Infrastructure Planning and Management

Construction, Operation and Maintenance of Infrastructure

Agenda

1. Montreal Olympics Case

2. Construction and Operations Risks

3. Infrastructure Maintenance

Construction Case Study of the Montreal Olympics Complex

- City of Montreal, Canada wanted to build a stadium for the 1976 Olympics
- Planning started six years earlier in 1970
- Initial cost estimate for the main stadium was $40 Million
- Eventual cost was $838 Million and the final product was lesser than what was envisaged
- What happened?

Design Issues

- The final design was very complex with several constructability issues
  - Irregular shaped structural elements such as the ring beam, ribs, façade etc were present
  - Low tolerances in design led to construction problems since precise construction was difficult.
  - Ice collection in post-tensioning tubes in the winter led to delays in the construction process

Labor and Material Issues

- Unionized labor went on strikes and approximately 100 days were lost
- Construction techniques regarding post-tensioning were new and required learning for the construction crew
- Resources in terms of material and manpower were scarce, leading to procurement delays

Other issues

- Weather in the winter in Canada was not conducive to construction and this led to delays
- Initial schedule was unrealistic and led to spatial conflicts where in order to finish on time, multiple crews had to work in the same area, leading to overcrowding of the site. This in turn led to reduced productivity
- Planning should have been started earlier than 1970
- Price Inflation affected the project economics
- Change of owner led to team-failure

Infrastructure Construction

- Construction of Infrastructure is not always a straightforward process. The preceding case study indicates several risks that might happen during the construction of a large project.
- What could have been done differently in this case?
  - More comprehensive planning could have been undertaken at an earlier stage
    - Procurement lead times should have been factored in
    - Sequencing of activities should have been done taking spatial conflicts into account
    - Weather conditions should have been taken into account
  - More constructible design should have been adopted
  - Team and relationship building should have been emphasized to ensure that conflicts that arose could have been amicably resolved

What are some types of risks that affect the construction phase?

- Site Related risks
- Relational/Coordination Risks
- Contractual Risks
- Other Miscellaneous Risks

Site Related Risks

Site Related Risks

- As the previous picture shows, unknown or unforeseen site conditions, or improper geological investigations can lead to the collapse of the infrastructure
- Site Contamination is another risk wherein pollutants in the soil can lead to hazards during construction, occupancy and use
- Archaeological Discoveries could lead to the site being closed off temporarily and delays in permits and approvals.
- In the Indian context, Land acquisition for infrastructure is another key site related issue that often causes considerable delays to the project.

Relational Risks in Construction

- Construction of infrastructure often involves a large project organization with several agencies and subcontractors. Very often coordination bottlenecks arise in the project organization. Request for Information or Changes are often processed slower than expected leading to delays.

- Miscommunication of Drawing Information or delays in the delivery of drawings due to a lack of coordination between the design and the construction team can also cause project delays.

- Antagonism between participants, particularly between the owner and the EPC contractor can lead to problems such as lack of timely release of funds, that would again hamper the progress of the project.

Other Risks in Construction

- Poor **quality** in construction workmanship often leads to the need for re-work, leading to delays and extra costs.
- Poor safety practices could lead to accidents that once again cause work stoppages and result in extra costs
- Infrastructure projects often involve contractors and personnel from different countries, each of whom are trained in a different system of construction. Cultural misunderstandings often arise that lead to conflicts and construction delays

Contractual Risks

- Changes in requirements during the middle of the construction phase might present a tricky proposition, based on the understanding in the contract.
- Liquidity Damages and Relational Damage Clauses could lead to severe monetary penalties in case of project delay
- Unrealistic contractual requirements such as building to “best international practices” are often agreed upon at the beginning of the project. Such conditions are hard to meet leading to disputes at later stages
- Unfair allocation of Risks between the owner/sponsor and the EPC contractor in the contract also leads to an inability to deliver on the contract, disputes, delays and cost overruns

Miscellaneous Risks

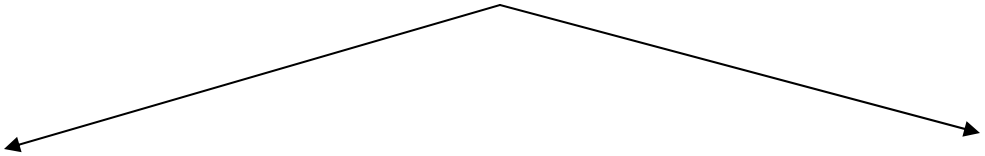
- Force Majeure events such as natural disasters can slow down construction
- Lack of labour and material resources due to macroeconomic conditions can lead to slippage of the schedule
- Material Procurement Delays and supply chain problems can lead to late delivery of material on site, thereby prolonging construction activities.
- Price Fluctuations after the contract has been signed can lead to the construction economics being distorted
- Sabotage and Vandalism from local community activists and strikes can lead to rework and delays

Mitigating Construction Risks

- The various challenges mentioned in the previous slides must be mitigated to ensure that the project can be built and operated on time.
- Proper project planning and control mechanisms should be in place
- Bar charts and Critical Path Method (CPM) schedules should be prepared and the critical path should be monitored.
- Daily Progress reports should be matched with the CPM chart to determine actual progress.
- Earned Value techniques can be used to determine whether the project is on time and on budget, or if other interventions are necessary

Ways to Mitigate Construction Risks

Risk Mitigation



Contractual

- **Insurance Requirements**
- **Bond Requirements**
- **Use of Standard Forms**
- **Exhaustive Allocation of Roles and Responsibilities**

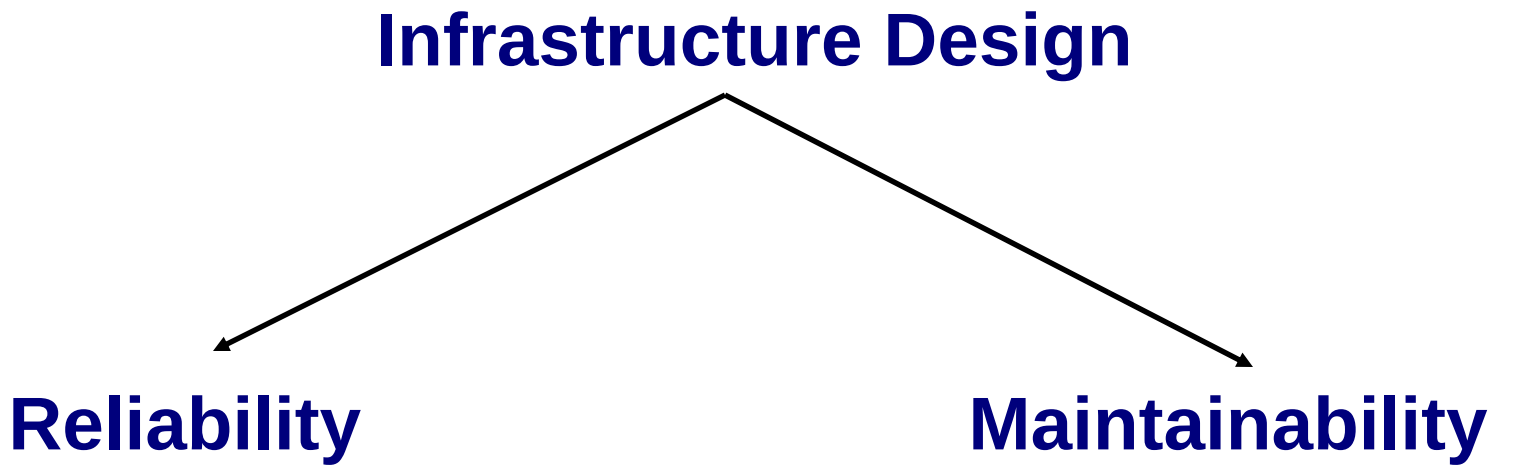
Non-Contractual

- **Partnering and Team Building**
- **Prequalification of Contractors**
- **Monitoring Systems (Prevention is better than cure)**
- **Equitable Risk Distribution**
- **Hiring Expert Consultants**

Other Risk Mitigation Techniques

- Apart from Planning and Controlling the process, risks in the construction phase can also be minimized through contractual and non-contractual means, as shown on the previous slide.
- Contracts can be used to allocate risks to the party best able to bear those risks. For instance, in cases of complex projects, Cost-Plus contracts can be used to place the risk of cost overruns on the clients who control the design
- Non contractual methods such as partnering and team building to reduce disputes and enable collaborative problem solving can also be followed.

Infrastructure Maintenance



Infrastructure Maintenance

- While designing infrastructure, maintenance of infrastructure must also be taken into consideration
- There is often a trade-off between reliability and maintainability. Reliability refers to designing the structure so that it does not fail, while maintainability acknowledges the potential for the structure to fail, and designs walkways etc to ease maintenance works without overly disrupting the activities of the entire asset. Reliability can be increased by adding factors of safety, but this adds a cost. On the other hand, maintainability reduces this initial cost, but can lead to more costs at a later stage

Types of Maintenance

- Routine Maintenance which happens periodically
  - Hard Time Replacement (HTR)
  - On Condition Maintenance (OCM)
- Reactive or Corrective Maintenance that responds to a critical situation
- Rehabilitation in case of major failures
- Reconstruction of the entire infrastructure

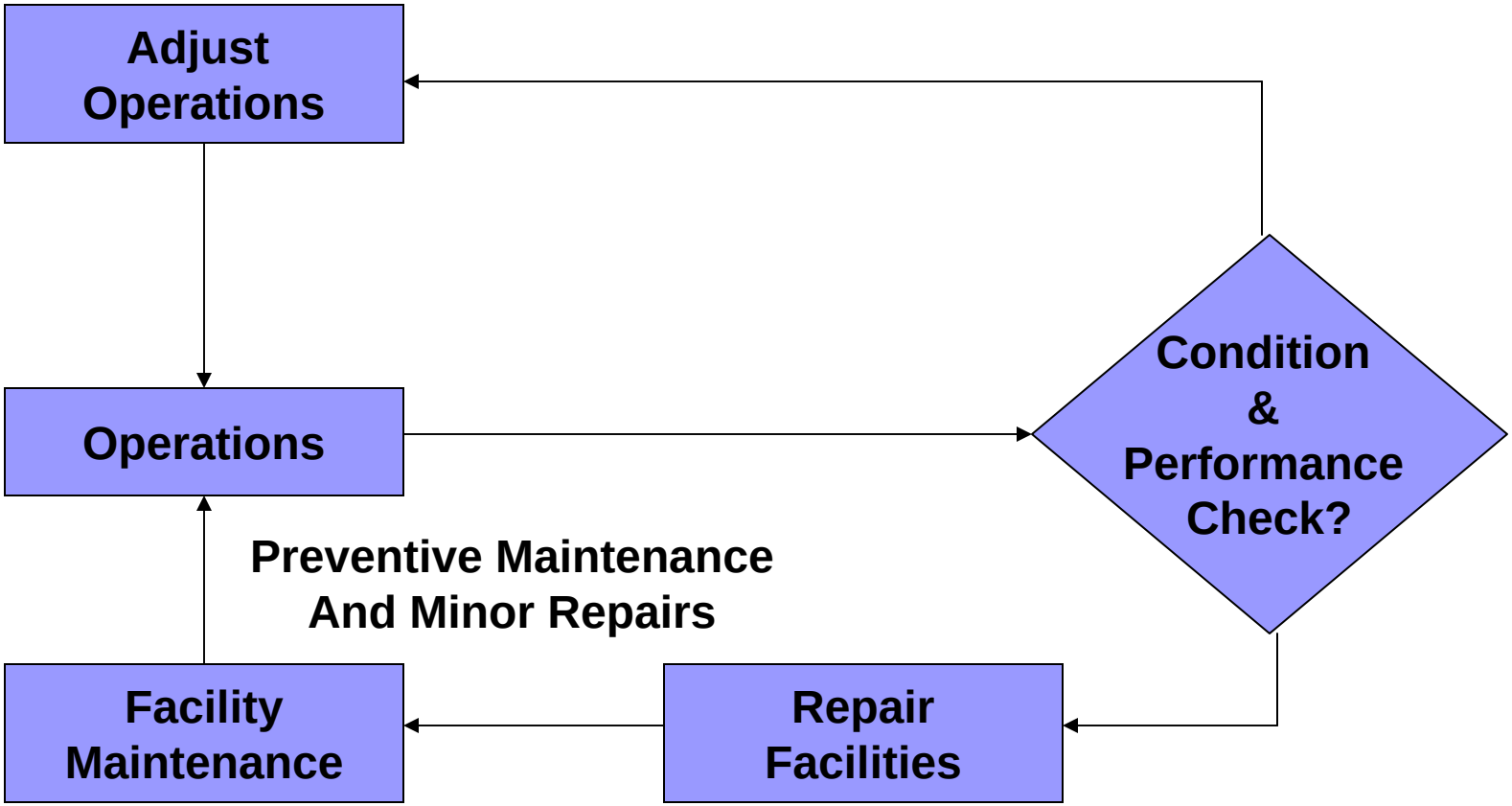
Maintainability Issues

- Design should ease the ability to maintain
  - Spatial coverage such as shoulder roads can be considered
- Maintenance should disrupt operations as little as possible
  - Service roads, underground catwalks can be designed for transportation structures so that maintenance can proceed without disruption
  - Redundant Systems can be designed such that infrastructure is operated while maintenance is done
  - Staggered Maintenance Schedules

More Maintainability Issues

- Metrics to monitor maintenance, quality
  - MTTR – Mean Time To Repair
  - MDT – Mean Down Time
  - MTBF – Mean Time Between Failures
- Availability of Infrasructure = MTBF/(MTBF+MTTR)
  - This measure can be used to determine the efficiency of the infrastructure

Linkage of Operations and Maintenance



Operations and Maintenance

- As the previous slide indicates, the condition of the infrastructure is checked. If maintenance needs to be done, the operation of the infrastructure is adjusted either by partially disrupting the infrastructure service, or by switching t a redundant source, until the maintenance is complete. Infrastructure can then continue to operate as before.
- Quality Control, Quality Assurance and Total Quality Management (TQM) are other strategies that can be used to ensure efficiency during construction and operations.

Difference Between QA and QC

- Quality Assurance – A set of procedures or processes that will assure reliable quality

- Quality Control – a set of operational techniques that monitor processes and eliminate unsatisfactory performance
  - E.g FMEA (Failure Modes and Effects Analysis) undertaken to determine a maintenance schedule

It is Vital to have QA and QC schedules or infrastructure

The TQM Philosophy (Deming, 1986)

- **Quality Is the Key**
- Customer Orientation is important
- **Employee involvement in Organizational activities is important**
- **Focus on Process not Product Quality**
- Use Management Tools
- **Foster Continuous improvement**
- Benchmark against industry leaders
- Be People Oriented
- **Consider a Life-Cycle outlook**

TQM Tenets

1. Create Constancy of Purpose toward service, product improvement
2. Management must accept leadership for change
3. Eliminate need for inspection by building quality in the first place
4. Select partners on long-term relationships and trust and move towards single supplier

More TQM

5. Constantly improve productivity and quality and decrease costs
6. Institute On the Job Training
7. Institute Leadership to help people do a better job
8. Drive out fear
9. Break down barriers to teamwork

Still More TQM

10. Eliminate explicit slogans asking for improvements
11. Eliminate metrics and work quotes
12. Remove barriers that rob people of pride in workmanship
13. Institute a program of education and self-improvement
14. Include everyone in this transformation

Final Thoughts

- Infrastructure Construction, Operation and Maintenance are key areas that are often neglected
- Using good planning and monitoring techniques, taking into accounts the various risks that arise in the design stage and using standardized processes are some strategies that can be used to streamline the construction and operation phases of infrastructure projects


Thank you