CB 519
Construction Project Management 2

Dr. Mohamed Saeid Eid

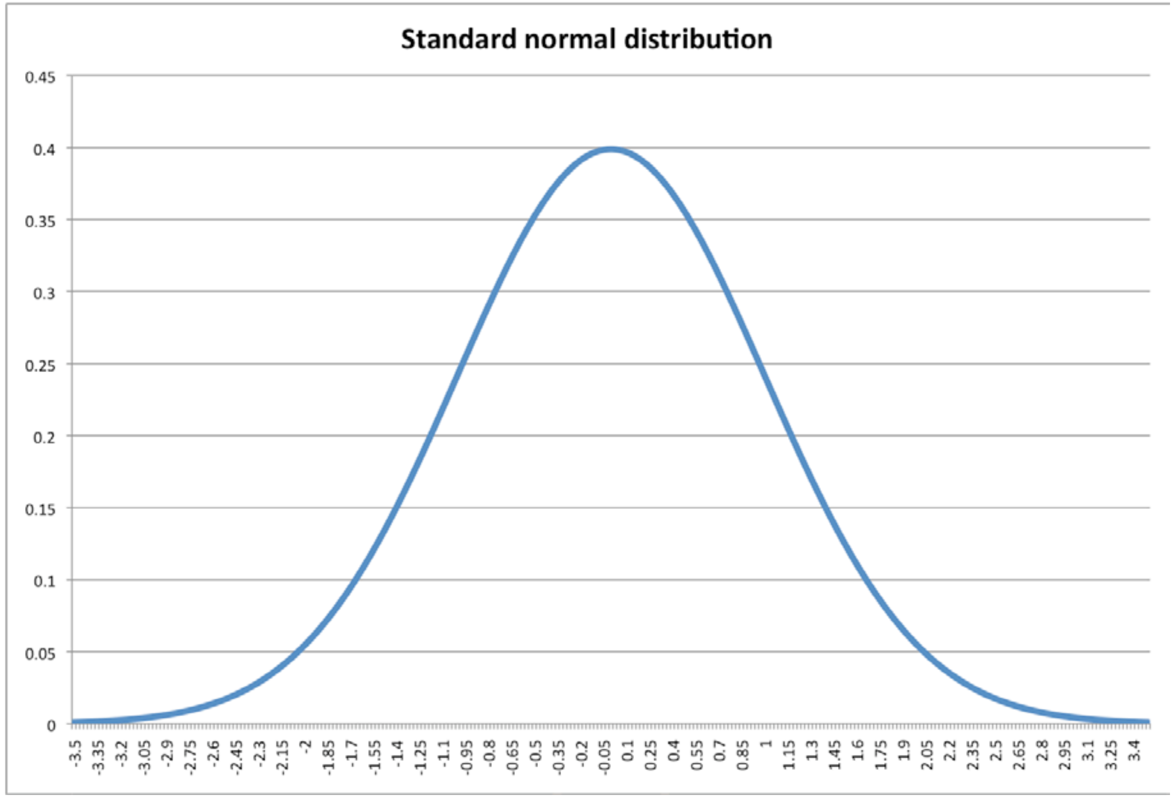
Fall - 2017

Stochastic Scheduling – Uncertainty

- Activities duration
  - How do we calculate duration?
  - Are production rates deterministic?
  - Assume we have an excavation activity with total duration of 30days. What does the 30days actually means?

Stochastic Scheduling – Uncertainty

- Stochastic/uncertain activity duration



Can CPM handle such uncertainty?

CPM duration drawback

- CPM is a single and deterministic duration estimate model.
- Such estimate ignores the probabilistic and variability associated with construction.
- Variation can be due to crew’s efficiency, weather, management conditions, etc.

PERT

- Program Evaluation Review Technique (PERT)

- Duration (T_e) is calculated through three time estimates

  - Optimistic (T_o)

  - Most-likely (T_m)

  - Pessimistic (T_p)

$$T_e = \frac{T_o + 4T_m + T_p}{6}$$

Example

Activity	Predecessor	T_o	T_m	T_p	T_e
A	--	1	1	1	
B	A	3	7	11	
C	A	2	6	7	
D	A	1	3	8	
E	B	1	3	5	
F	B,C	5	7	9	
G	D	5	8	9	
H	E,F	3	7	9	
J	F	2	5	7	
K	F,G	3	3	3	
L	H,J,K	2	5	8	

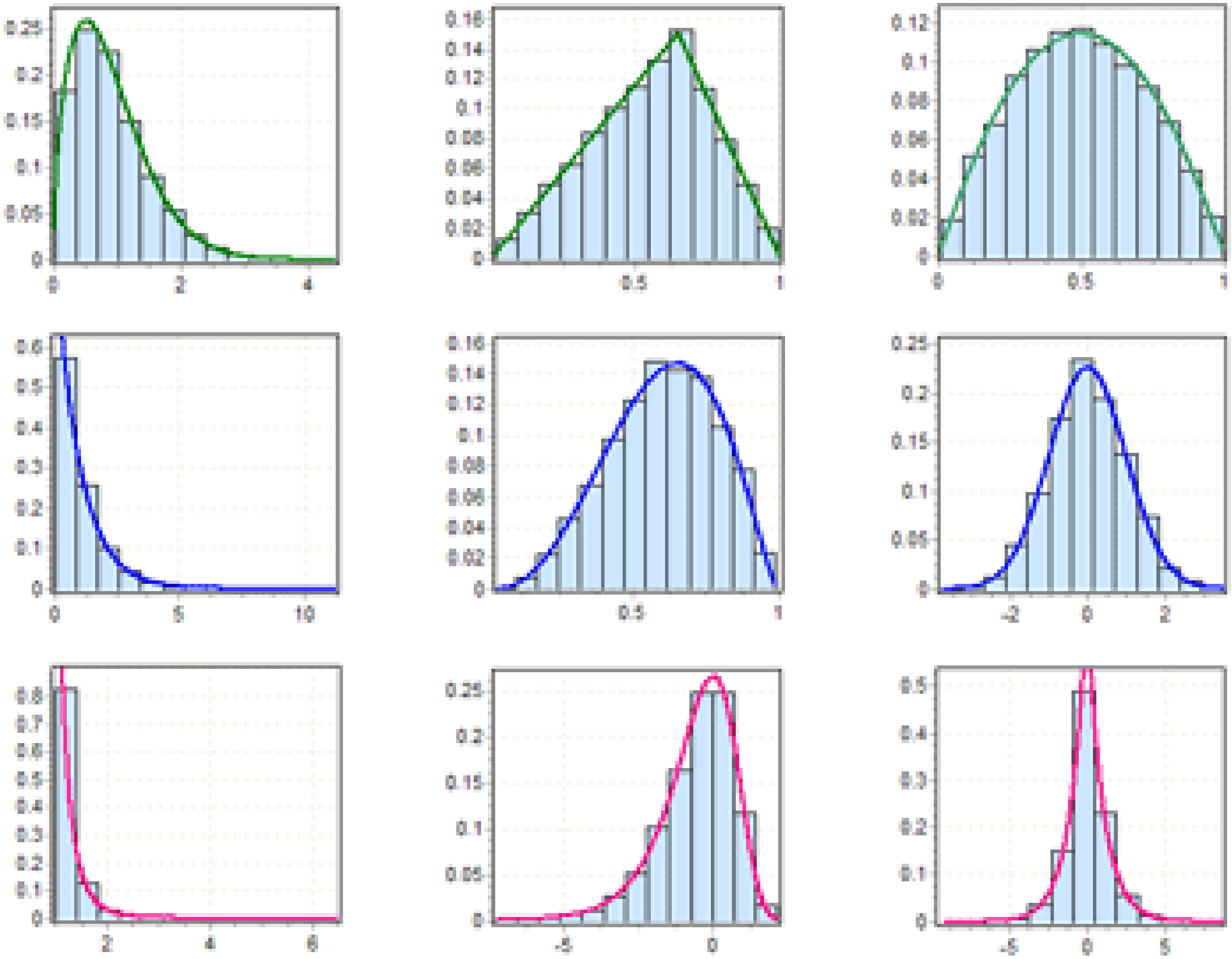
Example

Activity	Predecessor	T_o	T_m	T_p	T_e
A	--	1	1	1	1
B	A	3	7	11	7
C	A	2	6	7	5.5
D	A	1	3	8	3.5
E	B	1	3	5	3
F	B,C	5	7	9	7
G	D	5	8	9	7.666667
H	E,F	3	7	9	6.666667
J	F	2	5	7	4.833333
K	F,G	3	3	3	3
L	H,J,K	2	5	8	5

Still 50% probability

Probability

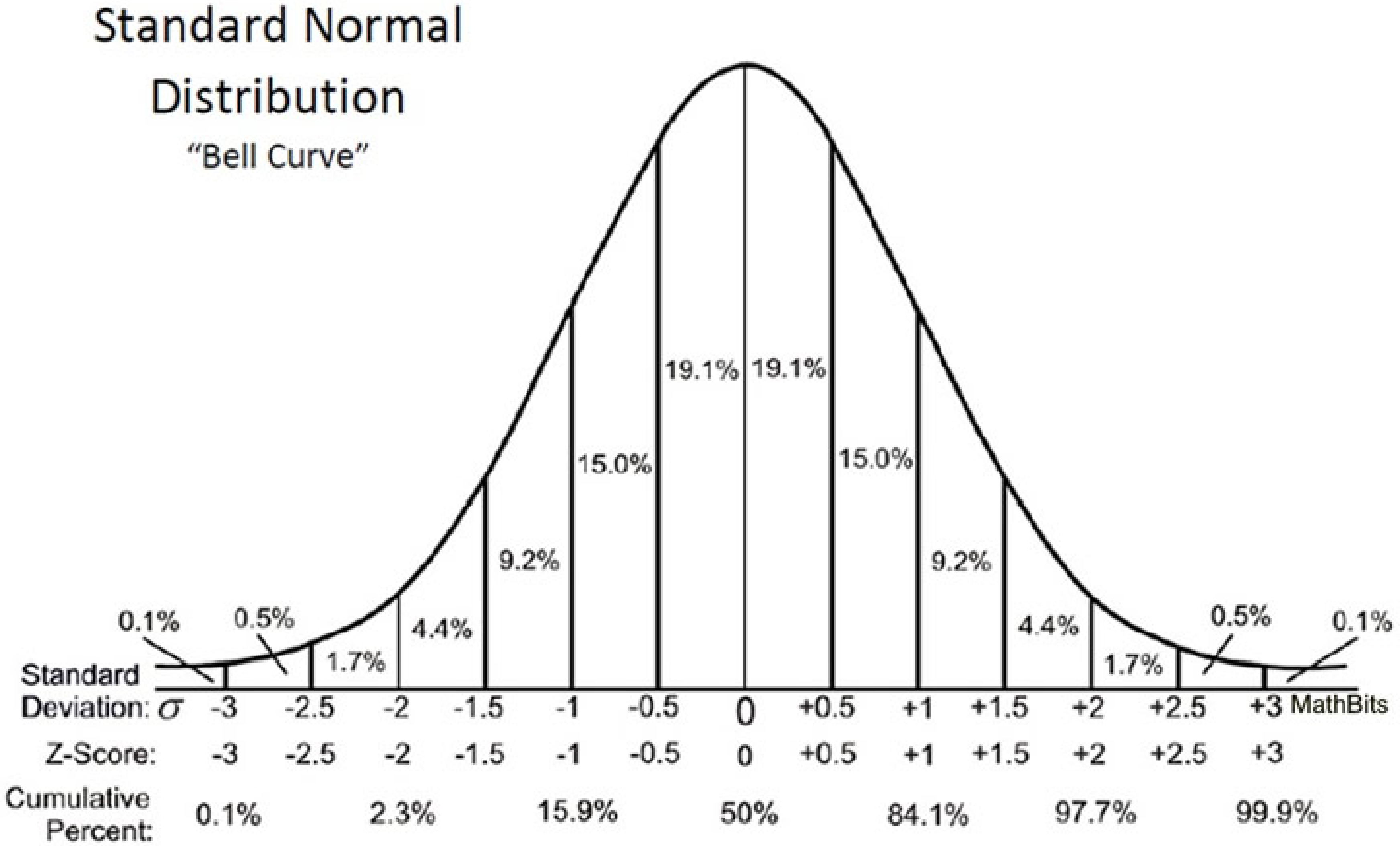
- What is probability?
    - Likelihood that an event will occur
- What is Probability distribution?
    - Probability function of a variable that governs its probability.



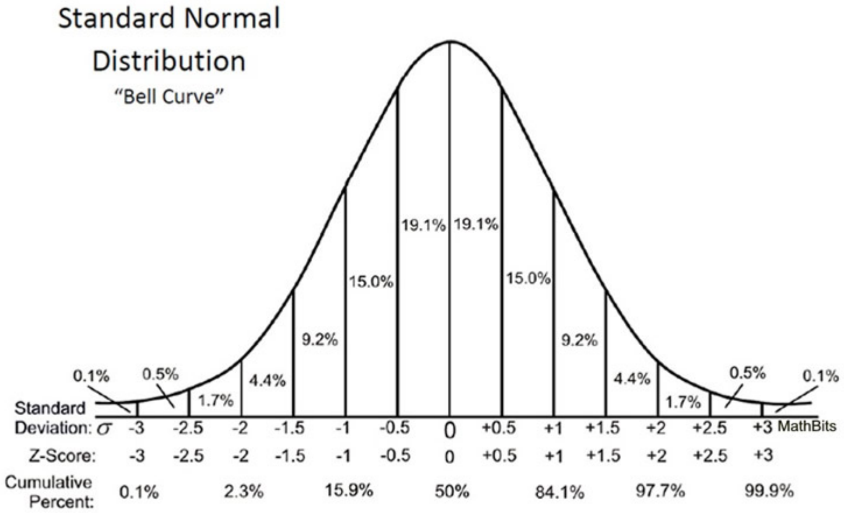
Exploring probability distributions

- Coin and dice games

Probability



Probability



- Mean
  - The average value at 50% probability
- Standard deviation
  - A number that express how much the values of each group differ from the mean
- Variance
  - Describes how are the numbers spread out from the mean.

Probability

- Mean (T_e)

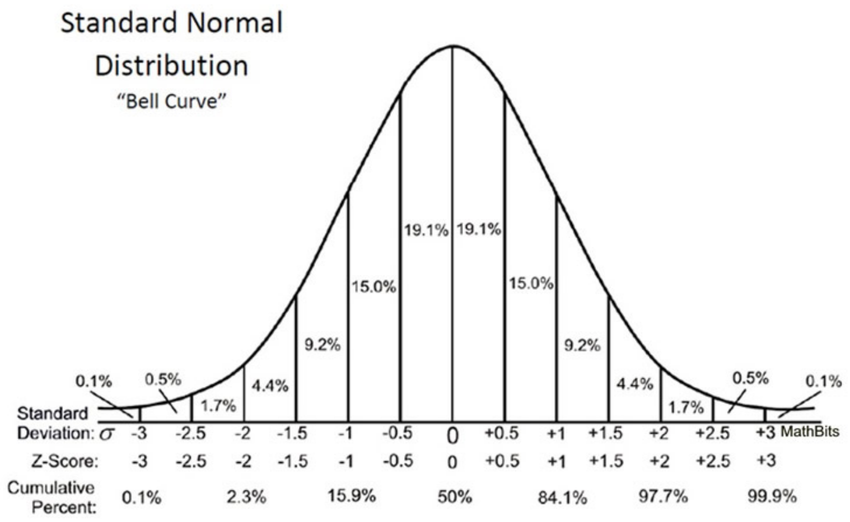
$$T_e = \frac{T_o + 4T_m + T_p}{6}$$

- Standard deviation (*s*)

$$s = \frac{T_p - T_o}{6}$$

- Variance (*v*)

$$v = s^2$$



Example

Activity	Predecessor	T_o	T_m	T_p	T_e	s	v
A	--	1	1	1	1		
B	A	3	7	11	7		
C	A	2	6	7	5.5		
D	A	1	3	8	3.5		
E	B	1	3	5	3		
F	B,C	5	7	9	7		
G	D	5	8	9	7.666667		
H	E,F	3	7	9	6.666667		
J	F	2	5	7	4.833333		
K	F,G	3	3	3	3		
L	H,J,K	2	5	8	5		

Example

Activity	Predecessor	T_o	T_m	T_p	T_e	s	v
A	--	1	1	1	1	0	0
B	A	3	7	11	7	1.333333	1.777778
C	A	2	6	7	5.5	0.833333	0.694444
D	A	1	3	8	3.5	1.166667	1.361111
E	B	1	3	5	3	0.666667	0.444444
F	B,C	5	7	9	7	0.666667	0.444444
G	D	5	8	9	7.666667	0.666667	0.444444
H	E,F	3	7	9	6.666667	1	1
J	F	2	5	7	4.833333	0.833333	0.694444
K	F,G	3	3	3	3	0	0
L	H,J,K	2	5	8	5	1	1

Stochastic properties of critical path

- Duration of critical path

$$T_{project} = \sum T_{e_{CP}}$$

- Variance of critical path

$$V_{project} = \sum V_{CP}$$

- Standard deviation of critical path

$$S_{project} = \sqrt{V_{project}}$$

What did we gain from this?

- Even though we still have T_e at 50% probability, we have better understanding on the likelihood of this estimation.

- Through the standard deviation and variance, we can predict the probability of finishing the activities on time, given the changes in any activity.

Another advantage of probabilistic distribution

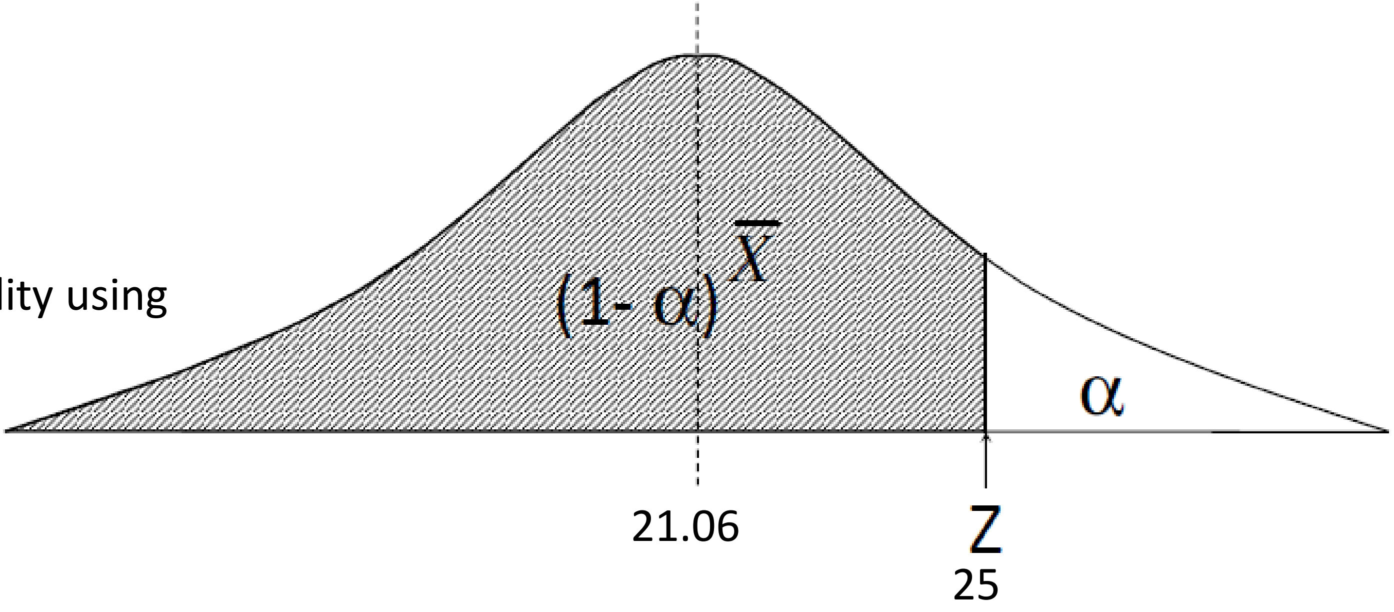
- Since we have the properties of the stochastic project, we can evaluate the probability of completing the project (or a task) at a given date.

Probability of completing before a given time.

What if we want to check the probability of finishing the project before 25 days?

$Z = (T_{new}-T_e)/s$

Then we can calculate the probability using the following table



z	0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.4878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952

More examples

- What is the probability of finishing before 23 days?
- What is the probability of finishing before 19 days?
- What is estimated project duration if we want to finish with probability 75%?