but not taking action to pursue it

7.7 Contingency Funding and Time Buffers

- **Contingency Funds**

- Are funds to cover project risks—identified and unknown
- For control purposes, contingency funds are divided into
  - Contingency reserves—cover identified risks and allocated to specific segments or deliverables of the project
  - Management reserves—cover unidentified risks and are allocated to risks associated with the total project

- **Time Buffers**

- Are amounts of time used to cushion against potential delays in the project
  - Add to activities with severe risks
  - Add to merge activities that are prone to delays
  - Add to noncritical activities to reduce the likelihood that they will create another critical path
  - Add to activities that require scare resources

Budget Estimate

- TABLE 7.1

Activity	Budget Baseline	Budget Reserve	Project Budget
Design	$500,000	$15,000	$515,000
Code	900,000	80,000	980,000
Test	20,000	2,000	22,000
Subtotal	$1,420,000	$97,000	$1,517,000
Management reserve	—	—	50,000
Total	$1,420,000	$97,000	$1,567,000

7.4 Step 4: Risk Response Control

- **Risk Register**
  - Details all identified risks, including descriptions, category, probability of occurring, impact, responses, contingency plans, owners, and current status
- **Risk Control** involves
  - Executing the risk response strategy
  - Monitoring triggering events
  - Initiating contingency plans
  - Watching for new risks

Establishing a Change Management System

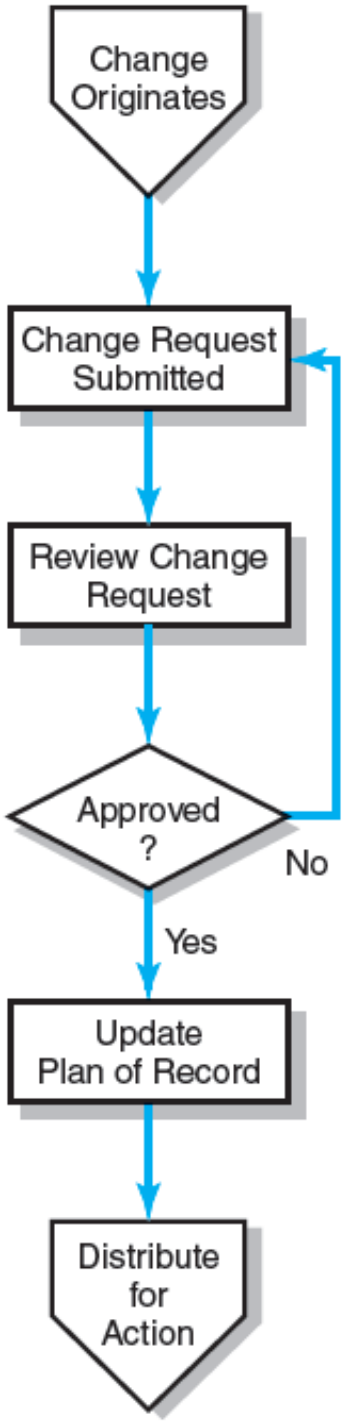
- Monitoring, tracking, and reporting risk
- Fostering an open organization environment
- Repeating risk identification/assessment exercises
- Assigning and documenting responsibility for managing risk

7.9 Change Control Management

- **Sources of Change**
  - Project scope changes
  - Implementation of contingency plans
  - Improvement changes
- **Change Management Systems**

1. Identify proposed changes
2. List expected effects of proposed change(s) on schedule and budget
3. Review, evaluate, and approve or disapprove of changes formally
4. Negotiate and resolve conflicts of change, condition, and cost
5. Communicate changes to parties affected
6. Assign responsibility for implementing change
7. Adjust master schedule and budget
8. Track all changes that are to be implemented

Change Control Process



- **FIGURE 7.9**

Benefits of Change Control Systems

1. Inconsequential changes are discouraged by the formal process.
2. Costs of changes are maintained in a log.
3. Integrity of the WBS and performance measures is maintained.
4. Allocation and use of contingency and management reserves are tracked.
5. Responsibility for implementation is clarified.
6. Effect of changes is visible to all parties involved.
7. Implementation of change is monitored.
8. Scope changes will be quickly reflected in baseline and performance measures.

Sample Change Request

Project name *Irish/Chinese culture exchange* Project sponsor *Irish embassy*

Request number *12* Date *June 6, 2xxx*

Originator *Jennifer McDonald* Change requested by *Chinese culture office*

Description of requested change

1. *Request river dancers to replace small Irish dance group.*
2. *Request one combination dance with river dancers and China ballet group.*

Reason for change

River dancers will enhance stature of event. The group is well known and loved by Chinese people.

Areas of impact of proposed change–describe each on separate sheet

[X] Scope [X] Cost [ ] Other _____

[ ] Schedule [ ] Risk

Disposition	Priority	Funding Source
[ ] Approve	[ ] Emergency	[ ] Mgmt. reserve
[X] Approve as amended	[X] Urgent	[ ] Budget reserve
[ ] Disapprove	[ ] Low	[X] Customer
[ ] Deferred		[ ] Other

Sign-off Approvals

Project manager *William O'Mally* Date *June 12, 2xxx*

Project sponsor *Kenneth Thompson* Date *June 13, 2xxx*

Project customer *Hong Lee* Date *June 18, 2xxx*

Other _____ Date _____

- **FIGURE 7.10**

Change Request Log

Owner Requested Change Status Report—Open Items — **OSU—Weatherford**

Rc#	Description	Reference Document	Dates: Date Rec'd	Dates: Date Submit	Amount	Status	Comments
51	Sewer work offset				–188,129	OPEN	FUNDING FROM OTHER SOURCE
52	Stainless Plates at restroom Shower Valves	ASI 56	1/5/2020	3/30/2020	9,308	APPROVED	
53	Waterproofing Options	ASI 77	1/13/2020		169,386	OPEN	
54	Change Electrical floor box spec change	RFI 113	12/5/2020	3/29/2020	2,544	SUBMIT	
55	VE Option for Style and rail doors	Door samples	1/14/2020		–20,000	ROM	
56	Pressure Wash C tower	Owner request	3/15/2020	3/30/2020	14,861	SUBMIT	
57	Fire Lite glass in stairs	Owner request			8,000	QUOTE	ROM BASED ON FIRELITE NT
58	Cyber Café added tele /OFOI equipment	ASI 65	1/30/2020	3/29/2020	4,628	APPROVED	
59	Additional Dampers in C wing	ASI 68	2/4/2020	3/29/2020	1,085	SUBMIT	
60	Revise Corridor ceilings	ASI 72	2/13/2020	3/31/2020	–3,755	SUBMIT	

OPEN—Requires estimate
ROM—Rough order magnitude
QUOTE—Subcontractor quotes
SUBMIT—RC letter submitted
APPROVED—RC letter approved
REVISE—RC letter to be reviewed
ASI—Architect's supplemental instructions
RFI—Request for information

- **FIGURE 7.11**

Key Terms

- Avoiding risk
- Change management system
- Contingency plan
- Contingency reserves
- Escalating risk
- Management reserves
- Mitigating risk
- Opportunity
- Retaining risk
- Risk
- Risk breakdown structure (RBS)
- Risk profile
- Risk register
- Risk severity matrix
- Scenario analysis
- Time buffer
- Transferring risk

Appendix 7.1

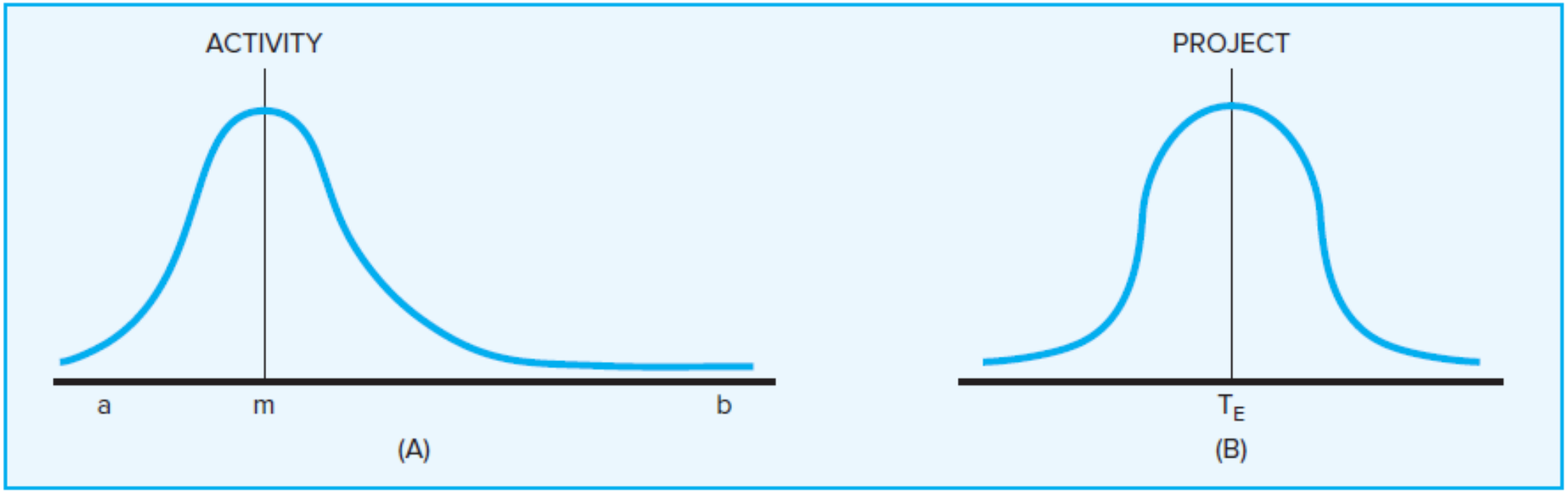
PERT and PERT Simulation

PERT—Program Evaluation and Review Technique

- Assumes each activity duration has a range that statistically follows a beta distribution
- Uses three time estimates for each activity: optimistic, pessimistic, and a most likely time estimate to represent activity durations
  - From these three time estimates, a weighted average time estimate and a variance is calculated
  - Knowing the weighted average and variances for each activity allows the project planner to compute the probability of meeting different project durations
  - The longer the project duration is, the higher is the probability of meeting that duration

Activity and Project Frequency Distributions

- **FIGURE A7.1**



Activity Time Calculations

The weighted average activity time is computed by the following formula:

$$t_e = \frac{a + 4m + b}{6} \qquad (7.1)$$

where t_e = weighted average activity time

a = optimistic activity time (1 chance in 100 of completing the activity earlier under *normal* conditions)

b = pessimistic activity time (1 chance in 100 of completing activity later under *normal* conditions)

m = most likely activity time

Activity Time Calculations (Continued)

The variability in the activity time estimates is approximated by the following equations:

The standard deviation for the *activity*

$$\sigma_{t_e} = \left(\frac{b - a}{6}\right) \qquad (7.2)$$

The standard deviation for the *project*

$$\sigma_{T_E} = \sqrt{\sum \sigma_{t_e}^2} \qquad (7.3)$$

The above formula is just the square-root of the sum of the variances of all critical tasks

Activity Times and Variances

- TABLE A7.1

Activity	a	m	b	t_e	$[(b-a)/6]^2$
1–2	17	29	47	30	25
2–3	6	12	24	13	9
2–4	16	19	28	20	4
3–5	13	16	19	16	1
4–5	2	5	14	6	4
5–6	2	5	8	5	1

Probability of Completing the Project

The equation below is used to compute the "*Z*" value found in statistical tables (*Z* = number of standard deviations from the mean), which, in turn, tells the probability of completing the project in the time specified.

$$Z = \frac{T_S - T_E}{\sqrt{\sum \sigma_{t_e}^2}} \qquad (7.4)$$

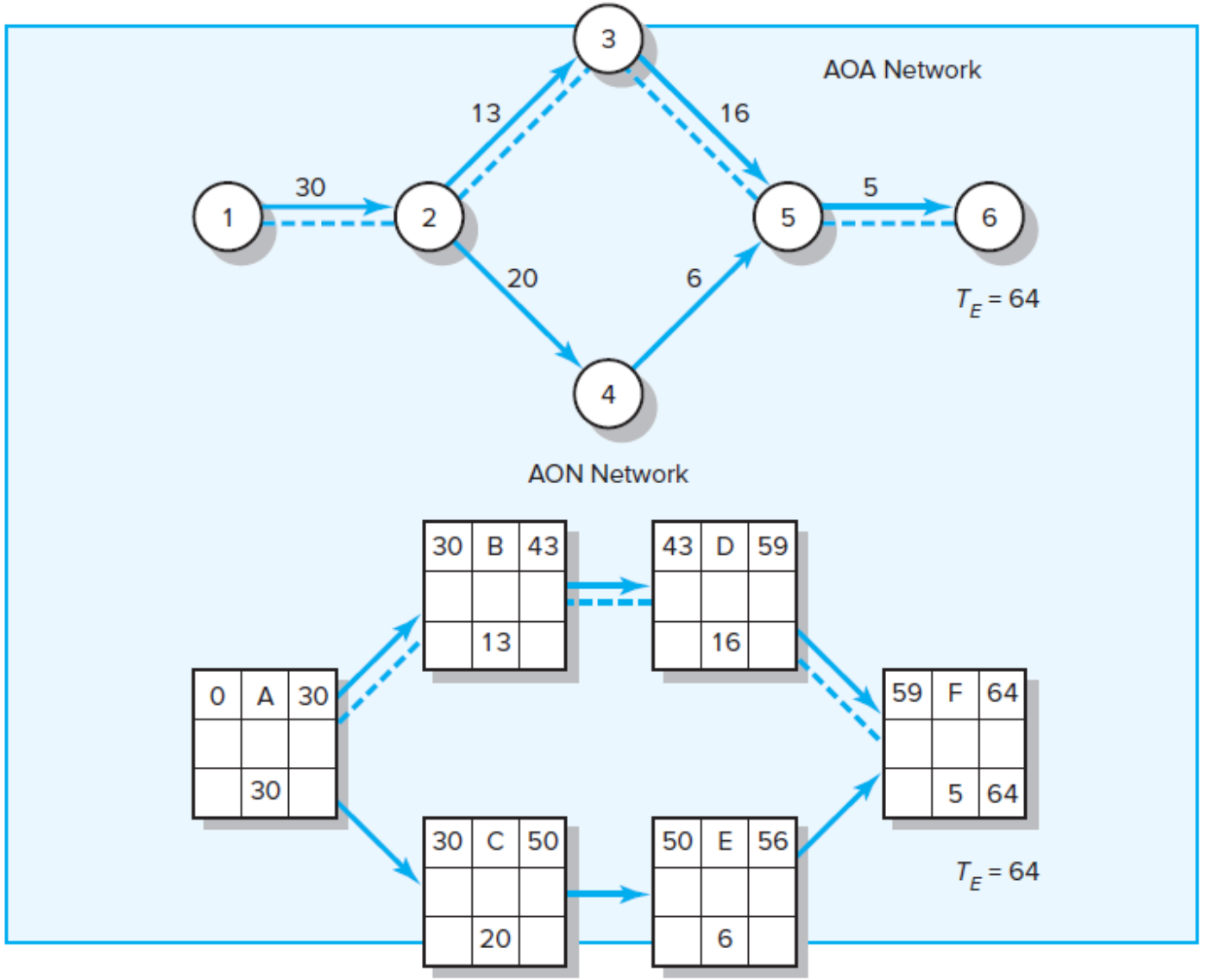
where T_E = critical path duration

T_S = scheduled project duration

Z = probability (of meeting scheduled duration)

(see statistical Table A7.2)

Hypothetical Network



- **FIGURE A7.2**

Possible Project Durations

Probability project is completed before scheduled time (T_S) of 67 units

$$Z = \frac{T_S - T_E}{\sqrt{\Sigma\sigma^2_{t_e}}}$$

$$= \frac{67 - 64}{\sqrt{25 + 9 + 1 + 1}}$$

$$= \frac{+3}{\sqrt{36}}$$

$$= +0.50$$

$$P = 0.69$$

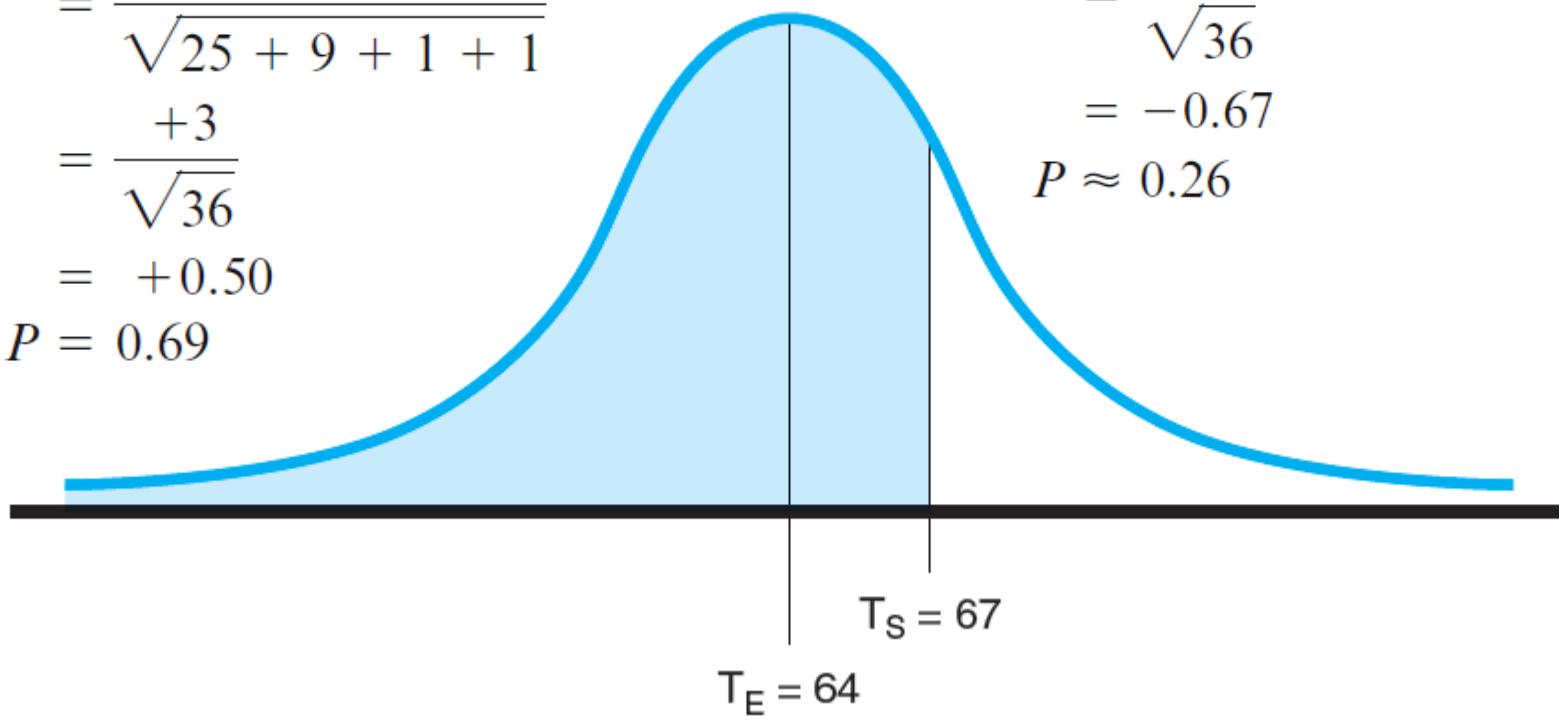
Probability project is completed by the 60th unit time period (T_S)

$$Z = \frac{60 - 64}{\sqrt{25 + 9 + 1 + 1}}$$

$$= \frac{-4}{\sqrt{36}}$$

$$= -0.67$$

$$P \approx 0.26$$



- FIGURE A7.3

Z Values and Probabilities

Z Value	Probability	*Z* Value	Probability
−3.0	.001	+0.0	.500
−2.8	.003	+0.2	.579
−2.6	.005	+0.4	.655
−2.4	.008	+0.6	.726
−2.2	.014	+0.8	.788
−2.0	.023	+1.0	.841
−1.8	.036	+1.2	.885
−1.6	.055	+1.4	.919
−1.4	.081	+1.6	.945
−1.2	.115	+1.8	.964
−1.0	.159	+2.0	.977
−0.8	.212	+2.2	.986
−0.6	.274	+2.4	.992
−0.4	.345	+2.6	.995
−0.2	.421	+2.8	.997

- TABLE A7.2

Any Questions!