Czech Technical University in Prague
Faculty of Civil Engineering

Department of Economics and Management in Civil Engineering

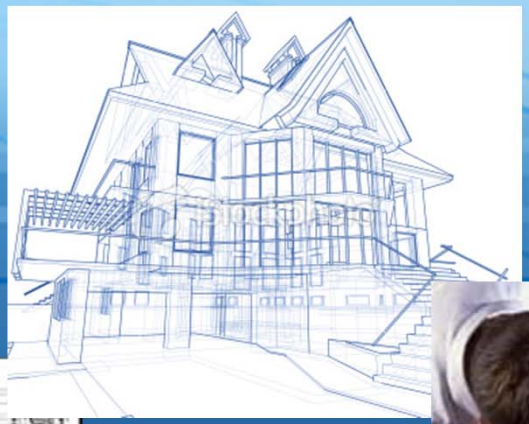
Czech Technical University in Prague
Faculty of Civil Engineering
Department of Mechanics

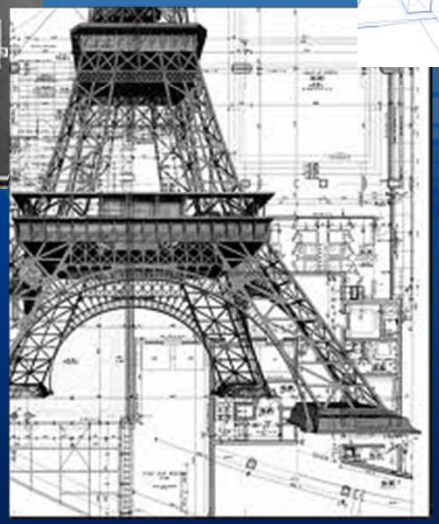
Centre for Integrated Design of Advanced Structures

ISUME 2011

1st International Symposium on Uncertainty Modelling in Engineering

DELAYS IN CONSTRUCTION TASKS





Ing. OMAR RUIZ

Leaning Pisa tower

War and battles in the region, flawed design, sink problems

Sagrada Familia

Loss of original plans, drawings and photographs
Funding of the project by donations
Designs during the ongoing construction

Three Gorges Dam

Additional projects
Complexity of the ship lift

Temelin Nuclear Power Station

Stops of the project
Alterations to the original design
Cost overruns
Opposition against nuclear power

DELAYS IN CONSTRUCTION TASKS

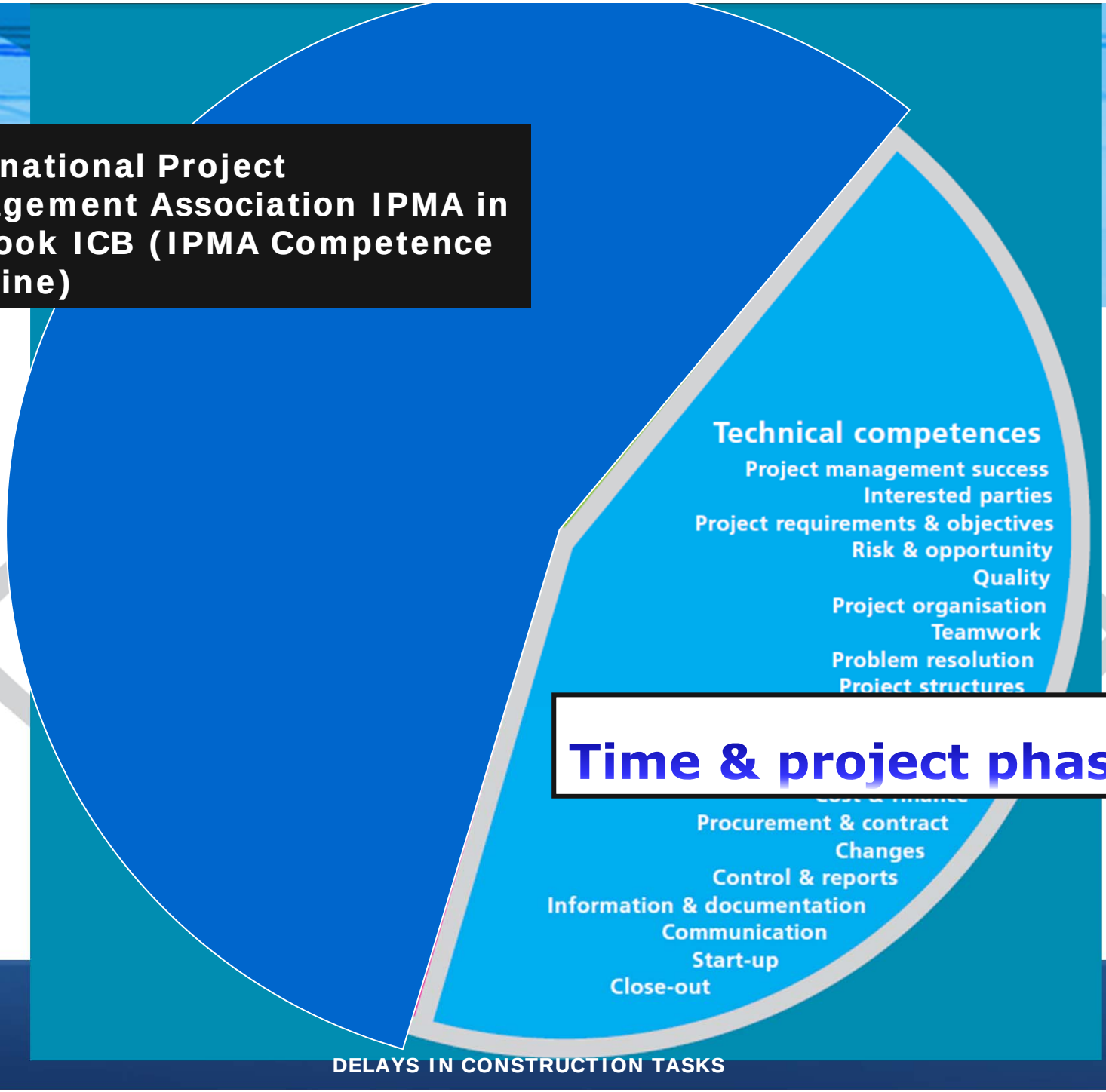
Planning and Scheduling

Construction management

Civil engineering

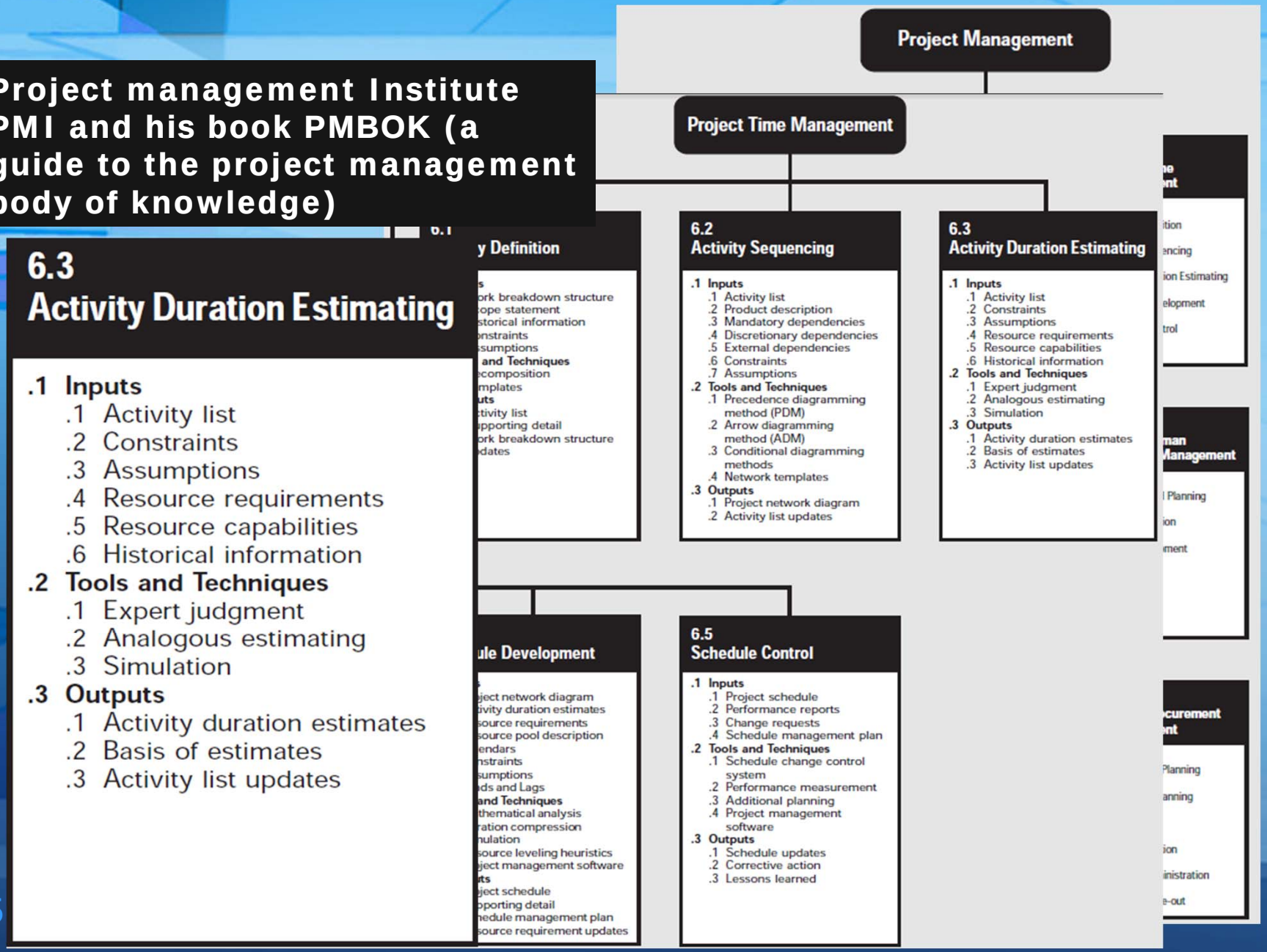
- Coastal engineering
- Construction engineering
- Earthquake engineering
- Environmental engineering
- Geotechnical engineering
- Water resources engineering
- Materials engineering
- Structural engineering
- Surveying
- Transportation engineering
- Municipal or urban engineering

International Project Management Association IPMA in his book ICB (IPMA Competence baseline)



Time & project phases

Project management Institute PMI and his book PMBOK (a guide to the project management body of knowledge)



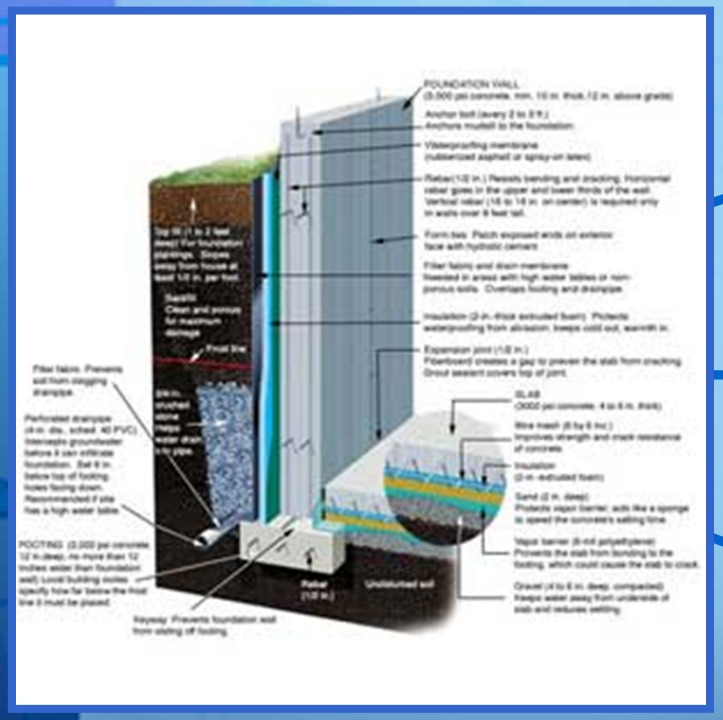
6.3 Activity Duration Estimating

.1 **Inputs**
- .1 Activity list
- .2 Constraints
- .3 Assumptions
- .4 Resource requirements
- .5 Resource capabilities
- .6 Historical information

.2 **Tools and Techniques**
- .1 Expert judgment
- .2 Analogous estimating
- .3 Simulation

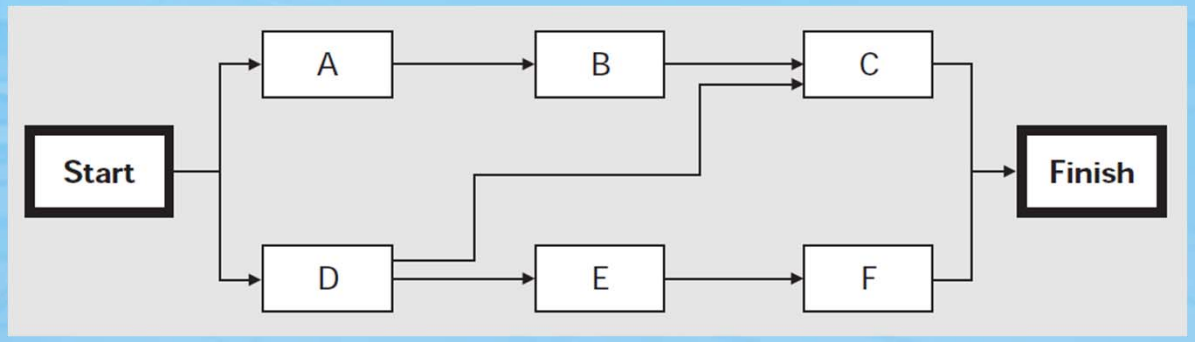
.3 **Outputs**
- .1 Activity duration estimates
- .2 Basis of estimates
- .3 Activity list updates

Construction activity efficiency parameters

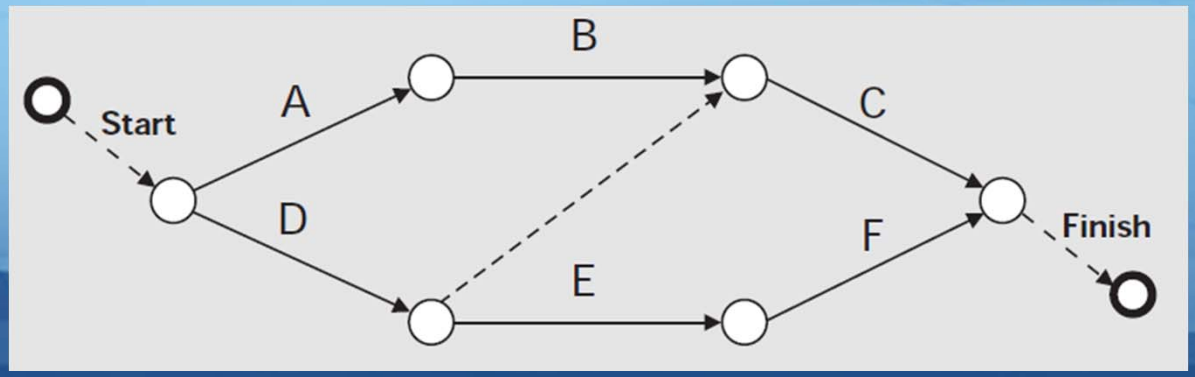


- TIME (SCHEDULE)
- COST (BUDGET)
- QUALITY (SPECIFICATION, NORMS, STANDARS)

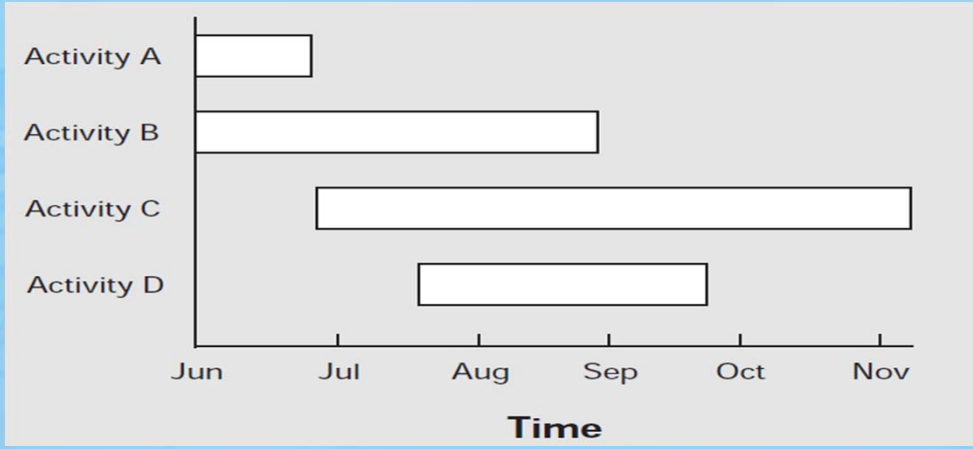
Network Logic diagram drawn using the Precedence diagramming method



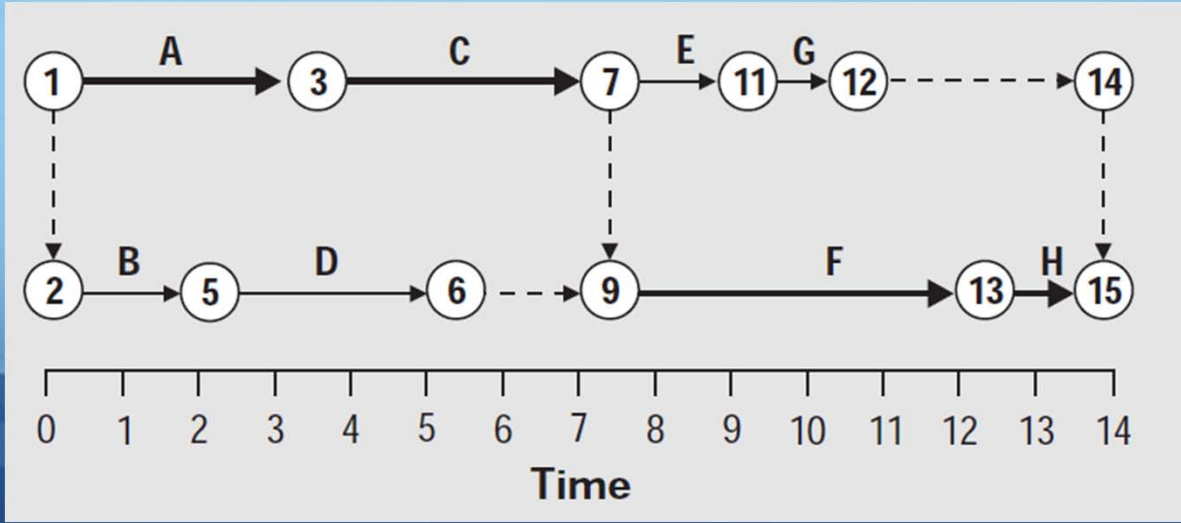
Network Logic diagram drawn using the Arrow diagramming method



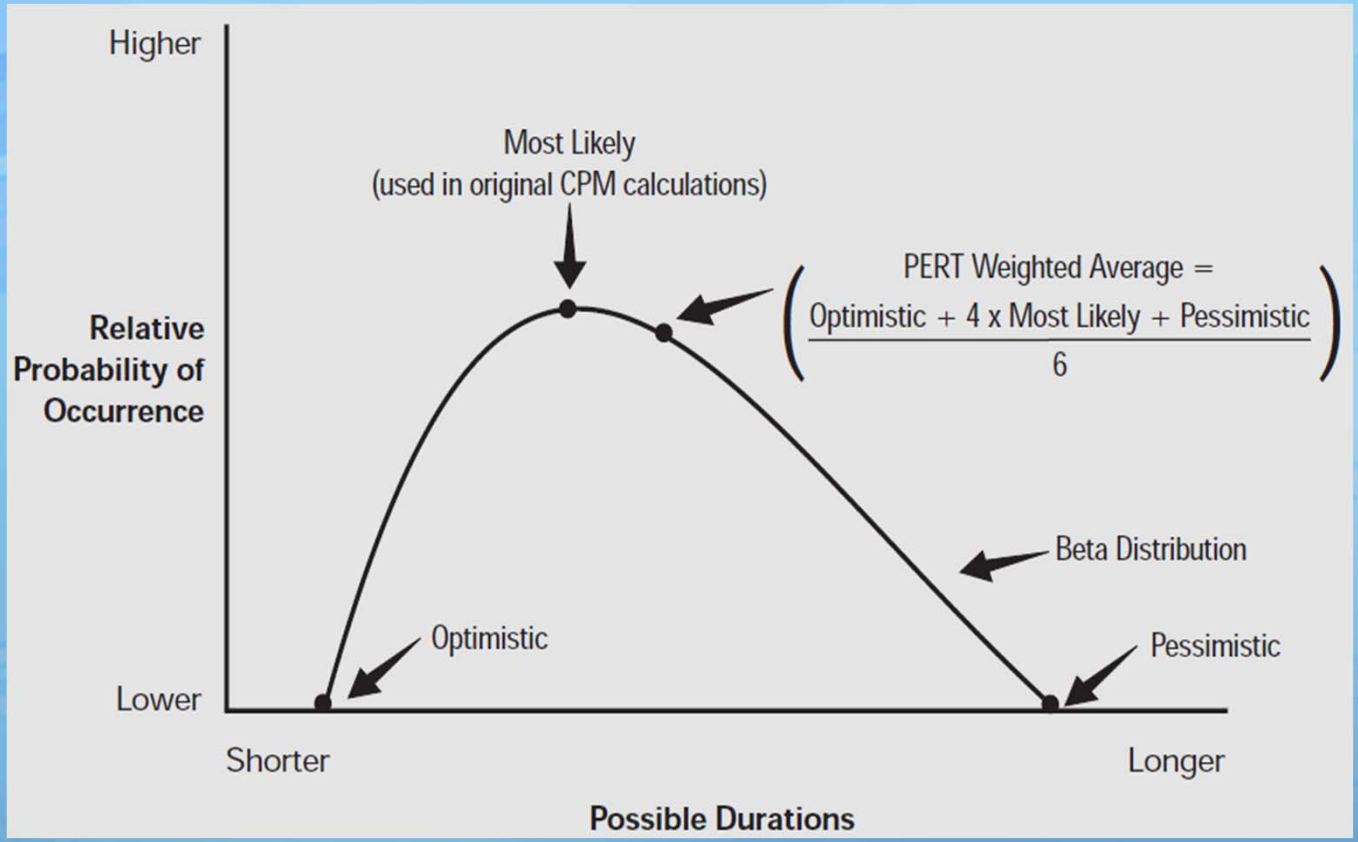
Bar (Gantt) Chart



Time scale network diagram



PERT duration Calculation



	Major causes				
	1	2	3	4	5
Vietnam (This study, 2007) (1)	Poor site management and supervision	Poor project management assistance	Financial difficulties of owner	Financial difficulties of contractor	Design changes
Malaysia (Sambasivan, 2007) (2)	Improper planning	Site management	Inadequate contractor experience	Finance and payments of completed work	Subcontractors
South Korea (Acharya *et al.*, 2006) (2)	Public interruptions	Changed site conditions	Failure to provide site	Unrealistic time estimation	Design errors
Hong Kong (Lo, 2006) (2)	Inadequate resources due to contractor/lack of capital	Unforeseen ground conditions	Exceptionally low bids	Inexperienced contractor	Works in conflict with existing utilities
UAE (Faridi, 2006) (2)	Preparation and approval of drawings	Inadequate early planning of the project	Slowness of the owner's decision-making process	Shortage of manpower	Poor supervision and poor site management
Jordan (Sweis, 2007) (2)	Financial difficulties faced by the contractor	Too many change orders from owner	Poor planning and scheduling of the project by the contractor	Presence of unskilled labor	Shortage of technical professionals in the contractor's organization
Kuwait (Koushki, 2005) (2)	Change orders	Financial constraints	Owner's lack of experience	Materials	Weather
(3)	Contractor	Materials	Financial constraints	Change orders	Weather
Ghana (Frimpong, 2003) (1)	Monthly payment difficulties	Poor contract management	Material procurement	Inflation	Contractor's financial difficulties
Nigeria (Aibinu, 2006) (2)	Contractors' financial difficulties	Clients' cash flow problem	Architects' incomplete drawing	Subcontractor's slow mobilization	Equipment breakdown and maintenance problem

(1): Delay and cost overruns; (2): Delay only; (3): Cost overrun only

Ref: Delay and Cost Overruns in Vietnam Large Construction Projects: A Comparison with Other Selected Countries

Summary of previous studies of the causes of delay in construction projects (middle east region)

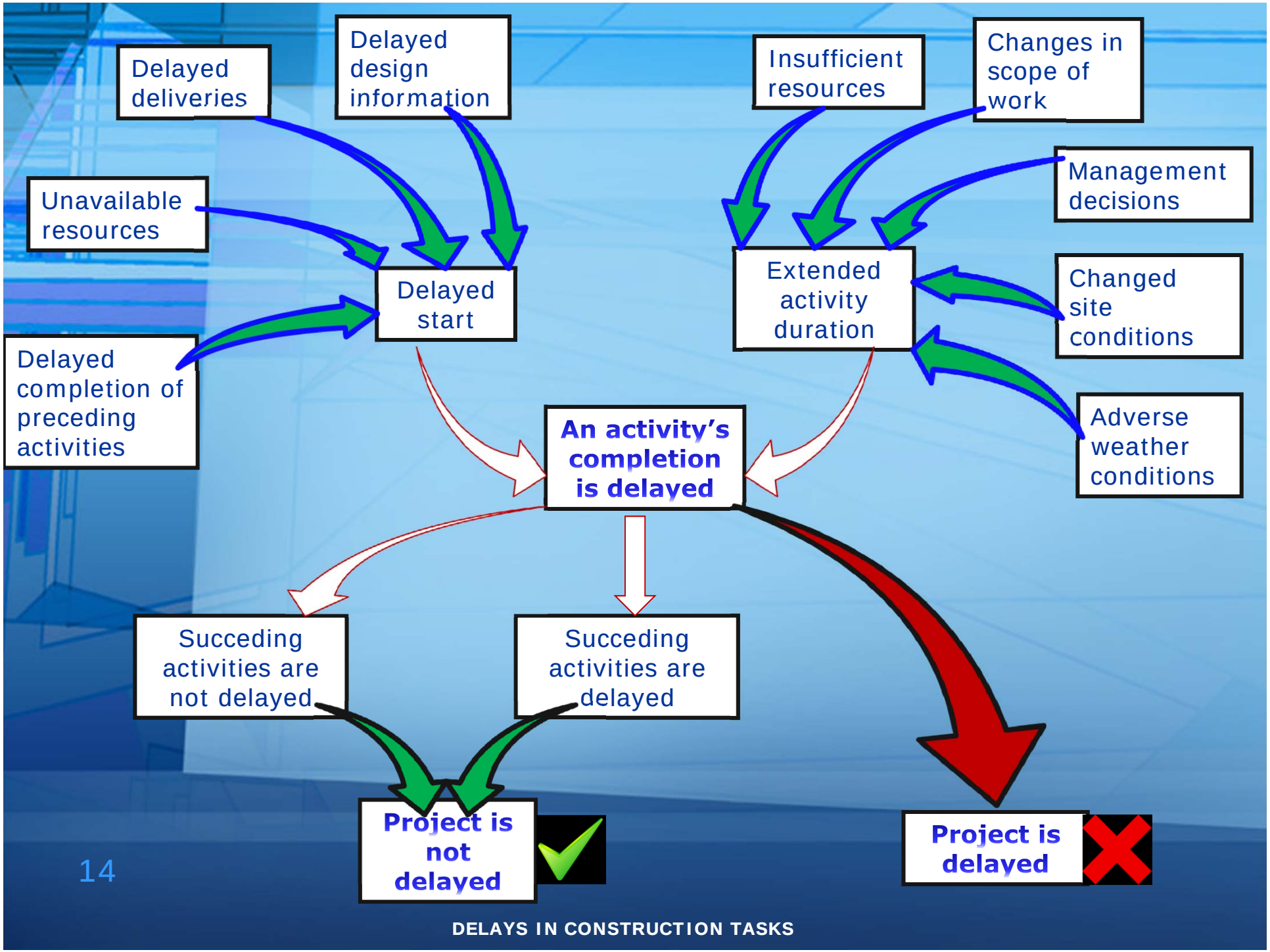
Country	Researchers	Major causes of delay
Saudi Arabia	Assaf et al. [3]	• Slow preparation and approval of shop drawings • Delays in payments to contractors • Changes in design/design error • Shortages of labor supply • Poor workmanship
Lebanon	Mezher et al. [4]	• Owner had more concerns with regard to financial issues • Contractors regarded contractual relationships the most important • Consultants considered project management issues to be the most important causes of delay
Saudi Arabia	Al-Khal and Al-Ghafly [5]	• Cash flow problems/financial difficulties • Difficulties in obtaining permits • "Lowest bid wins" system
Jordan	Al-Moumani [7]	• Poor design • Changes in orders/design • Weather • Unforeseen site conditions • Late deliveries
Kuwait	Koushki et al. [6]	• Changing orders • Owners' financial constraints • Owners' lack of experience in the construction business
United Arab Emirates (UAE)	Faridi and El-Sayegh [15]	• Slow preparation and approval of drawings • Inadequate early planning of the project • Slowness of owner's decision making • Shortage of manpower • Poor site management and supervision • Low productivity of manpower
Saudi Arabia	Assaf and Al-Hejji [13]	• Change in orders by the owner during construction • Delay in progress payment • Ineffective planning and scheduling • Shortage of labor • Difficulties in financing on the part of the contractor

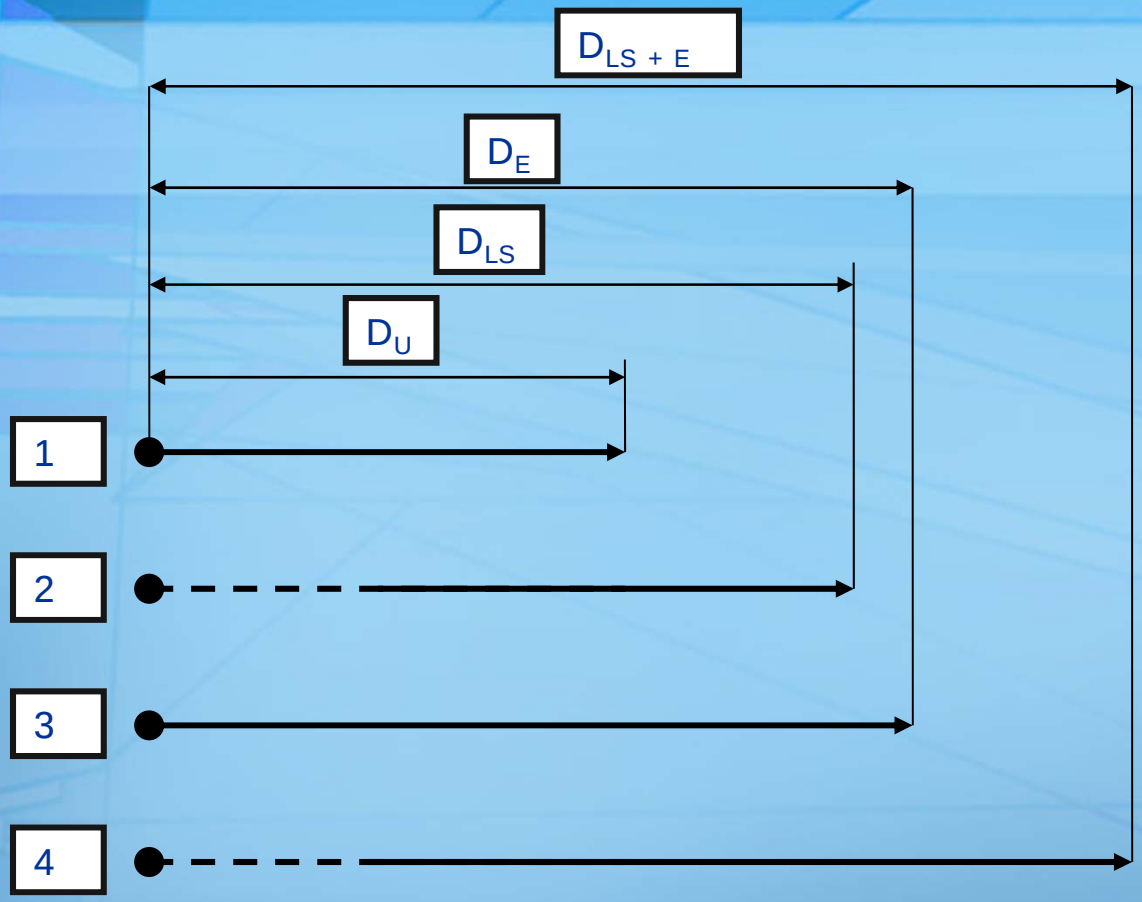
Ref: Delays in construction projects: The case of Jordan

		Average (consultant)	Average (contractor)	Average (owner)	Overall average
Labor (L)					
1	Shortage of manpower (skilled, semi-skilled, unskilled labor)	3.50	4.16	2.52	**3.39**
2	Presence of unskilled labor	3.96	3.19	4.08	**3.74**
Material (M)					
3	Shortage of materials	3.11	2.97	2.88	**2.99**
4	Delay in materials delivery	2.71	3.08	2.96	**2.92**
5	Materials price fluctuations	2.82	2.65	2.16	**2.54**
6	Modifications in materials specifications	2.04	2.59	2.24	**2.29**
Equipment (E)					
7	Shortage of equipments	3.04	2.89	3.32	**3.08**
8	Failure of equipments	2.93	2.62	2.76	**2.77**
9	Insufficient equipments	2.50	2.46	3.12	**2.69**
Internal Environment (IE)					
Contractor					
10	Lack of contractor's administrative personnel	3.39	2.49	3.36	**3.08**
11	Shortage of technical professionals in the contractor's organization	4.18	2.92	4.04	**3.71**
12	Insufficient coordination among the parties by the contractor	4.07	2.59	3.8	**3.49**
13	Delay in mobilization	2.64	2.49	2.32	**2.48**
14	Safety rules and regulations are not followed within the contractor's organization	3.93	2.19	3.96	**3.36**
15	Incompetent technical staff assigned to the project	3.82	2.86	4.12	**3.60**
16	Improper technical study by the contractor during the bidding stage	3.89	2.81	3.88	**3.53**
17	Poor planning and scheduling of the project by the contractor	4.39	2.95	4.32	**3.89**
18	Improper handling of the project progress by the contractor	2.86	2.32	2.76	**2.65**
19	Ineffective quality control by the contractor	3.96	2.76	3.84	**3.52**
20	Use of unacceptable construction techniques by the contractor	2.75	2.11	2.84	**2.57**
21	Financial difficulties faced by the contractor	4.32	4.35	4.24	**4.30**
22	Delays in contractor's payments to subcontractors	3.75	2.73	3.92	**3.47**

		Average (consultant)	Average (contractor)	Average (owner)	Overall average
Owner					
23	Delays in site preparation	1.96	2.57	2.24	**2.26**
24	Delay in contractor's claims settlements	2.54	3.81	2.72	**3.02**
25	Work suspension by the owner	1.89	2.30	2.48	**2.22**
26	Too many change orders from owner	4.21	4.24	3.64	**4.03**
27	Slow decision making from owner	3.86	3.81	2.88	**3.52**
28	Inference by the owner in the construction operations	3.68	3.76	2.28	**3.24**
29	Delay in progress payments by the owner	3.43	4.03	2.84	**3.43**
30	Financial constraints faced by the owner	3.54	2.89	3.32	**3.25**
31	Insufficient coordination among the parties by the Owner	3.07	2.70	3.24	**3.00**
Consultant					
32	Ambiguities and mistakes in specifications and drawings	2.43	3.46	2.76	**2.88**
33	Poor qualification of consultant engineer's staff assigned to the project	2.89	3.11	2.88	**2.96**
34	Delay in the approval of contractor submissions by the engineer	2.68	4.11	3.08	**3.29**
35	Poor coordination by the consultant engineer with the parties involved	2.46	2.92	2.72	**2.70**
36	Slow response by the consultant engineer regarding testing and inspection	2.61	3.05	2.76	**2.81**
37	Slow response by the consultant engineer to contractor inquiries	2.79	3.30	3.04	**3.04**
Exogeneous factors (EF)					
Weather					
38	Severe weather conditions on the job site	1.71	1.92	1.92	**1.85**
Government regulations					
39	Difficulties in obtaining work permits	2.11	2.00	2.44	**2.18**
40	Changes in Government regulations and laws	1.82	1.89	1.88	**1.86**

Ref: Delays in construction projects: The case of Jordan


Delayed deliveries
Delayed design information
Insufficient resources
Changes in scope of work
Unavailable resources
Management decisions
Delayed start
Extended activity duration
Changed site conditions
Delayed completion of preceding activities
An activity's completion is delayed
Adverse weather conditions
Succeding activities are not delayed
Succeding activities are delayed
Project is not delayed
Project is delayed
DELAYS IN CONSTRUCTION TASKS



Example 1 is the representation of one task with *unimpacted duration* (D_U).
Example 2 is the same task but with late *start duration* (D_{LS}).
Example 3 again the same task but with *extended duration* (D_E)
Example 4, the same task taking into account both effects *late start and extended duration* ($D_{LS + E}$)

ANALYSIS PROCESS

RESOURCES

Materials

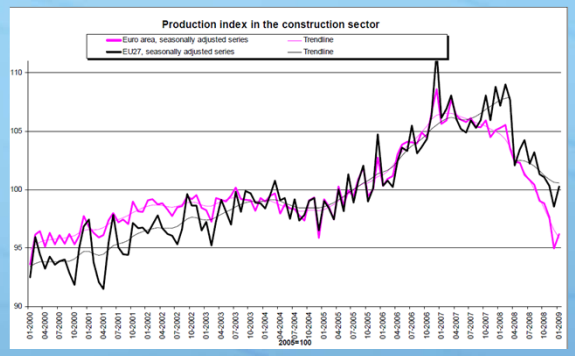
Labor

Equipment

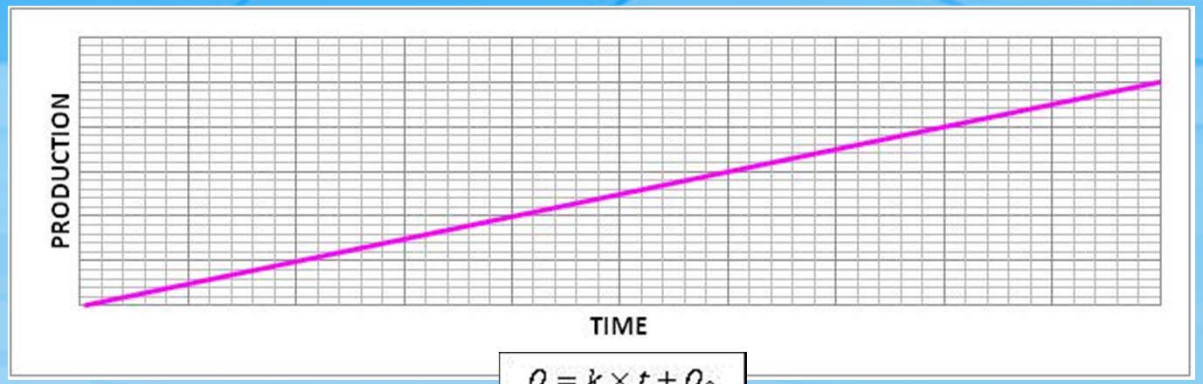
Transport

AMOUNT

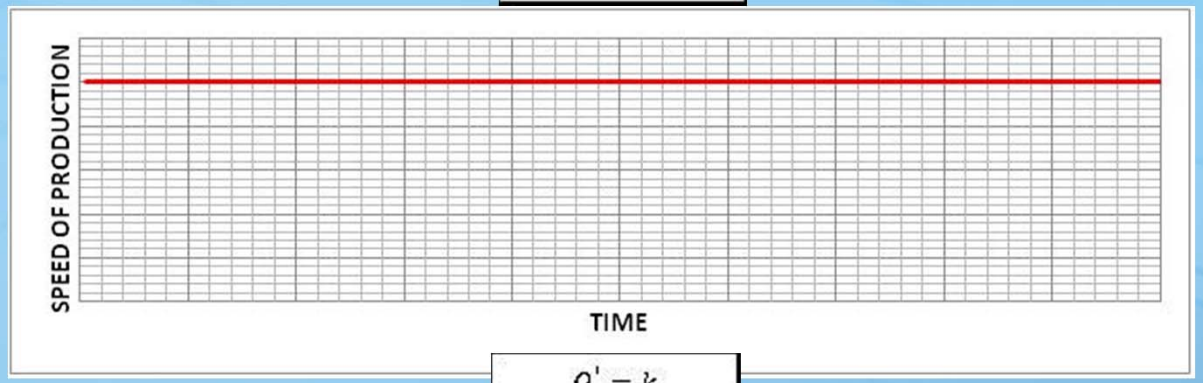
PRODUCTION GRAPH



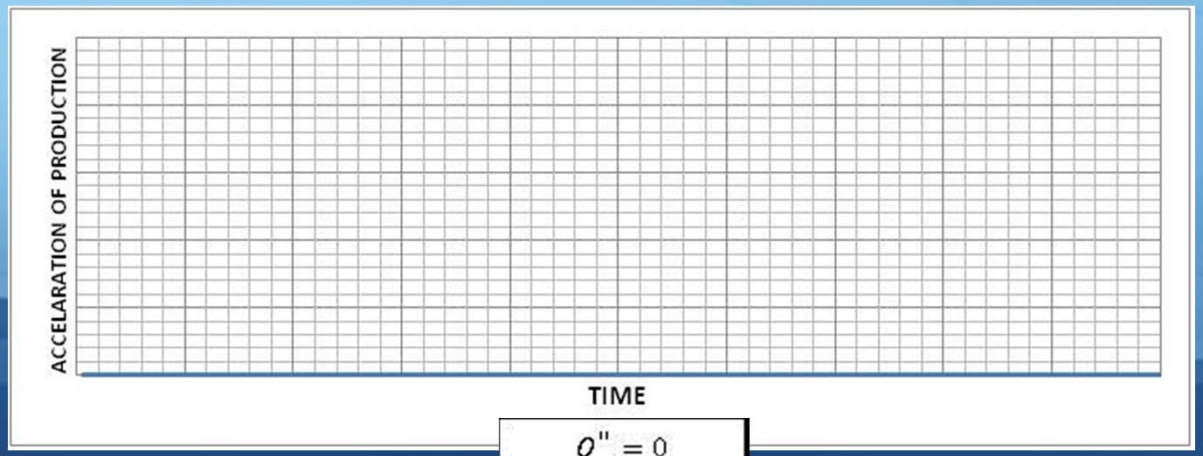
Deterministic model of the activity production



$$Q = k \times t + Q_0$$

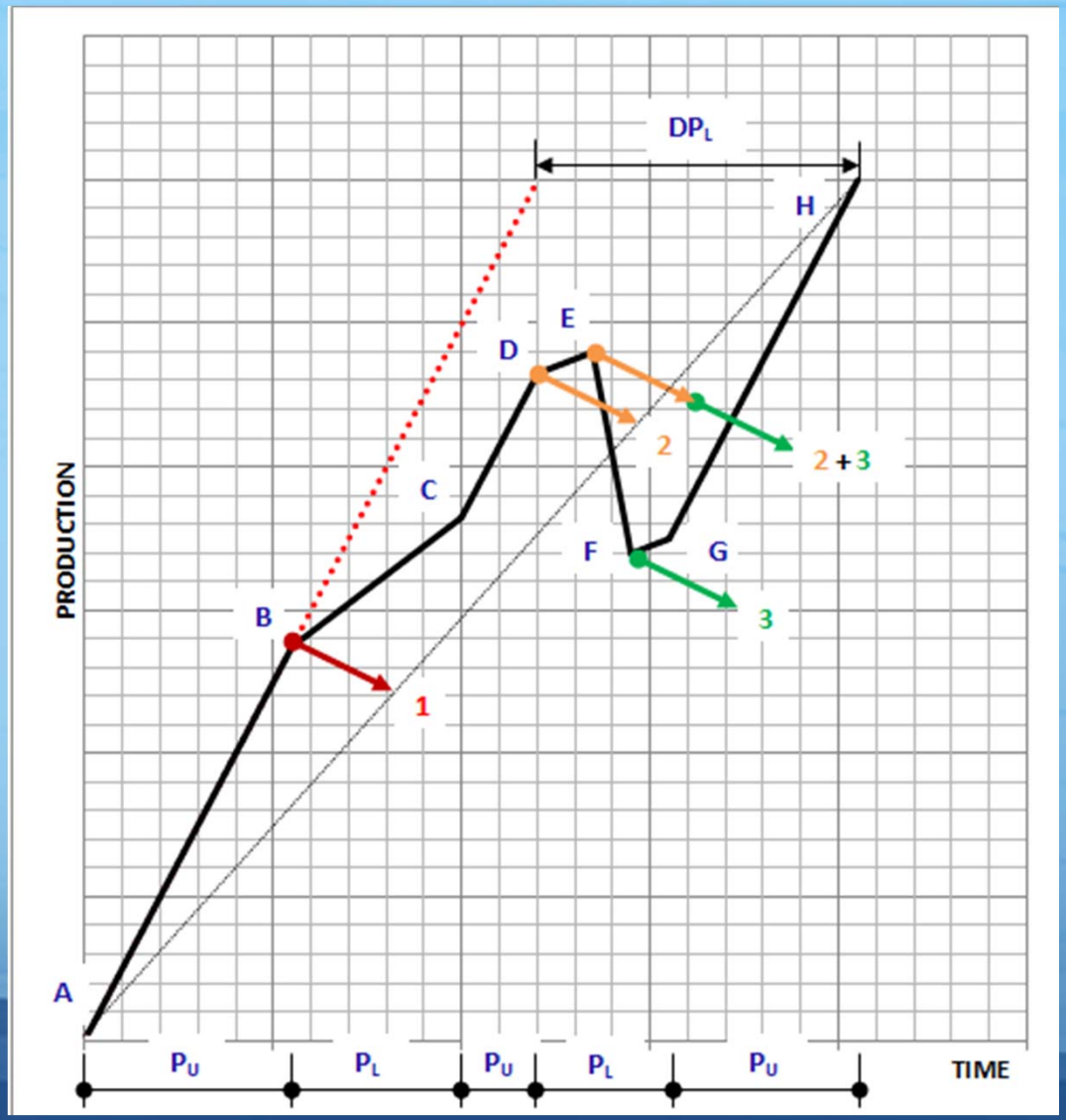


$$Q' = k$$



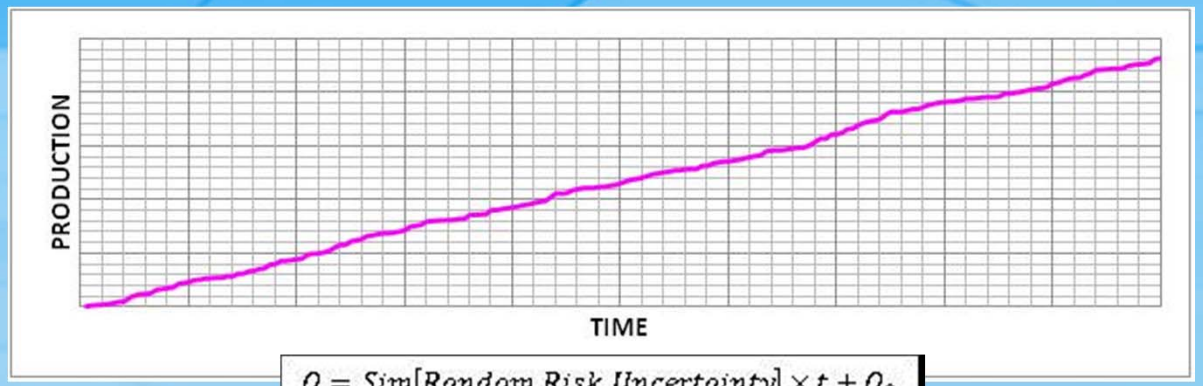
$$Q'' = 0$$

Effect of the factors affecting the production

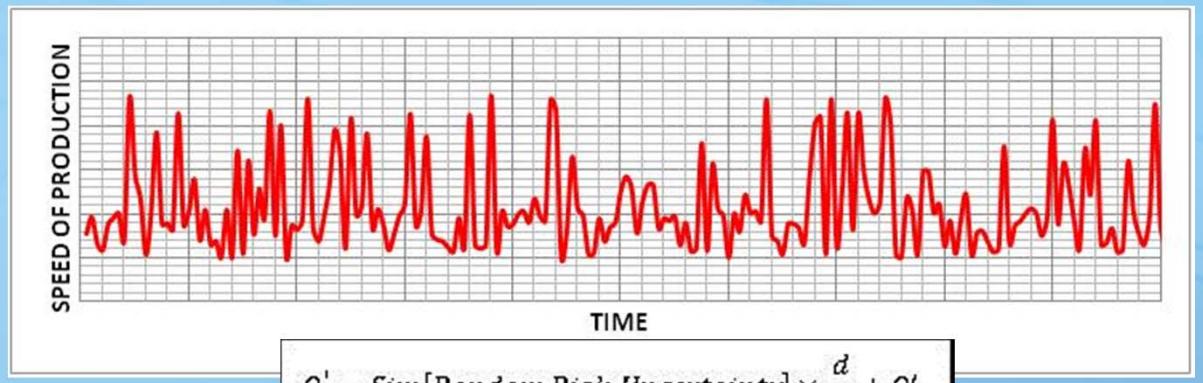


P_U = Unaffected Production
P_L = Lost Production

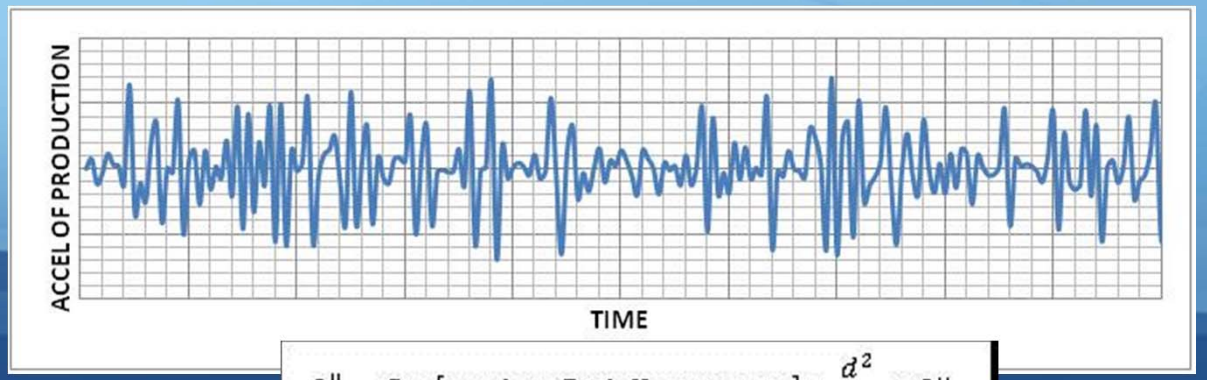
Stochastic model of the activity production



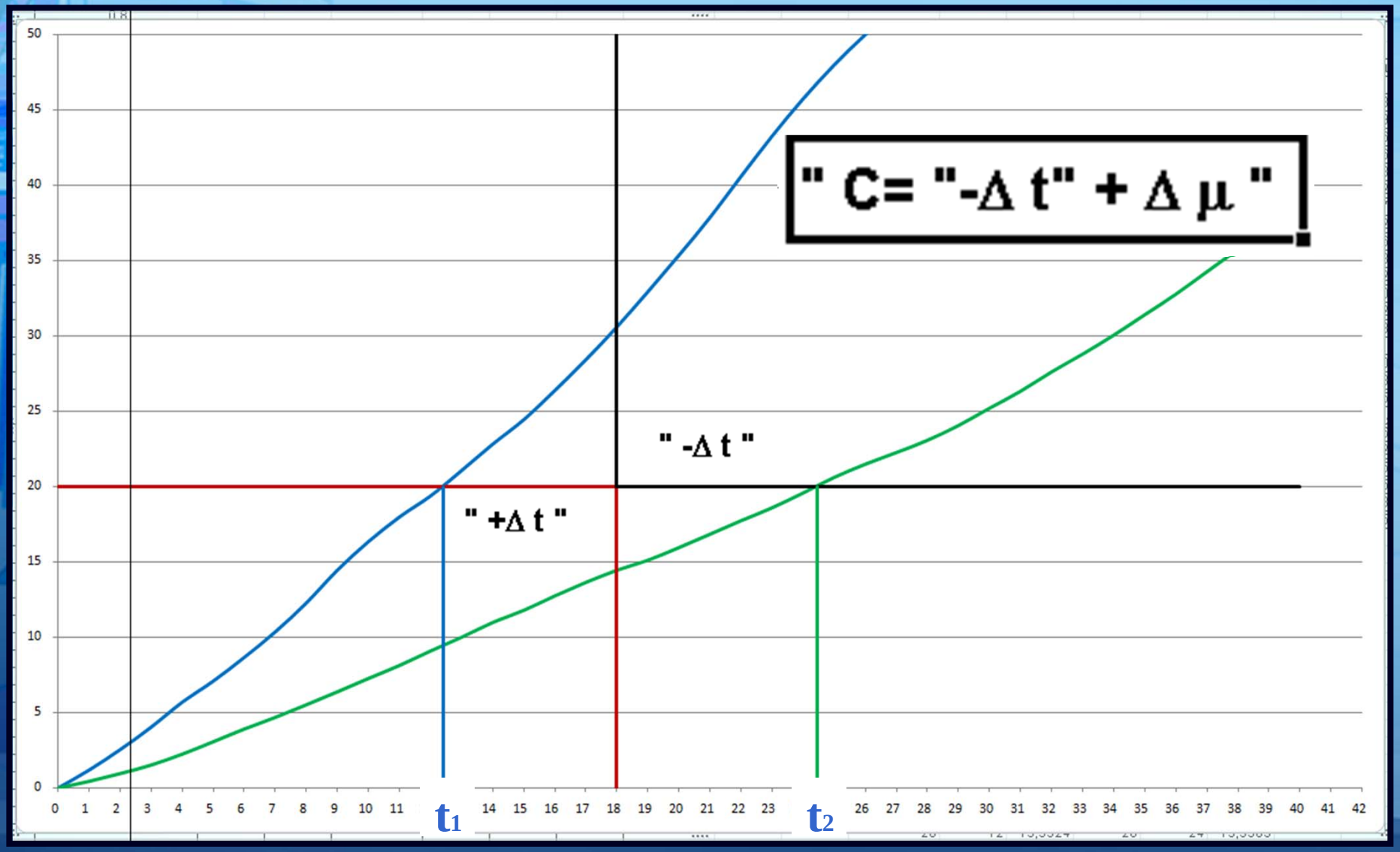
$$Q = Sim[Random, Risk, Uncertainty] \times t + Q_0$$

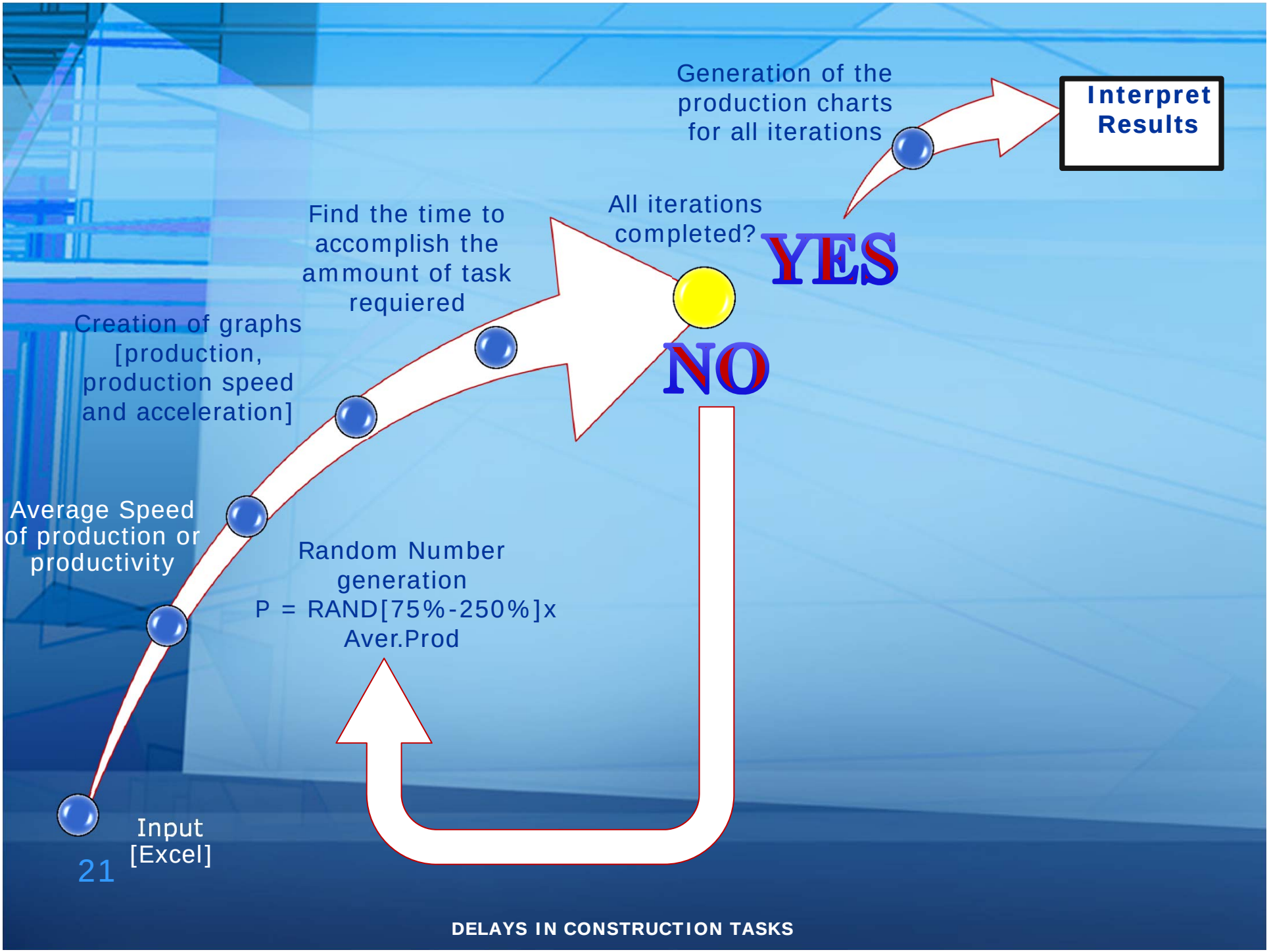


$$Q' = Sim[Random, Risk, Uncertainty] \times \frac{d}{dt} + Q'_0$$

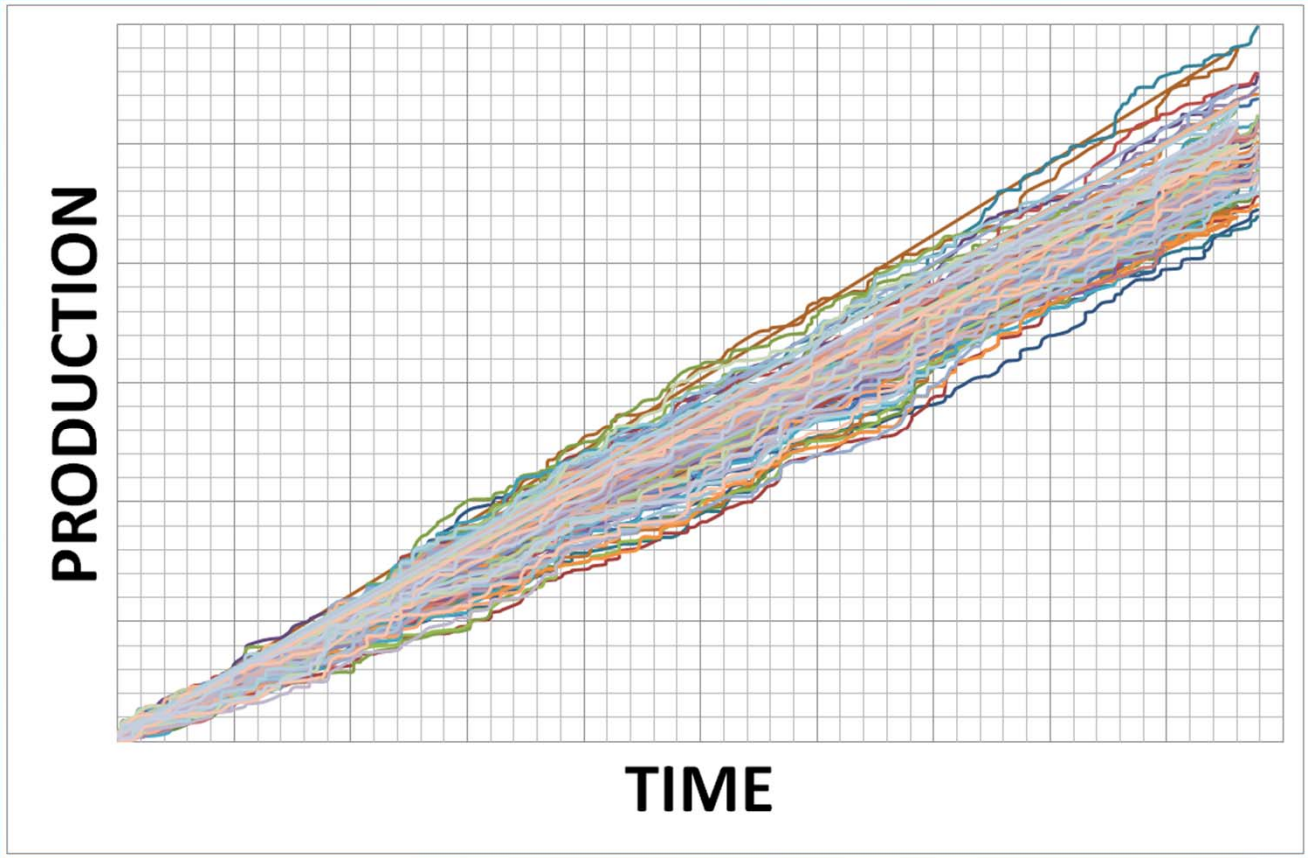


$$Q'' = Sim[random, Risk, Uncertainty] \times \frac{d^2}{dt^2} + Q''_0$$

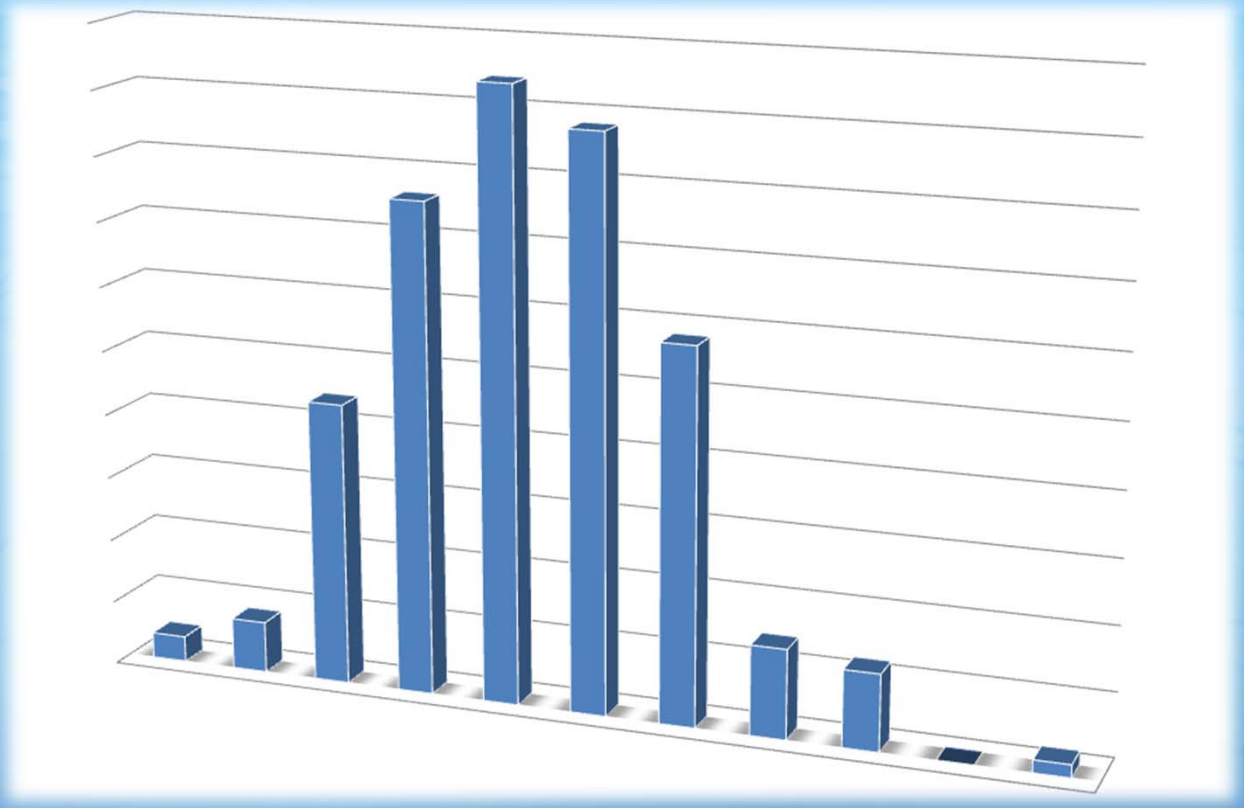

" C= "-Δ t" + Δ μ "
" -Δ t "
" +Δ t "
t1
t2


Input
[Excel]
Average Speed of production or productivity
Random Number generation
P = RAND[75%-250%]x Aver.Prod
Creation of graphs [production, production speed and acceleration]
Find the time to accomplish the ammount of task requiered
All iterations completed?
NO
YES
Generation of the production charts for all iterations
Interpret Results

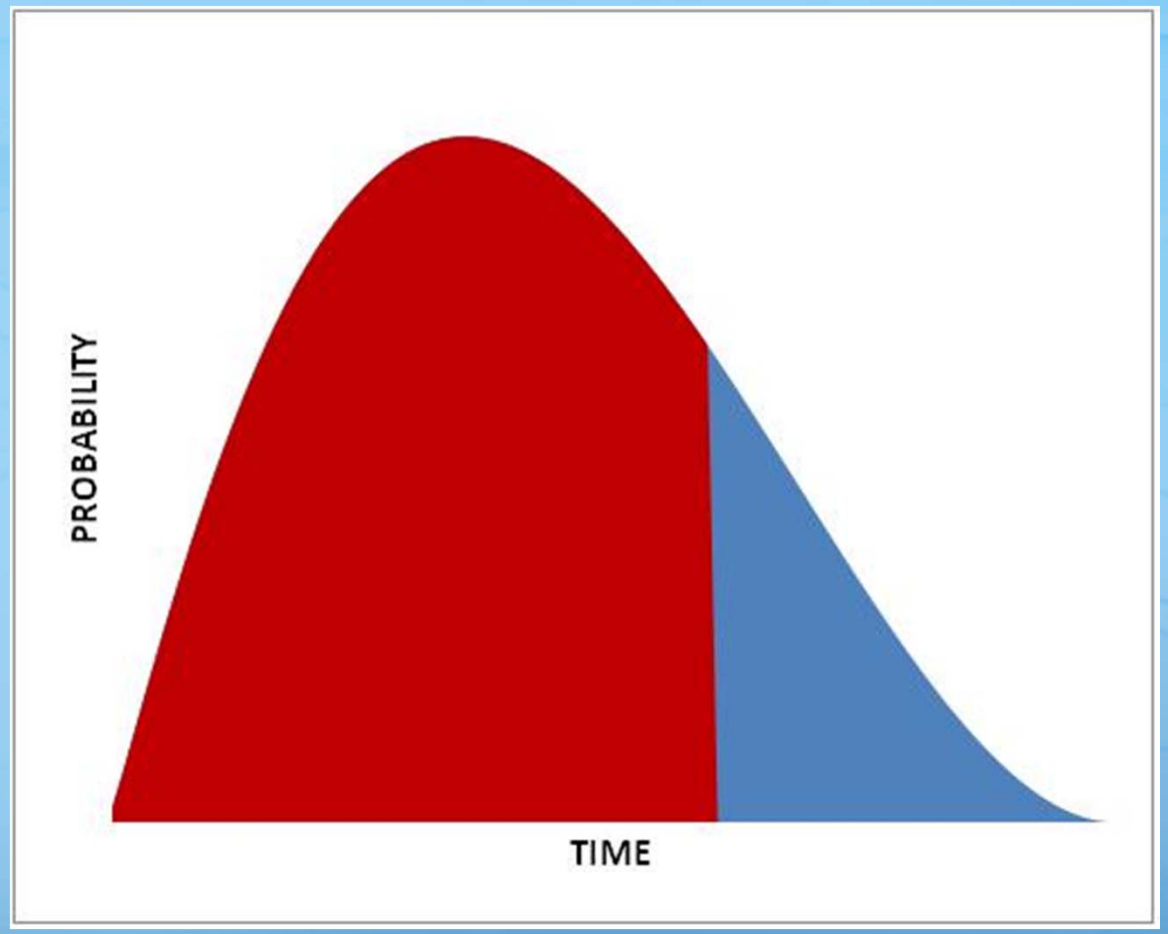
200 simulations given the randomness in the process



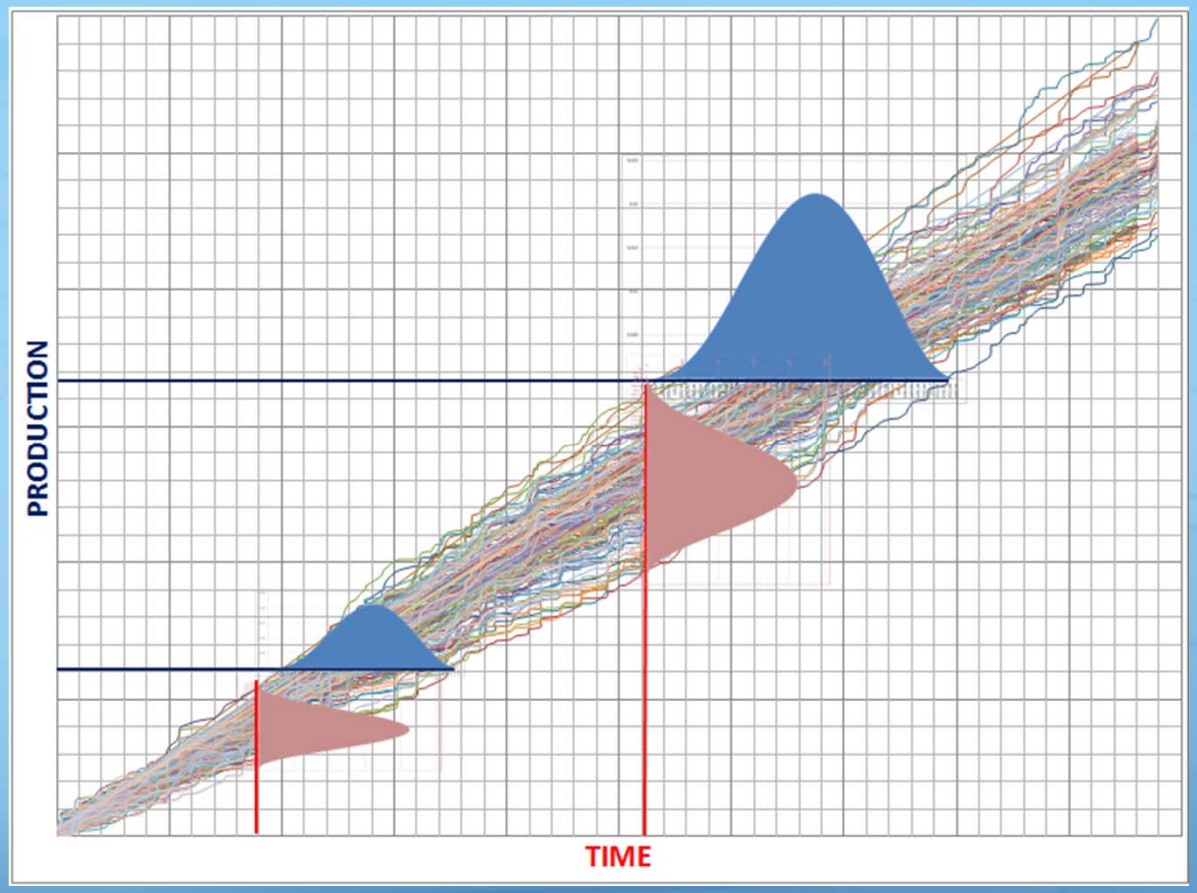
Frequency time distribution



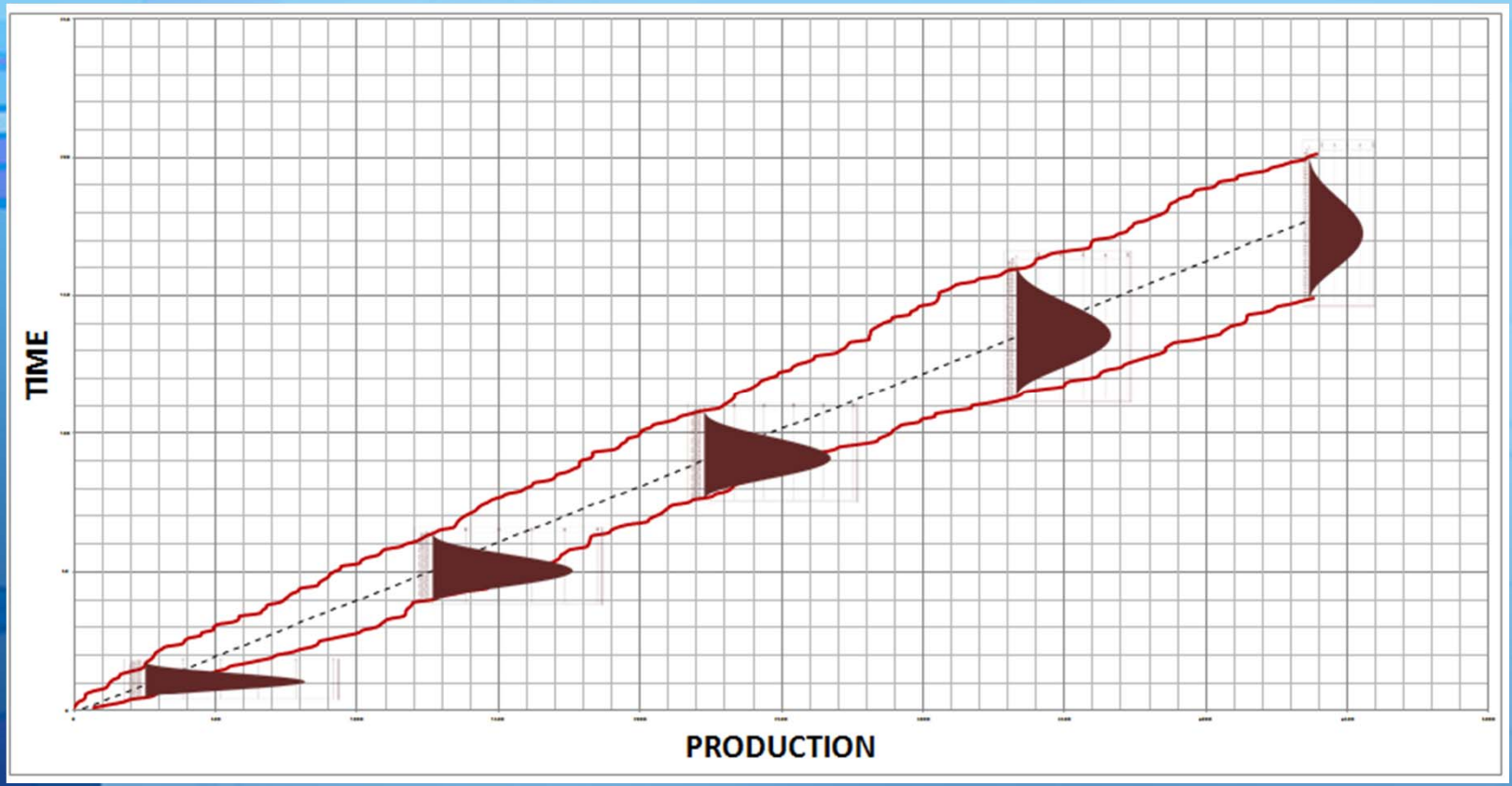
Beta distribution with 80% of probability



Distributions of times and productions



Envelope line for the range of times and its distributions



CONCLUSIONS

- The model gives another managerial parameters such as speed and acceleration through the virtual management momentum simulation to evaluate the execution of the activity and not only the production chart.

- A further step is to assess also the cost implications in the execution of the activity.

- And still ambitious step is not just application of the classical mechanical model to the economic model of production but also look for the efficient energy required to perform the activity and maybe the concurrent use of dynamical systems theory, chaos theory and Recurrent plots Analysis for a better understanding of the model.

QUESTIONS


THANK YOU.