# College of Science & Technology

**Risk Management in Construction Engineering**

# Risk Management

- Risks are ever present
- The management of risk is an area of significant expansion over the last decade.
- Within the construction and process industries the consequences of an accident can be significant .
- Detailed management of risks are routinely carried out, conducted at all stages of a project life cycle
- This lecture will:
  - Define risk concepts.
  - Introduce the Risk Management Procedure.
  - Provoke our own Case Study.

# There are x sections for discussion in this Risk Management in Construction Engineering:

| Section | Type of risk |
|---|---|
| i | Financial risk |
| ii | Legal risk |
| iii | Management risk |
| iv | Market risk |
| v | Policy and political risk |
| vi | Technical risk |
| vii | Environmental risk |
| viii | Social risk |
| ix | Any other risk |
| x | Extra Comments |

It is important for us to understand your role and responsibilities when making routine construction.

Be familiar with the roles and responsibilities of other purchasing, procurement, and contracting staff you work with to accomplish your task.

For example, the purchasing and procurement professional will advise on things such as the types of risk in contract and pricing model.

This discussion will review different types of contracts risk management in your cost model, and how to apply critical thinking where appropriate before making contract management in order to use good business practices.

For purposes of this discussion, the laws and policies discussion of the state and individual agencies are not reflected that tend to be more restrictive and may apply if required for discussion.

# Risk Assessment

One of the key elements of the construction management is that delegations of authority based on a risk assessment, which is administered district wide through a Risk Assessment Tool.

The goal is to gather pertinent information related to in carrying out contract in support of the delegated authority that you need.

Risk assessments are intended to obtain information that is unique to each agency, and assesses agency contracting and procurement practices and risk mitigation strategies.

The outcome of each assessment depends in part on the agency's mission, expertise, methods, etc.

# The risk assessment in risk management addresses the following areas:

- Leadership – How well does your agency manage its procurements?
- Resources – How does your agency capture its spending information and use it to forecast its future needs?
- Objectives – How does your agency engage with and support small, veteran-owned and diverse businesses?

Procurement Processes – How does your agency incorporate best practices into procuring and contracting for goods and services and how does your agency protect private information?

By law, each agency is subject to the risk assessment. Once completed, we use the results of the risk assessment to determine the agency's level of delegated authority.

Project risk management includes the processes concerned with

identifying,

analyzing,

and responding to project risk.

It includes maximizing the results of positive events and minimizing the consequences of adverse events.

Generally, risk is a choice in an environment rather than a fate.

BS 6079 (British Standard Institution 1996) defines risk as:

‘It is the uncertainty inherent in plans and possibility of something happening that can affect the prospects of achieving, business or project goals’.

The money spent to fund each and every activity we do involve risk, only the amount of risk varies.

Risk is “Unpredictability incorporations/businesses outcome variables”.

Consequences of uncertainty and its exposure in a project, is risk.

In a project context, it is the chance of something happening that will have an impact upon objectives.

It is vulnerable to the numerous technical & business risks that often represent greater exposures than those that are traditional.

Thus risk assessment need arises.

Risk assessment is a tool to identify those risks in a project and manage it accordingly with proper treatment.

Risk assessment is defined in this discussion as a "technique that aims to identify and estimate risks to personnel and property impacted upon by a project.

# Poor Planning...

# Definitions

**Harm**

**"Physical injury or damage to health, property or the environment"**

Source:BS8444 Part 3: 1996

- In all aspects of project management, we want to minimise, if not eliminate any kind of harm
- Harm may be, for example:
  - Employee accidents or death
  - Financial collapse
  - Environmental accident

# Definitions cont.

**Hazard**

**"A source of potential harm or a situation with potential for harm in terms of human injury, damage to property, damage to the environment, or combination thereof"**

- In project management terms, we need to control financial hazards as well as physical ones
- Examples may be:
  - Falls from heights
  - Collapse of excavations
  - Dropped objects
  - Poor environmental management
  - Abnormal inflation
  - Abnormal weather conditions

# Definitions cont.

**Risk**

**"The combination of the probability of an abnormal event or failure and the consequence(s) of that event or failure to a system's operators, users or its environment"**

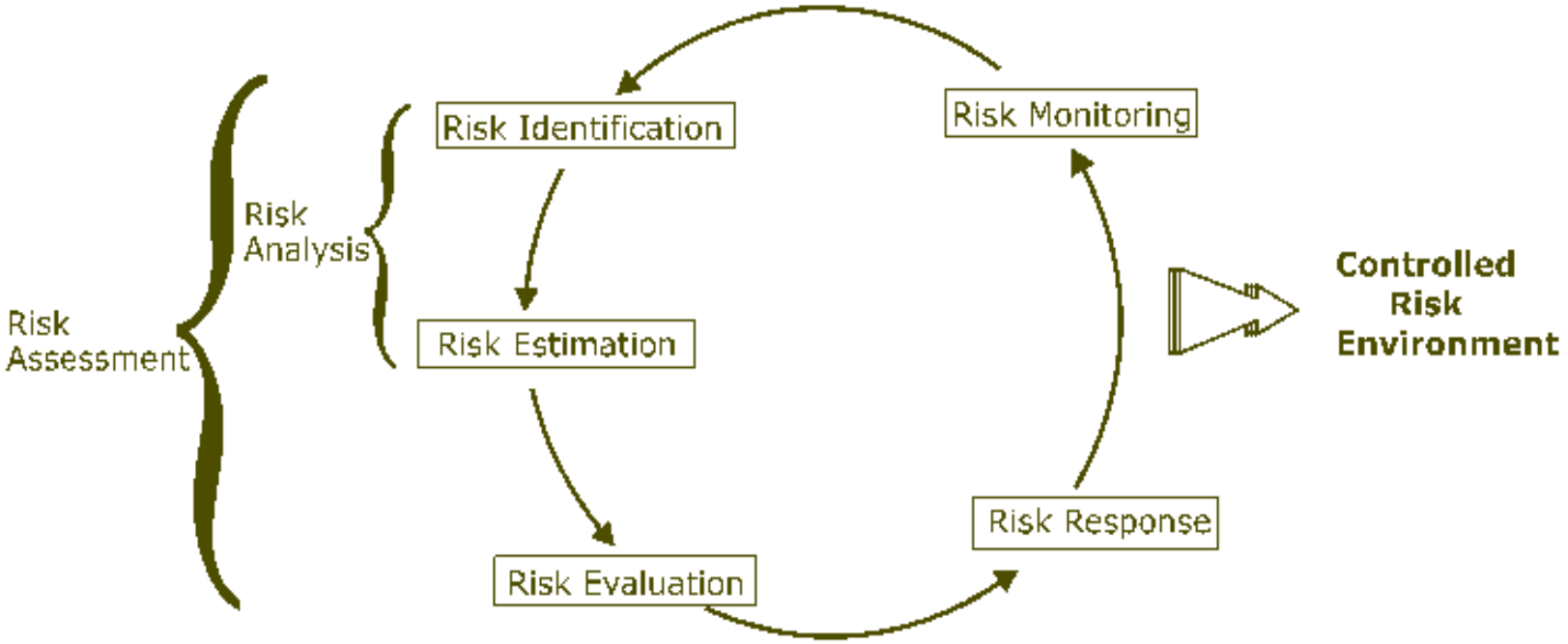
- Risk involves two aspects:
  - Probability of a hazard taking place, and
  - The severity of the harm that occurs.
- Low probability, high severity = high risk
- High probability, low severity = intermediate risk
- Low probability, low severity = low risk

# Definitions cont.

## Risk Management

**"The systematic application of management policies, procedures and practises to the tasks of identifying, analysing, evaluating, responding and monitoring risk"**

- Five stages:



# Risk Identification

- The stage where all potential hazards in a project are identified
- Three main methods of identification
  - *Individual Consultation*
    - interviews with project personnel
    - lengthy & time consuming
  - *Group discussions*
    - formal brainstorming
    - requires motivation & teamwork
  - *HAZOP*
    - **HAZ**ard and **OP**erability studies
    - Formal questioning of processes, e.g design

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# Risk Estimation

- Potential hazards have been identified
- Now need to assess:
  - Probability of occurrence
  - Severity if occurs
- Can be done in two main ways:
  - Qualitatively
    - in a linguistic manner
    - usually done first; high probability/severity cases then may be examined:
  - Quantitatively
    - in a numerical manner

# Risk Estimation cont

## Qualitative Techniques

- Fuzzy set analysis
  - expresses the likelihood and consequences of a risk in readily understood language terms.
- Interviewing and Brainstorming
  - is an extension of two of the techniques employed in the identification stage.
- Personal and Corporate Experience
  - if it exists should be exploited.
- Engineering Judgment

# Risk Estimation cont

## Quantitative Techniques

- Expected Monetary Value (EMV)
  - i.e. putting a financial value to the expected result of a risk.
- Expected Net Present Value (ENPV)
  - is an extension of EMV by calculating the net present value of a probability state.
- Decision Analysis
  - looks at possible outcomes and determining optimal choices

# Risk Estimation cont

## Quantitative Techniques cont

- Sensitivity Analysis
  - tests how sensitive an event outcome is to slight changes on the input variables.
- Delphi peer groups
  - attempts to put quantitative values to results obtained in a manner similar to discussion groups and brainstorming.
- Simulation
  - creates a probable life history of an event and thus allows its outcome to be predicted.

# Risk Evaluation

- 3rd part of *Risk Assessment*
- Need to combine the severity and probability of the identified hazards
- Can be done using a risk matrix:

| Category of Occurence | Frequency of Occurence / year | Consequences | | | |
|---|---|---|---|---|---|
| | | Catastrophic | Major | Severe | Minor |
| Frequent | >1 | H | H | H | I |
| Probable | 1 to $10^{-1}$ | H | H | I | L |
| Occasional | $10^{-1}$ to $10^{-2}$ | H | H | L | L |
| Remote | $10^{-2}$ to $10^{-4}$ | H | H | L | L |
| Improbable | $10^{-4}$ to $10^{-6}$ | H | I | L | T |
| Incredible | < $10^{-6}$ | I | I | T | T |

# Practical Risk Assessment Procedure

1. Identify the principal hazards that will be present in the operation.
2. Assign a number 1 to 5 for both *Consequences of Hazard* and *Probability of Occurrence*.
   - The *Risk* (i.e. the product of *Consequence x Probability*), indicates the level of action.
3. Identify persons affected by the risk
4. Respond to the risk
5. Monitor and update as necessary.

# Risk Response

- If risks are identified as being *intolerable* how can these be dealt with?
- There are four main methods of responding to such risks:
  - Risk Avoidance
  - Risk Transfer
  - Risk Retention
  - Risk Reduction

# Risk Response

## Risk Avoidance

- Managing or developing a situation in which the identified risks do not occur, e.g:
  - not proceeding with the project
  - tendering at a very high bid
  - placing conditions on a bid
  - changing design

# Risk Response cont

**Risk Transfer**

- Via Subcontractors
  - a third party undertakes the high risk portion of the work and the responsibility that goes with it
- Via Insurance
  - A pre-determined insurance premium is often better than unexpected costs due to risk
  - may be done using a *captive* insurance company
  - involves excesses
  - some risks may result in premiums higher than the probable financial loss

# Risk Response cont

**Risk Retention**

- Some risks may be better managed internally
- High frequency/low severity or very low frequency/high severity risks may be best retained

**Risk Reduction**

- The most usual way in which to manage common risks is to reduce either the severity, the chance of occurrence or both.
- E.g:
  - early warning systems
  - improved maintenance
  - better housekeeping

# Risk Response cont

- The choice of method used to respond to risk will largely depend on company policy
- Using the risk matrix model, a typical company scenario may be:

| Category of Occurence | Consequences | | | |
|---|---|---|---|---|
| | Catastrophic | Major | Severe | Minor |
| Frequent | Transfer | Transfer | Retain | Avoid |
| Probable | Reduce | Transfer | Retain | Avoid |
| Occasional | Reduce | Transfer | Transfer | Retain |
| Remote | Reduce | Transfer | Transfer | Retain |
| Improbable | Avoid | Transfer | Transfer | Retain |
| Incredible | Avoid | Transfer | Transfer | Retain |

# Risk Monitoring

- The final stage of risk management
- Risk situation will continue to change throughout the life of the project
  - New hazards will become present
  - Existing hazards will stop or change
- The management must be continually monitored, reviewed and improved
- Existing risks may be managed differently
    - therefore
- Risk monitoring completes cycle back to risk identification

Our general discussion for today is designed to probe the cross-sectional behavioral pattern of construction risks in our construction industry for the betterment of different sizes.

A thorough literature review is initially conducted to identify the risk factors that affect the performance of construction industry as a whole.

The general discussion of today is formulated by seeing the relevant literatures in the area of construction risk management.

Thus we expect response rate is 100% which will Be considered a good response in this discussion.

Our discussion will seek for identifying and assessing the risks and to develop a risk management framework which the investors/ developers/ contractors can adopt when contracting construction work in Bhutan.

# "Risk in Construction industry"

| Type of risk | Probability level of the risk occurrence (a) | Degree of impact or the leve l of loss if the risk occurs (b) | Total risk (a)×(b) |
|---|---|---|---|
| Slno | i)Financial risk | | |
| 1 | Bankruptcy of project partner | | |
| 2 | Loss due to fluctuation of inflation rate | | |
| 3 | Loss due to fluctuation of interest rate | | |
| 4 | Loss due to fluctuation of exchange rate | | |
| 5 | Loss due to rise in fuel prices | | |
| 6 | Low credibility of shareholders and lenders | | |
| 7 | Changes in Bank formalities andregulations | | |
| 8 | Insurance risk | | |

| | ii) Legal risk |
|---|---|
| 1 | Breach of contract by project partner |
| 2 | Lack of enforcement of legal judgment |
| 3 | Improper verification of contract documents |
| 4 | Lack of knowledge of arbitration |
| 5 | Uncertainty and unfairness of court justice |

| | iii) Management risk |
|---|---|
| 1 | Change of Top management |
| 2 | No past experience in similar projects |
| 3 | Short tendering time |
| 4 | Sub-contractor related problems |

| | iii) Management risk |
|---|---|
| 5 | Improper project feasibility study |
| 6 | Improper project planning and budgeting |
| 7 | Inadequate choice of project partner |
| 8 | Improper project organization structure |
| 9 | Poor relation and disputes with partner |
| 10 | Poor communication between clients |
| 11 | Internal management problems |
| 12 | Team work |
| 13 | Poor relation with government departments |
| 14 | Time constraint |
| 15 | Project delay |

| | iv) Market risk |
|---|---|
| 1 | Competition from other companies |
| 2 | Fall short of expected income from project |
| 3 | Increase of accessory facilities price |
| 4 | Increase of labour costs |
| 5 | Increase of materials price |
| 6 | Increase of resettlement costs |
| 7 | Inadequate forecast about market demand |
| 8 | Local protectionism |
| 9 | Unfairness in tendering |

| | **v) Policy and political risk** |
|---|---|
| 1 | Cost increase due to changes of Govt policies |
| 2 | Loss incurred due to corruption and bribery |
| 3 | Loss incurred due to political changes |
| 4 | Loss due to bureaucracy for late approvals |

| | vi) Technical risk |
|---|---|
| 1 | Accidents on site |
| 2 | Design changes |
| 3 | Equipment failure |
| 4 | Errors in design drawings |
| 5 | High degree of difficulty in construction |
| 6 | Stiff environmental regulations |
| 7 | Incompetence of transportation facilities |
| 8 | Industrial disputes |
| 9 | Materials shortage |
| 10 | Obsoleteness of building equipment |
| 11 | Poor quality of procured materials |
| 12 | Problems due to partner's different practice |

| | |
|---|---|
| | **vi) Technical risk** |
| 13 | Shortage in supply of water |
| 14 | Shortage in supply fuel |
| 15 | Shortage in supply electricity |
| 16 | Unknown site physical conditions |
| 17 | Following government standards and codes |
| 18 | Wastage of materials by workers |
| 19 | Theft of materials at site |
| 20 | Site distance from urban area |
| 21 | Surplus materials handling |
| 22 | Architect Vs Structural Engineer dispute |
| 23 | Shortage of skillful workers |

| | |
|---|---|
| | **vii) Environmental risk** |
| 1 | Any adverse impact on project due to climatic conditions |
| 2 | Any impact on the environment due to the project |
| 3 | Healthy working environment for the workers |
| | **viii) Social risk** |
| 1 | Resettlement and rehabilitation of people |
| 2 | Problems due to adjacent or nearby projects |
| 3 | Local people support for the project |

| | **ix) Any other risk** | NA | Very small | Small | Normal | Large | Very large | NA | Very low | Low | Medium | High | Very high |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 |
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
| | **Extra Comments** | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

| | |
|---|---|
| | The table below is fully optional: |
| 1 | Name: |
| 2 | Age: |
| 3 | Sex: |
| 4 | Company: |
| 5 | Location: |
| 6 | Total time taken for completing this survey: |
| 7 | Was the survey comfortable to you?: |

# Theory of Construction Management

## Construction management aims to undertake construction efficiently

# Efficiency

**means achieving agreed objectives**

# Agreed Objectives

**Means the outcomes which motivate those involved in construction.**

**Agreed objectives and the measures used to manage actual performance should be explicitly agreed by all those involved.**

# Construction Management Strategy

**A coordinated set of decisions which guide a construction project organization**

**The decisions aim to reduce the inherent difficulty of construction in ways which increase the chances of agreed objectives being achieved**

# Inherent Difficulty

**results from the complexity of construction**

**and external interference**

# External Interference

A measure of the impact of factors external to a construction project which

are outside the direct control of the project organization

# Complexity

**A measure of the number of interacting teams in a construction project, the quality of the relationships between them, and their performance variability**

# Construction Teams

**Formal group of individuals who work together on a permanent basis to undertake specialist construction and the essential machines and equipment the team uses**

# Construction Teams

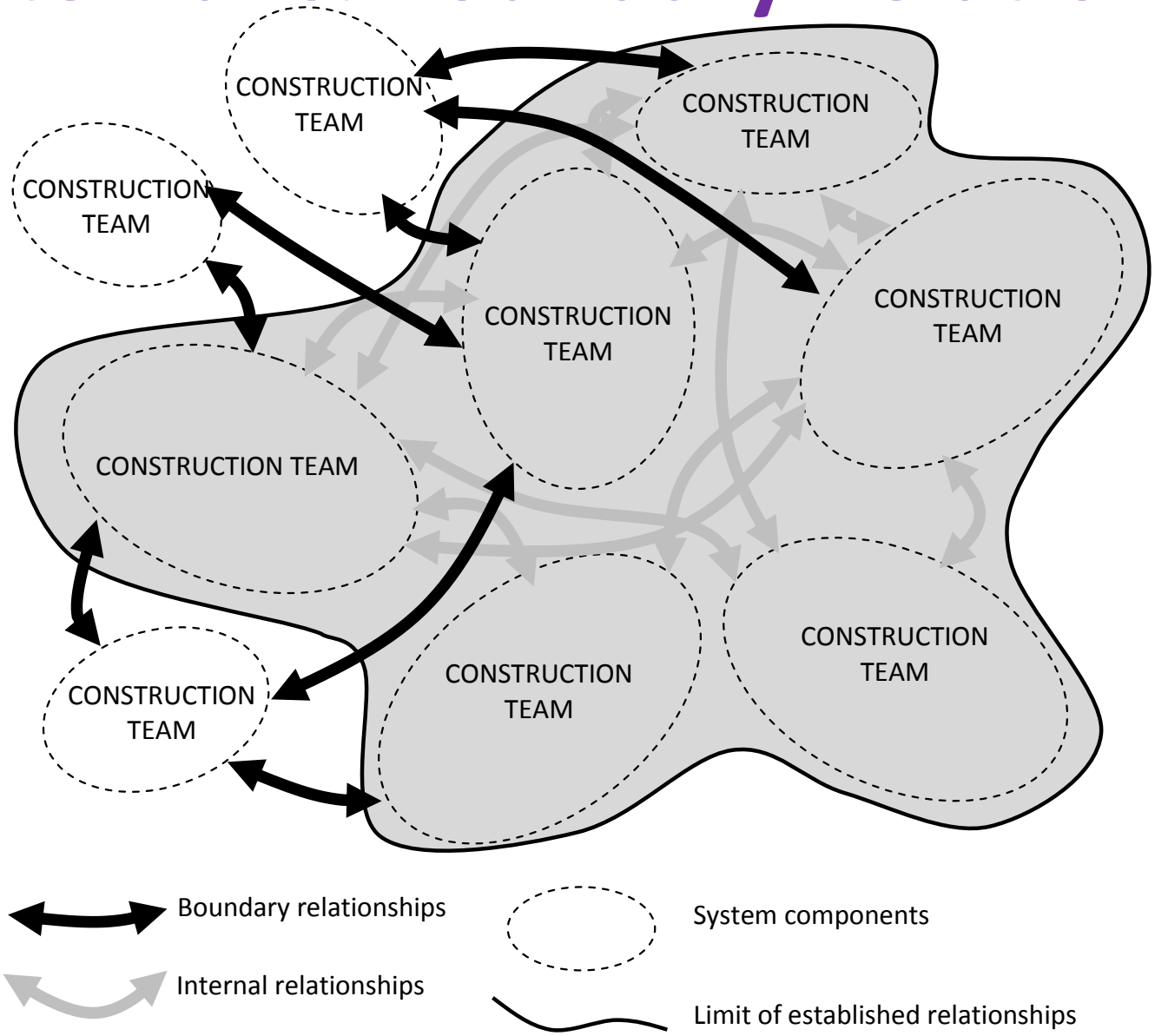
- Designers
- Managers
- Manufacturers
- Production specialists
- Commissioning specialists

# Relationships between Construction Teams

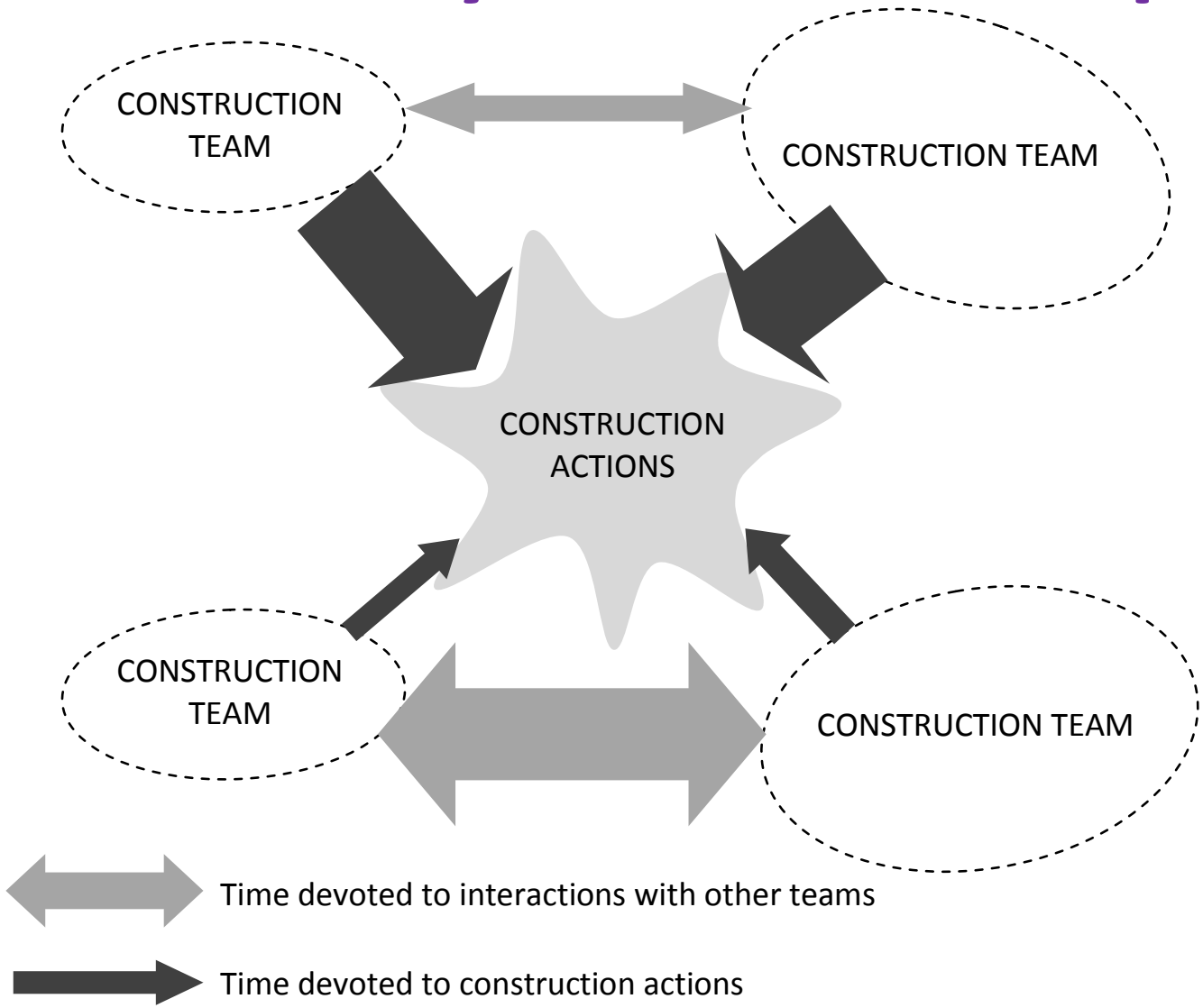
**Boundary relationships: behaviour is guided by teams' perception that they are parts of different organizations.**

**Internal relationships: behaviour is guided by teams' perception that they are parts of a joint organization**

# Internal & Boundary Relationships



# Quality of Relationships

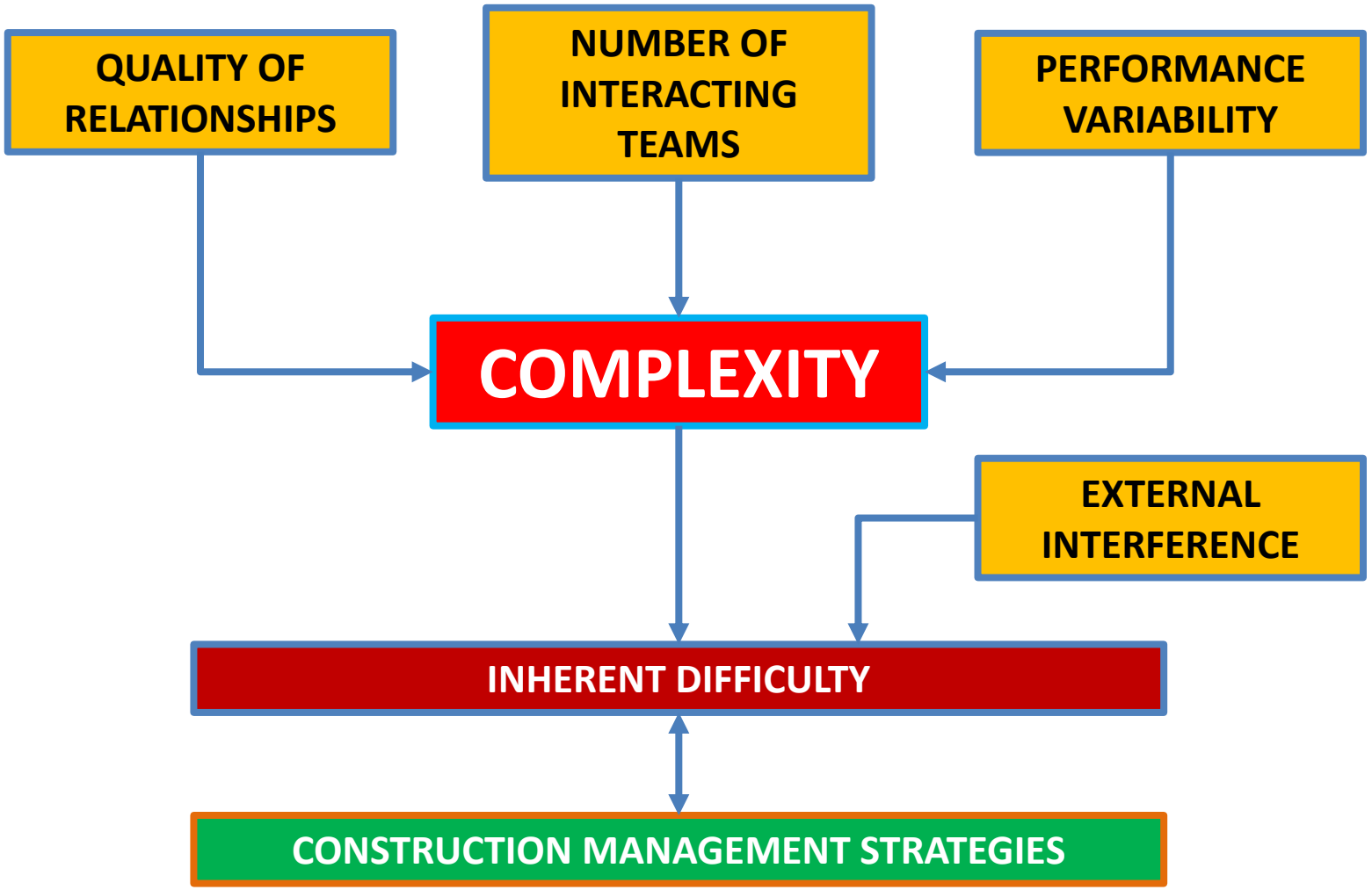


# Performance Variability

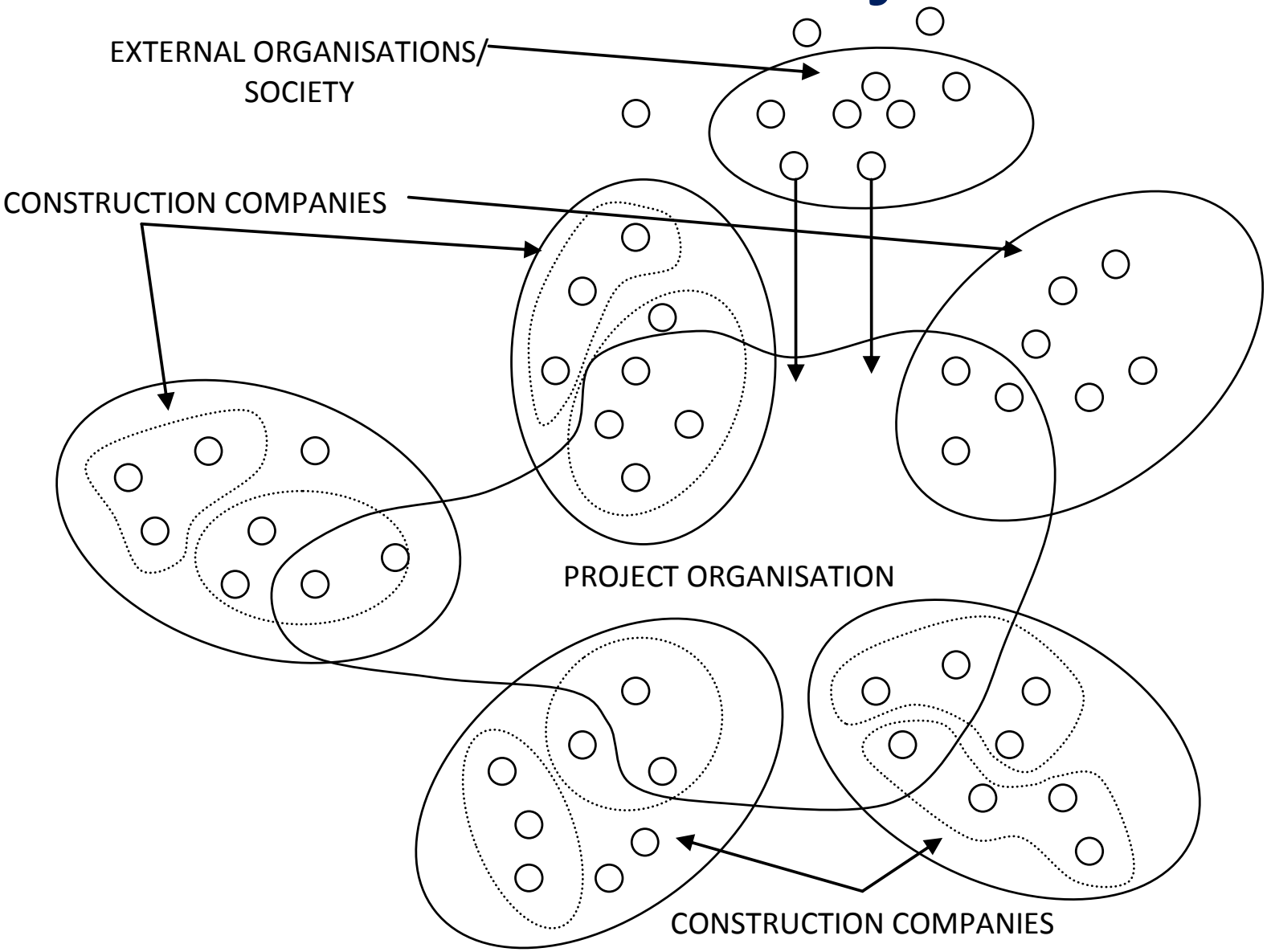
**A measure of the range of performance achieved by a construction team.**

**The performance variability achieved by teams varies widely but typically ranges around a norm by plus or minus 50% or more.**

# Inherent Difficulty



# Difficult Project



# Difficult Project

- Vague and incomplete brief
- Complex and incomplete designs
- Technologies outside the competence of local companies
- Complex, contradictory and incomplete plans
- Select numerous teams which lack the required skills, knowledge and equipment
- Boundary relationships used to defend individual interests

# Difficult Project continued

- **Manufacturing requires components and materials outside the competence of available manufacturing companies**
- **Production uses inappropriate skills, knowledge and equipment and faces constant changes to the design**
- **Commissioning delivers an incomplete facility which fall far short of the brief**

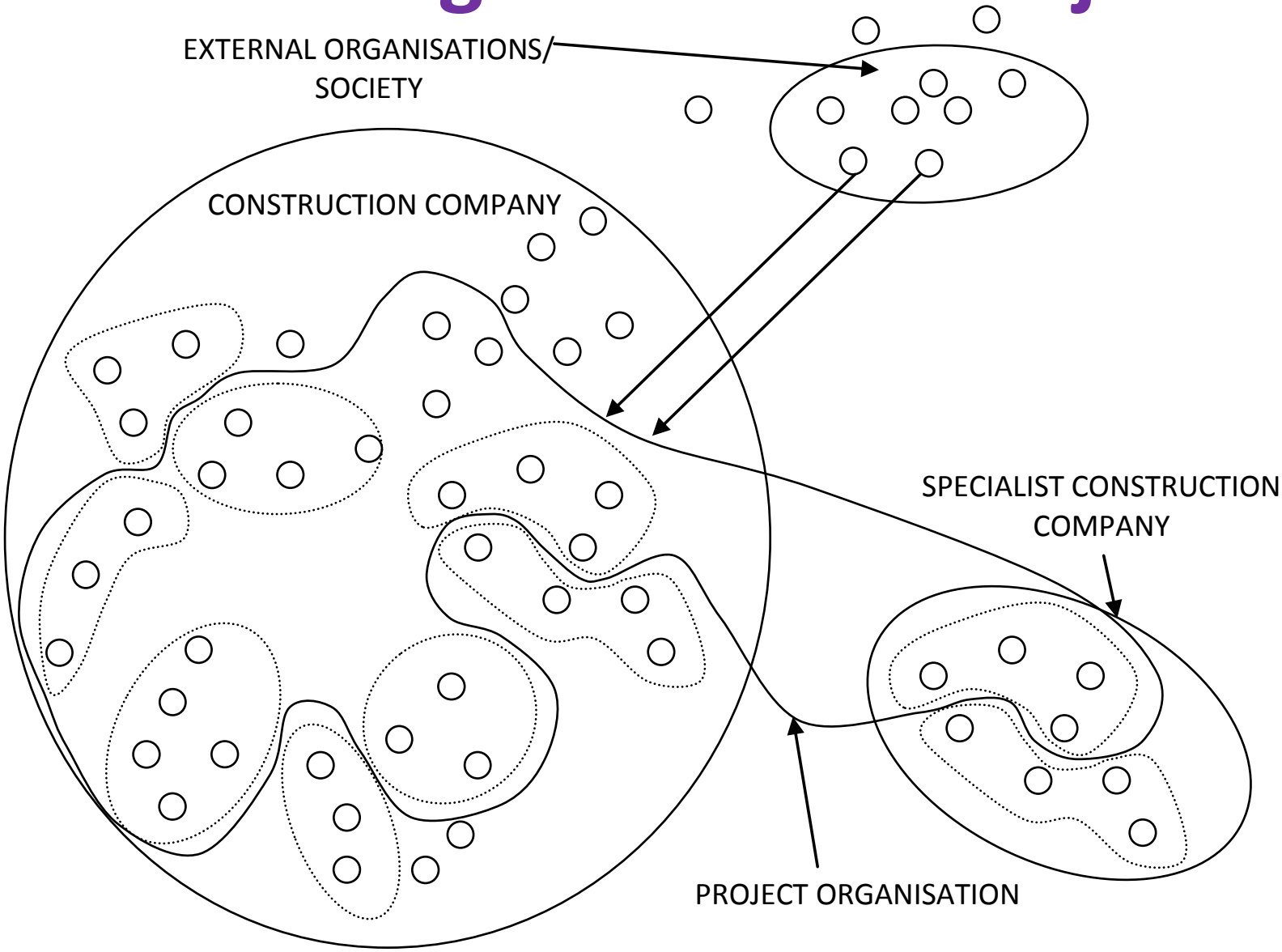
# Construction Management Strategies

**Aim to reduce inherent difficulty**

**to make the project**

**more straight forward**

# Straight Forward Project



# Straight Forward Project

- Clear and complete brief
- Single organization responsible for project
- Clear and complete design and plan
- Competent teams with established internal relationships
- Standard and readily available materials and components
- Efficient production and commissioning

# Theory of Construction Management

**Provides propositions**

**to guide construction**

**away from difficult projects**

**towards straight forward projects**

# Construction Management Propositions

- **Reduce the number of teams involved**
- **Improve the quality of relationships**
- **Reduce performance variability**
- **Reduce external interference**

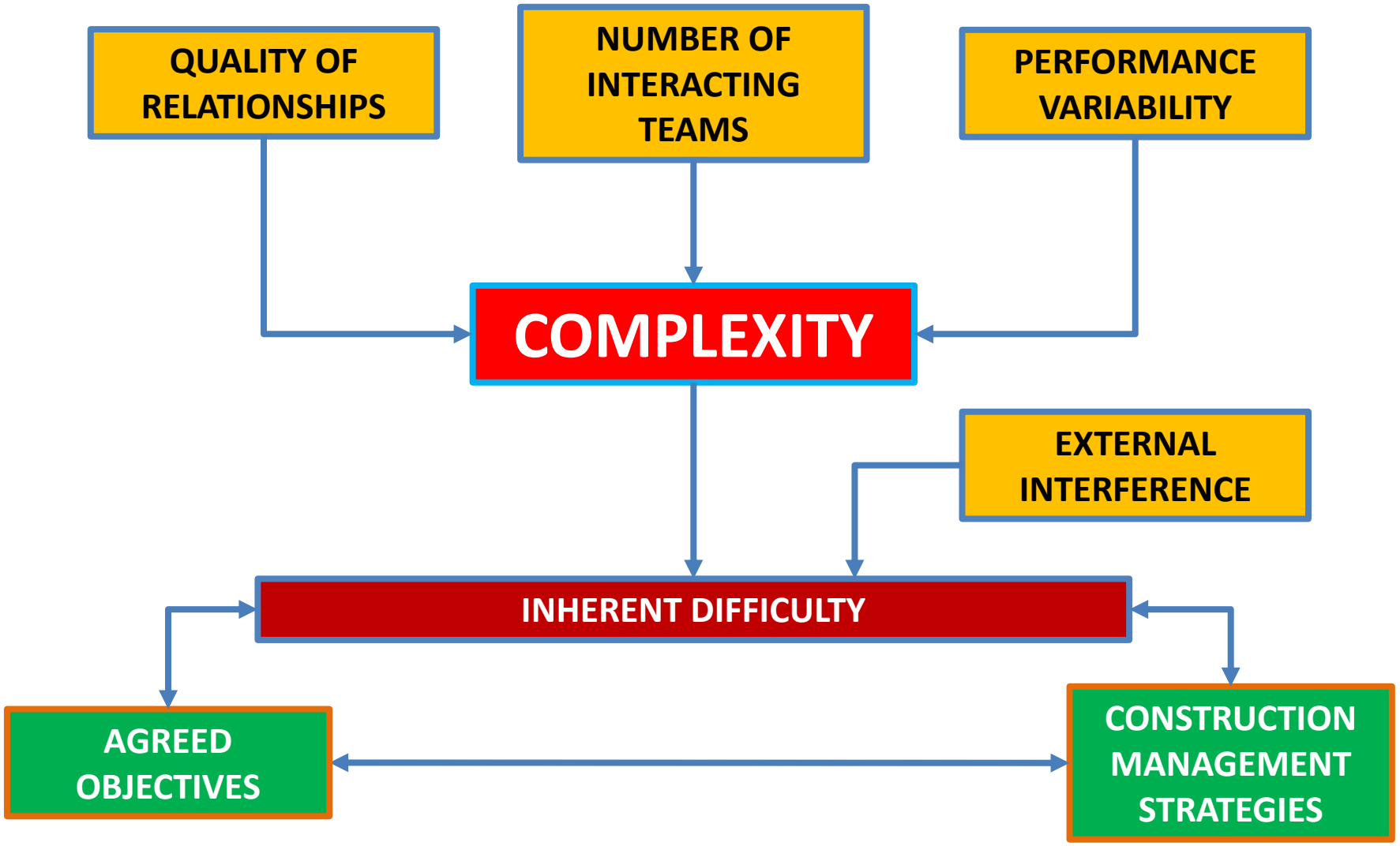
# Construction Management Propositions

- Select teams competent in the technologies required by the project
- Ensure teams accept the agreed objectives
- Ensure teams are motivated to achieve agreed objectives
- Foster accurate communications between teams
- Minimise the effort needed to achieve accurate communications between teams

# Construction Management Propositions

- **Minimise the length and intensity of negotiations over the transactions which bring teams into the project organization**
- **Ensure teams regard the transactions as advantageous to themselves**
- **Minimise the resources teams devote to improving the terms of the transactions which brought them into the project organization**

# Construction Management Strategies



# Construction Teams

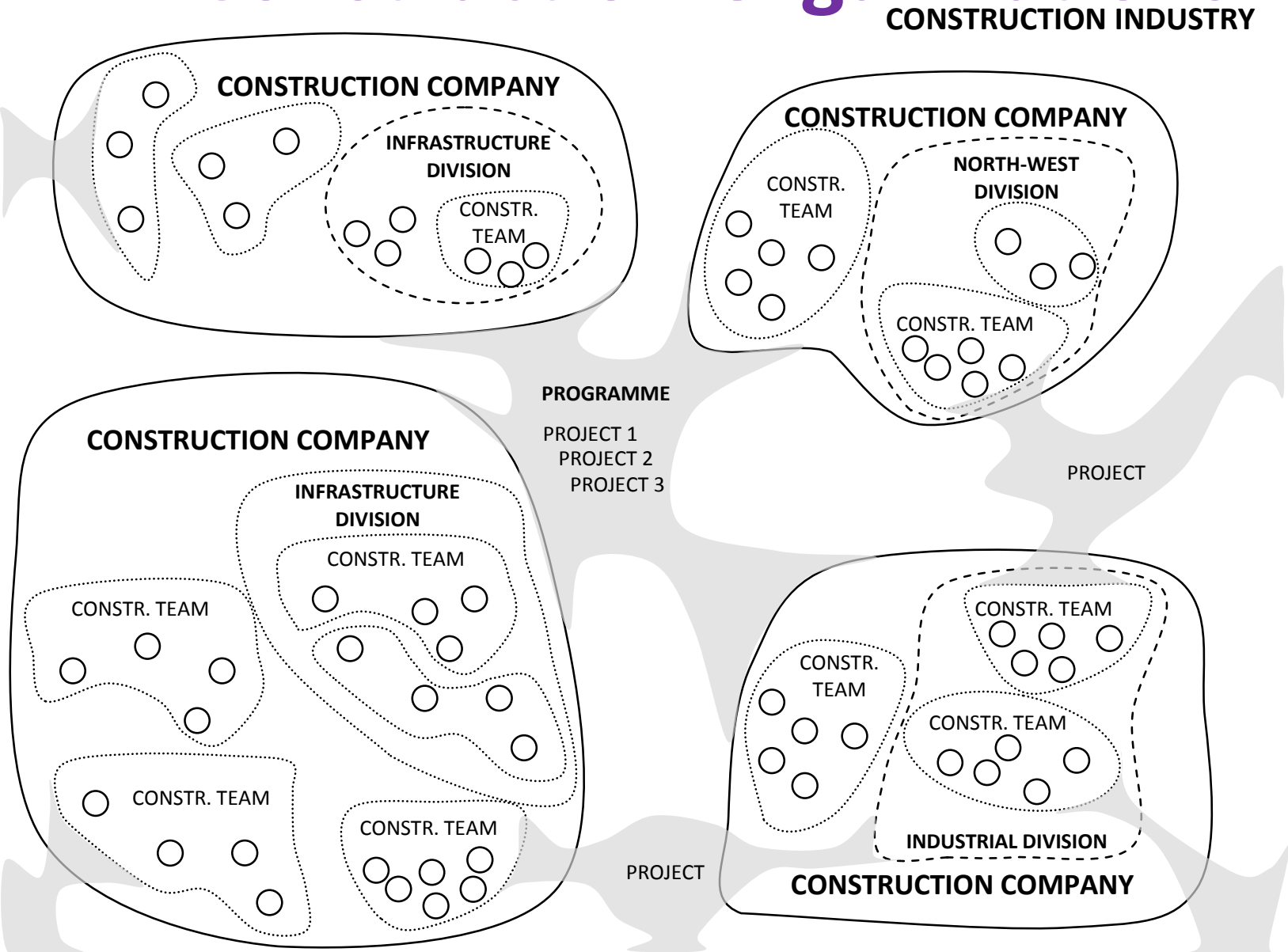
**Construction teams form part of**

**project organizations**

**and**

**construction companies**

# Construction Organizations



# Construction Companies

**Directly influence the efficiency of the teams they provide to undertake construction**

**The theory of construction management provides propositions to guide this influence**

# Construction Management Propositions

- **Satisfy the requirements of local or specialised markets to ensure company's survival**
- **Develop teams with well developed skills and knowledge which match the requirements of projects**
- **Develop teams integrated by established relationships**
- **Improve the quality of support provided to teams by their companies**

# Construction Management Propositions

- **Foster innovations which match the requirements of projects**
- **Ensure the use of effective information systems**
- **Establish values which run consistently throughout their organization**
- **Ensure their organization acts in ways which are intended and authorised**

# Construction Management Propositions

- **Ensure communications are effective and result in common understandings**
- **Ensure transactions are agreed with minimum effort, accepted as fair, foster established relationships, and are acted on in the spirit in which they were agreed**
- **Ensure their organization forms established relationships with other organizations**

# Construction Management Propositions

- **Ensure their organization collects, reviews and acts on feedback about the effects of its action on its objectives**
- **Ensure their organization collects, reviews and acts on feedback about the effects of established norms and procedures**

# Inherent Difficulty Indicators

**IDIs provide measures**

**of the inherent difficulty**

**of construction projects**

# Established Relationships

$$E_R = \frac{n}{\frac{N(N-1)}{2} - k} = \frac{2n}{N(N-1) - 2k}$$

Where:

*n* total number of established relationships

*N* represents the total number of teams in the project

*k* represents the number of inconsequential relationships

# Relationship Fluctuations

$$E_R(t) = \frac{n^*(t)}{\frac{N(t)(N(t)-1)}{2}} = \frac{2n^*(t)}{N(t)(N(t)-1)}$$

Where:

*n*(t)* represents the number of established relationships in the interval at time t

*N(t)* represents the number of directly interacting teams at time *t*

# Relationship Fluctuations

$$F_E = 1 - \frac{\sqrt{\frac{1}{v}\sum_v (E_{Rv} - \mu)^2}}{0.707}$$

Where:

$\mu$ is the mean value

$E_{rv}$ is $E_R(t)$ in interval $v$ *(see previous slide)*

0.707 is a unit correction factor

# Relationship Quality

$$Q_{Ri} = \left(1 - \frac{t_i}{T_i + t_i}\right) w_i \qquad Q_R = \frac{\sum_i Q_{Ri}}{R - k}$$

Where:

$t_i$ represents the number of days two teams work together on the current project

$T_i$ represents the number of days these two teams have worked together on previous projects

$w_i$ weighting to recognise that some relationships may be more important than other

$R$ represents the total number of possible relationships between teams within the project organisation

$k$ represents the number of inconsequential relationships

# Relationship Configuration

$$C_R = \left(1 - \frac{v}{v_{max}}\right)\alpha + \left(1 - \frac{\bar{t}}{T_p}\right)\beta + \left(1 - \frac{N(t)_{max}}{N}\right)\gamma$$

Where:

| | |
|---|---|
| $v$ | represents the number of independent time intervals in a project with different constitution of interactions; |
| $v_{max}$ | represents the number of all possible time intervals in a project; |
| $\bar{t}$ | represents the average duration of time intervals in a project which involve two or more teams; |
| $T_p$ | represents project duration; |
| $N(t)_{max}$ | represents the maximum number of directly interacting teams per time interval throughout the project. |
| $\alpha, \beta, \gamma$ | factors denoting relative importance of the number of time intervals, length of time intervals and maximum number of simultaneously interacting teams |

# Performance Variability

$$R_P = \sum_j \frac{R_{pj}}{N} c_j \qquad R_{Pj} = \frac{n_{0j} + n_{ej}}{n_{0j} + n_{ej} + n_{lj}}$$

Where:

$R_{pj}$ represents percentage of occurrences of work completed early or on time for the *j-th* team (*j=1,...,N*)

$n_{0j}$ occurrences of work being completed on time,

$n_{ej}$ occurrences of work being completed early

$n_{lj}$ occurrences of work being completed late

*N* represents the total number of teams in the project

$c_j$ represents a performance variability impact indicator for team *j*

# External Interference

$$I = \frac{\sum_j \left( \left( 1 - \frac{t_j}{T} \right) a_j \right)}{m}$$

Where:

$m$ is the total number of perturbations,

$t_j$ is the duration of $j$-th perturbation,

$a_j$ is the indicator of interference magnitude representing the relative impact of $j$-th perturbation, and

$T$ is the total duration of a project

# IDIs for Project of moderate difficulty

| | | |
|---|---|---|
| Established Relationships | $E_R$=0.45 |  |
| Relationship Fluctuation | $F_E$=0.64 |  |
| Relationship Quality | $Q_R$=0.56 |  |
| Relationship Configuration | $C_R$=0.47 |  |
| Performance Variability | $R_p$=0.53 |  |
| External Interference | $I$=0.52 |  |

# Size of Projects