Scheduling Challenges in Horizontally Distributed Projects

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Agenda

- Statement of general problem
- CPM theory
- Project types that don't fit the CPM theory
- Typical wind farm projects
- Practical considerations
- Legal considerations
- Conclusions and future actions

Statement of general problem

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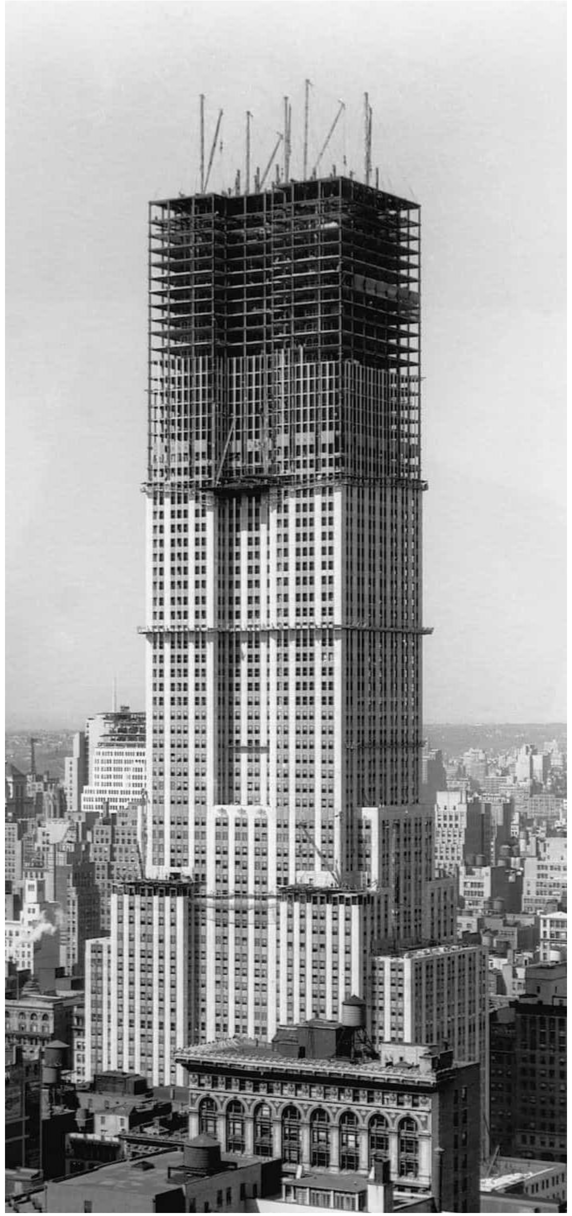
Statement of general problem

- Critical Path Scheduling (CPM) has been used for 65 years
- The theory of CPM scheduling has underpinned
  - Contract drafting
  - Legal precedents
  - Project controls practice
- But many projects do not conform to CPM theory
- A new way of thinking and working is needed
- Supported by better contracts and legal processes
- This presentation is the start of a journey!

CPM theory

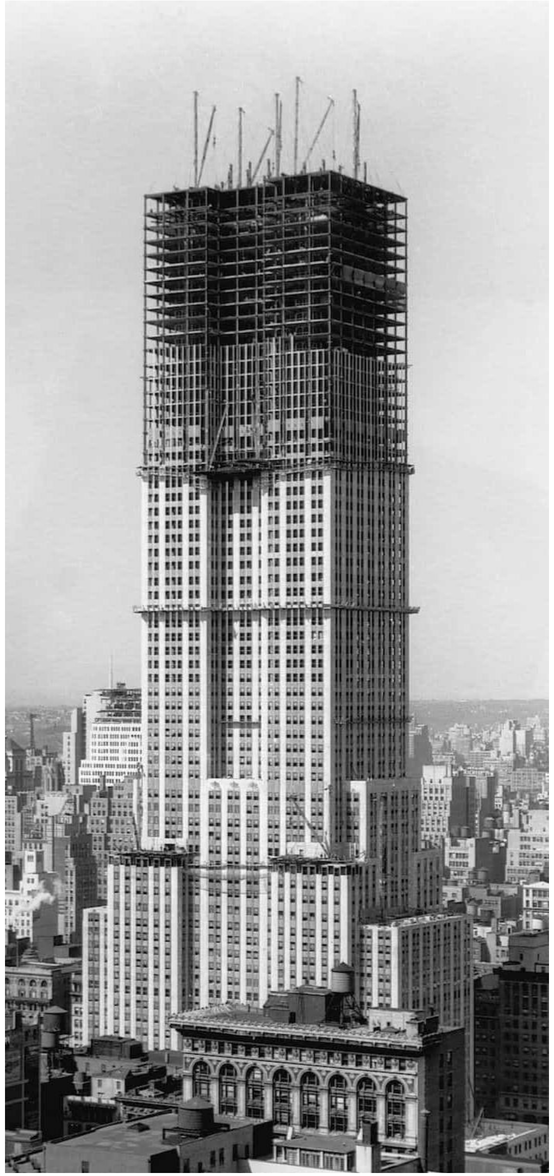
CPM theory

- CPM theory is derived from scientific management
  - Developed in the early 20th century (1910 – 1920)
- It assumes one best way of doing the project
- Which is described in the CPM schedule
- The schedule allows the critical path and float to be calculated
- Delays can be assessed based on the schedule



CPM theory

- CPM theory works in the right situations and can be forced to fit most other projects
- But there are major issues:
  - Logic structures that create incorrect outcomes*
  - No concept of critical resource flows
- Vested interests try to paper over these problems
  - Scheduling software developers
  - Scheduling practitioners
  - Lawyers and claims experts



* For some examples see:
https://mosaicprojects.wordpress.com/2022/05/18/cpm-scheduling-the-logical-way-to-error-1/

CPM theory

- CPM theory and calculations are 65 years old
- They have survived because they are useful in a lot of situations
- Plus there is an entire industry devoted to maintaining the status quo
- But there are many projects that cannot be effectively scheduled using CPM or other deterministic approaches

CPM theory

- CPM theory and calculations are 65 years old
- They have survived because they are useful in a lot of situations
- Plus there is an entire industry devoted to maintaining the status quo
- But there are many projects that cannot be effectively scheduled using CPM or other deterministic approaches
- **You need to use different techniques**

Image from : https://youtu.be/m_MaJDK3VNE

Project types that don't fit the CPM theory

Project types that don't fit the CPM theory

- The entire Agile / Scrum / Iterative project family
  - CPM (or more usually bar charts (Gantt) can be used for the high level road map)
  - Other techniques are used for lower levels of control
- The essence of agile is flexibility people chose what to work on next
- But this is a topic for a later paper

Project types that don’t fit the CPM theory

- Distributed physical projects where significant amounts of the work can be done in any sequence
  - Infrastructure upgrades (eg, removing asbestos telecom pits)
  - Hardware upgrade / replacement
  - Some social housing projects
  - Normal road maintenance work

To remove 200 asbestos cement pits in a suburb you need:
- Somewhere to dispose of the old pits
- New pits to install (procurement)
- Trained people

But the actual work can be done in almost any sequence……..

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Project types that don't fit the CPM theory

- Characteristics of distributed projects
  - Work sequence is easily changed
  - Management focus is on optimizing resource workflows
  - Control is based on key resource productivity
- Access to next 'task' is based on conditions precedent (constraints), not mandated logic
- But efficient workflows still need appropriate planning and preparation at each location
  - Everything ready to start
  - Relocation / travel distances optimized
  - Work done in the correct sequence

Project types that don't fit the CPM theory

- **Constraints** may affect each task and the overall project
- Some constraints affect the whole project
  - Planning approvals
  - Design and approvals
  - Safe work procedure approvals
  - Resource and supply contracts / agreements / deliveries
- Some affect the ability to complete a task
  - Access to the specific work area
  - Supply of components
  - Internal sequence of working

Project types that don't fit the CPM theory

- **Constraints** exist is a spectrum from almost none to highly constrained

Very few constraints

Highly constrained

Almost any sequence of work is acceptable

Agile approaches to management work well

Considerable flexibility in some aspects of the work but not others

Overall work flow needs deterministic planning but agility is required to optimize some aspects

The sequence of work is largely predetermined

Traditional deterministic (CPM) planning works well

Typical wind farm projects

Typical wind farm projects

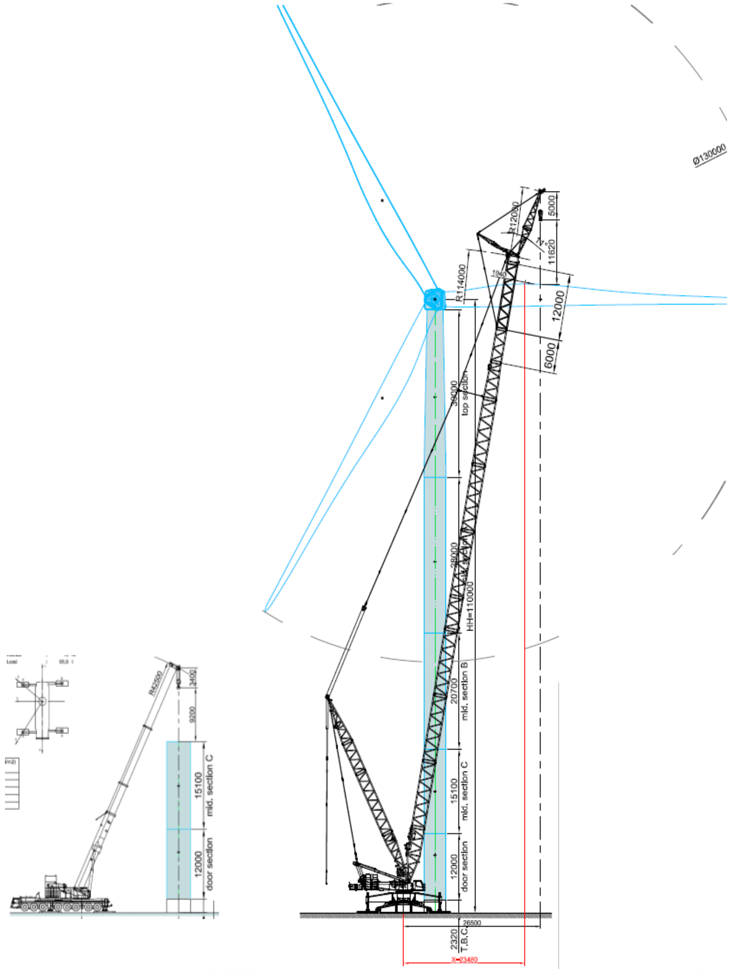
- Wind farms present and complex series of schedule and control problems
- Some sequences are mandatory
- Others are almost unconstrained

Typical wind farm projects

- Big picture mandatory sequences:
  - The substation and grid connection must be complete before any electricity generation can start
  - The turbines and towers need to be designed, ordered and delivered before erection can start (usually about 1 year)
  - Civil engineering and foundations need to be complete before tower erection can start in an area including the collector mains to the substation
  - All towers need to be complete before the overall wind farm reliability testing can start

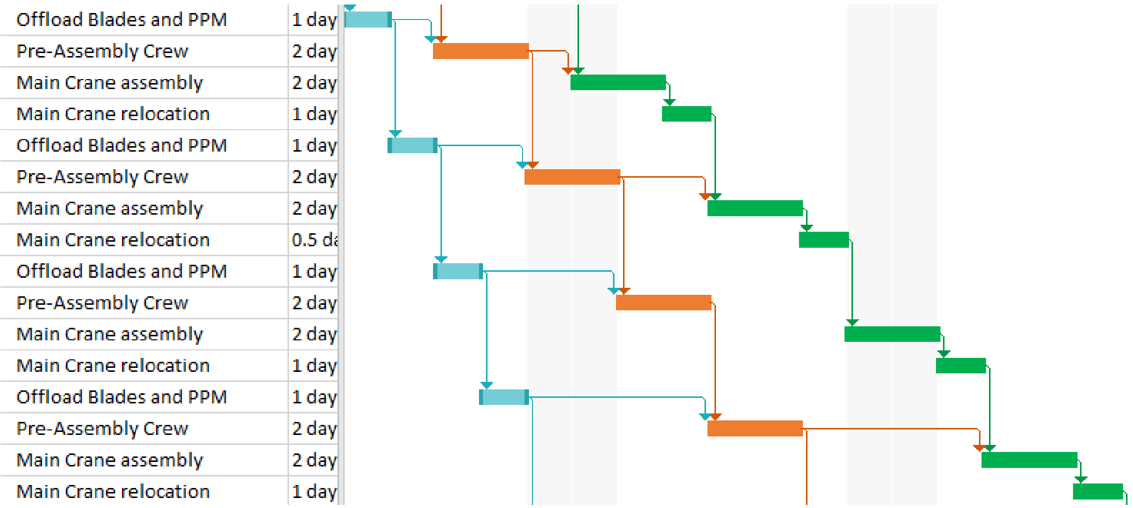
Typical wind farm projects

- Detail mandatory sequences (per wind turbine):
  - Foundations cabling and access need to be complete
  - Turbine components need to be delivered
  - Tower erection sequence is mandated:
    - Lower sections by one crane crew (can be capped and left)
    - Upper sections and nacelle by the ‘primary crane’
    - Hub and blades
  - Electrical and mechanical fit out
  - Commissioning (requires connection to the grid)
  - Reliability testing:
    individual tower -> area -> full wind farm



Typical wind farm projects

- Different speed of working create gaps in the schedule
- Weather delays are not consistent:
  - Offloading and transport only delayed by extreme weather
  - Tower base only affected by extreme high winds
  - Main erection seriously affected by wind
  - Fit out largely immune from weather effects but constrained by the main erection progress



Typical wind farm projects

- Different management approaches are needed:
  - Civil works need to be focused on allowing efficient deliveries
  - Off loading and base erection crews need to work efficiently and then move off site
  - Primary focus is to keep the critical main crane working
  - Fit out crews need to be sized to achieve average erection times* allowing for wind delays, not net erection times

* The average time the main crane needs per tower including wind delays

Typical wind farm projects

- Aspects that are not logically constrained, subject to the necessary prerequisites being in place:
  - Any tower component can be used on any wind turbine
  - Foundations can be constructed in any sequence
  - Towers can be erected in any sequence
  - Commissioning can be performed in any sequence
- The key consideration is the efficient use of resources not an arbitrary build sequence
- The various stages of tower assembly can be undertaken in different sequences provided following crews are not inconvenienced

Typical wind farm projects

- In summary:
  - Crew production rates vary significantly between the different crews
  - Weather delays affect each of the crews differently
    - Primary crane can have 300% more downtime than other crews
  - Crew access to a tower is based on conditions precedent, not arbitrary sequence logic
  - Crew handovers need to consider average rates (after delays)
  - Traditional critical path scheduling is less than optimal – flexibility is needed

Practical considerations

Practical considerations

- Big picture logic matters:
  - Civil works, substation, towers, commissioning, etc.
  - An overarching CPM schedule is ideal for this
- Internal logic matters – for each tower
  - Foundations, deliveries, lower tower, upper tower, fit out
  - Different crews perform each stage – handovers are important
  - Logistics and completing each stage to 100% is important
- The key is maximising the efficiency of each crew
  - Minimum time on site
  - The standing costs for each crew are significant

Practical considerations

- There is a need to balance the 'big picture' with resource utilization
- The build sequence of the towers is irrelevant, what matters is starting the final overall commissioning ASAP
- Electrical safety is a key constraint:
  - Within each tower
  - Within each collector group
  - Overall
- Maximizing resource efficiency is a day-to-day process on 3 or 4 different work faces

Practical considerations

- JIT is one option
  (but high risk)

Source: *Building a Wind Turbine GE, entire assembly process (timelapses, landscapes)* is available at: https://youtu.be/fpmd_br6loI

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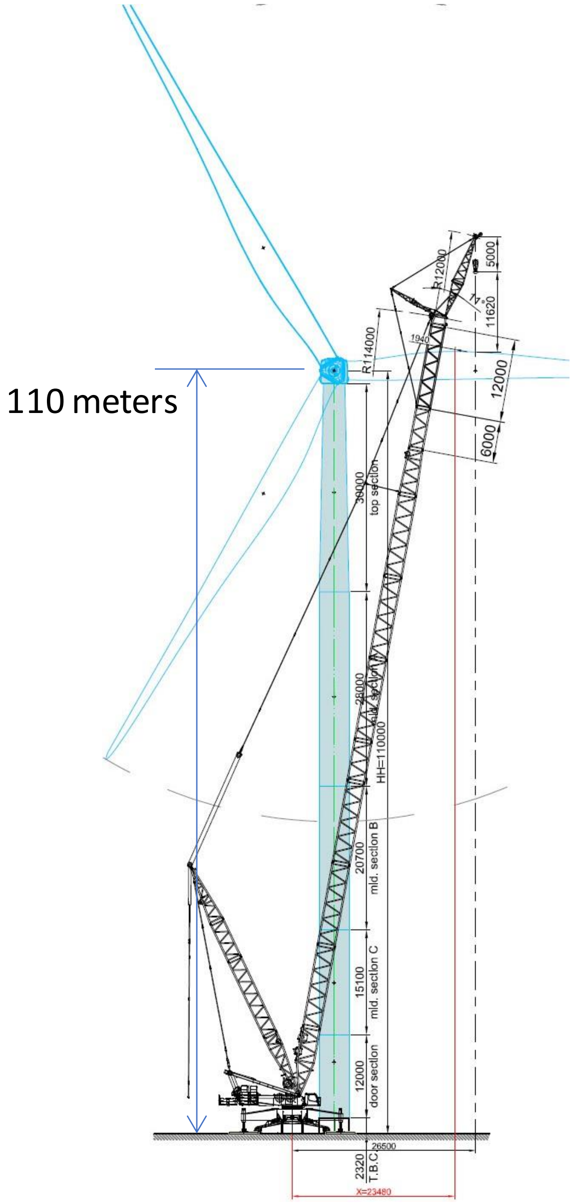
Practical considerations

- Staged working with time buffers is safer
  - Civil works -feeds- deliveries
  - Deliveries -feed- tower base
  - Tower base -feeds- main erection
  - Erection completion -feeds- fit out
  - Fit out -feeds- commissioning
- Focus on the main ~~crane~~ game – keep the slowest resource crew working to 100%
- Deal with the inevitable delays and disruptions proactively



Practical considerations

- Critical Path schedules cannot deliver the required sophistication
- Use AI or 'sprint' / rolling wave / lean approaches
- Work out the best plan for the next 2 to 4 weeks regularly
- Balancing the competing options:
    - Keeping the primary crane 100% effective with minimum travel distances
    - Allowing generation to start progressively and early
    - Keeping the other crews 100% effective to minimize time on site
    - Dealing with problems and issues
- Flexibility / agility is the key to minimizing costs

Legal considerations

Legal considerations

- Most contracts are incapable of dealing with an agile approach to management
- Assessing the consequences of a delay or disruption contemporaneously is difficult
  - If a crew cannot work on one tower they can often simply relocate to another - work is continuous but may be less efficient
- Delays affecting sub-critical crews are expensive but may not delay overall completion
  - The ***Delay and Disruption Protocol**** separates the cost of disruption from EOTs

*See: https://www.scl.org.uk/sites/default/files/documents/SCL_Delay_Protocol_2nd_Edition_Final.pdf

Legal considerations

- A particular delay event (eg, wind of 15 m/sec) may delay one crew (the primary crane), but have no effect on some of the other crews
  - The above example will delay the primary crane, fit out and commissioning but have no effect on civil works, deliveries and the tower base erection
- Consideration of the planned time for each crew to be on site is needed
- Processes for assessing the effect of delays on the different work crews are needed

Legal considerations

- This problem affects:
  - All distributed projects (not just wind farms)
  - All ‘agile’ projects where development is done in sprints or iterations (not just IT)
  - Projects using ‘lean construction’ and ‘last planner’ techniques
- There are no recognised techniques for assessing disruptions that affect resource efficiency where the inefficiency may flow through to a project delay
  - Determining the cost of the imposed inefficiency is difficult
  - Determining the consequential delay (if any) is difficult

Conclusions and future actions

Conclusions and future actions

- The 'agile' approach is to assume the client, end user, and delivery team work together to proactively solve these problems – this is a good idea if it works…..
- This can translate into engineering projects via various alliancing and partnering contracts (pain share gain share)
- Traditional contracts are not fit for purpose – the only management approach is to:
  - Keep rigorous and detailed records of everything
  - Provide all of the notices and determinations in the time required
  - Try and sort the mess out afterwards by negotiation or mediation

Conclusions and future actions

- There is a lot of work needed in this area:
  - Efficient risk allocation
  - Contract improvements
  - Developing protocols for dealing with the issues pragmatically within existing forms of contract
    - For the contractor
    - For the superintendent / client

- **Watch this space…………**

THANK YOU

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