

ENCE 667  
Spring 2001



# Bottling Plant Upgrade

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# Problem Background



- Existing bottling plant in Cali, Colombia
- Launch new product
- Existing equipment is inadequate

## Need to:

- Perform current system evaluation
- Perform requirement analysis
- Evaluate alternatives
- Implementation of the chosen alternative
  - *Plan strategy*
  - *Evaluate risk*
  - *Execute the installation*
  - *Within the scope of this project*



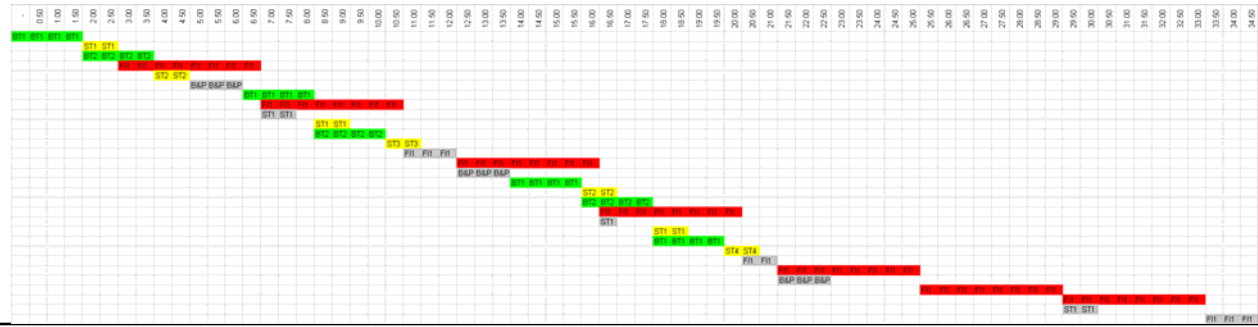
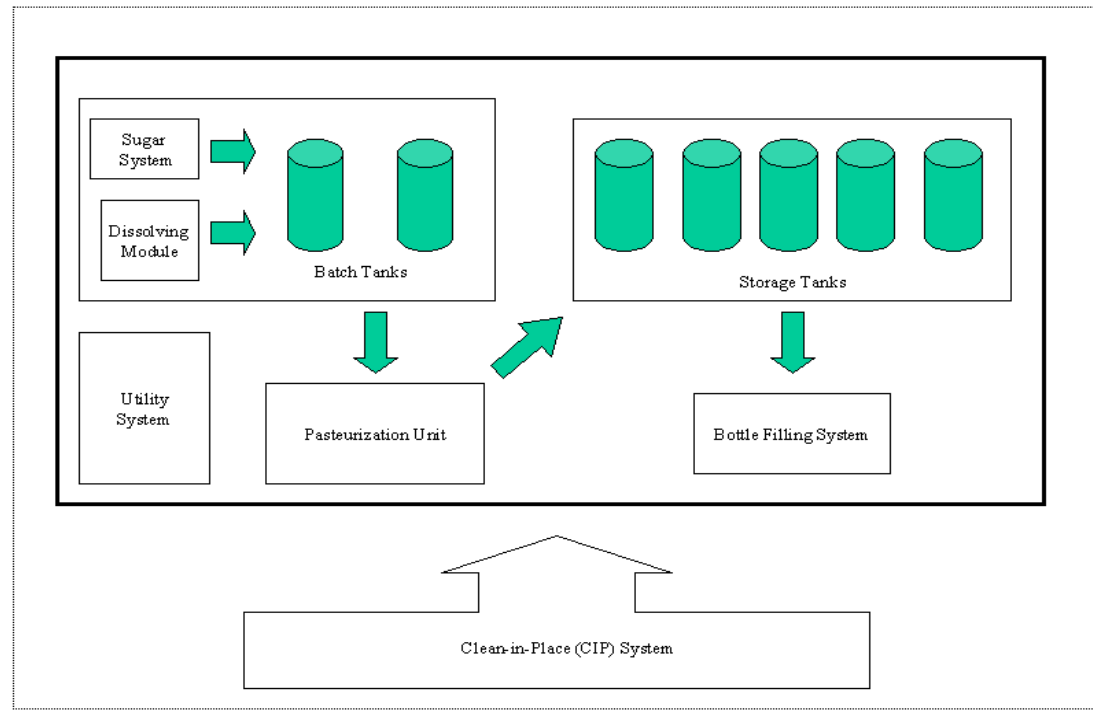
# Juice Processing Plant



**Processes:**

- Batching (preparation)
- Pasteurization
- Filling the package
- Cleaning the equipment

Current System Components - Juice System



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# Clean In Place Unit (CIP)



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# CIP's Graphical User Interface (GUI)



4/8/01 12:32:23 AM **Falla Comunicación DH+** ? CIP Ok

Circuito a Limpiar

Pasos: 0

Terminado	Variables	System On
Funcionando	Estado	Faltan
		# Min.

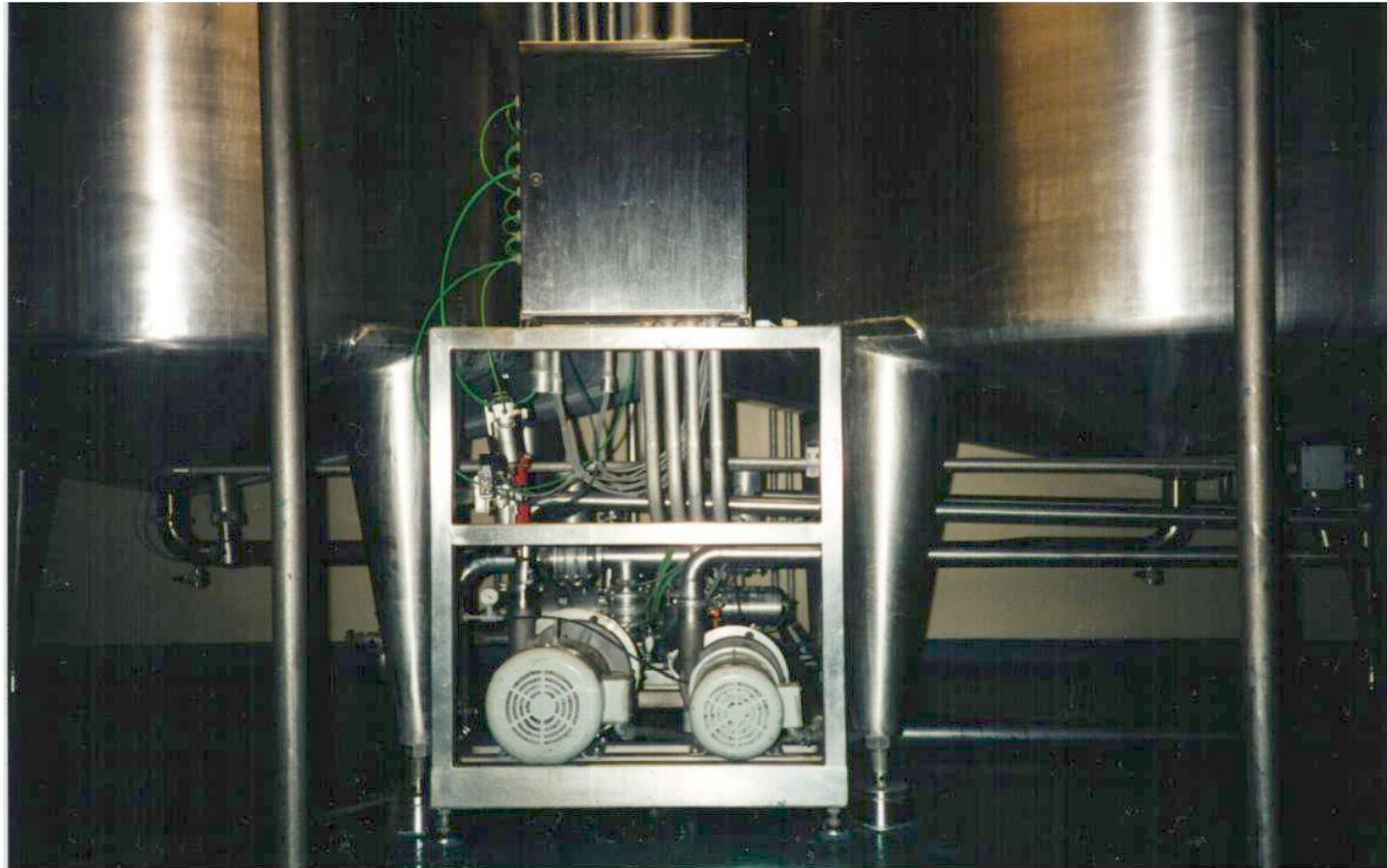
1 Paso	Min.	Van ..
0	0	0.00
2 Paso	Min.	Min.
0	0	0.00
3 Paso	Min.	Min.
0	0	0.00
4 Paso	Min.	Min.
0	0	0.00
5 Paso	Min.	Min.
0	0	0.00
6 Paso	Min.	Min.
0	0	0.00

Arrancar Pausa Omitir Interrumpir PID



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# Batch Tank Discharge



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# Another view Batch Tanks



# Procedure



## Steps:

- Travel to site
- Gather information
- Analyze current status
- Analyze new product requirements
- Compare requirements to existing
- Evaluate alternatives
- Choose Alternative
- Plan installation
- Perform upgrade

- Done
- Pending

## After the alternative is selected

- Identify Components
- Identify activities to be done
- Estimate times
- Calculate critical path
- Evaluate risk
- Review possible scenarios

## Options that were selected:

- Install new Cleaning equipment
- Make batch tanks independent
- Install new filling equipment
- By customer

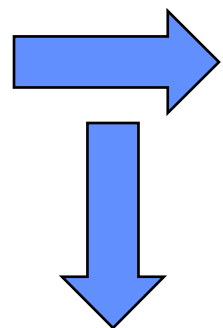




# Determination of Alternative



Production plan  
Number of components  
Relationships  
Constraints  
Cost



UTILIZATION TABLE											
HOURS	BT1	BT2	PAS	ST1	ST2	ST3	ST4	ST5	FILLER 1	CIP	FILLER2
WORKING	16.50	13.50	11.50	17.25	11.25	6.25	6.25	0.00	31.75	10.50	0.00
BUSY	16.50	13.50	11.50	26.75	18.00	11.00	15.00	0.00	31.75	10.50	0.00
WAITING	0.00	0.00	0.00	9.50	6.75	4.75	8.75	0.00	0.00	0.00	0.00
PERCENTAGE											
WORKING	47.48%	38.85%	33.09%	49.64%	32.37%	17.99%	17.99%	00.00%	91.37%	30.22%	00.00%
BUSY	47.48%	38.85%	33.09%	76.98%	51.80%	31.65%	43.17%	00.00%	91.37%	30.22%	00.00%
WAITING	00.00%	00.00%	00.00%	27.34%	19.42%	13.67%	25.18%	00.00%	00.00%	00.00%	00.00%

Initial Time: 1:17:25 PM    Iter No: 30    Throughput: 0.2014 Batches/hr  
 End Time: 1:17:27 PM    Number of Batches: 7  
 Time to Calculate: 2 seconds    Start    Number of Flavor changes: 2  
 Enable Printout     **DONE**    Close    Time to complete the activities: 34.75 hrs  
 Enable Detailed Log     Number of tasks: 30  
 Use One Filler:     Number of Tasks Done: 30



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# Project Management Project



- **Generate activity on arc diagram**
- **Find critical path**
- **Find sub critical paths**
- **Estimate project completion with 95% confidence**
- **Identify potential problems**
- **Estimate throughput**



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# Activities



	Activity	Predecessor	Start Node	Finish Node	Best Time <days>	Worst Time <days>	Probable time <days>	Estim. Time <days>
A	Flowsheet	-	0	1	5	15	8	9
B	Electrical Schematics	-	0	2	7	20	10	12
C	Plant Layout	-	0	3	2	5	3	4
D	Review	A,B,C	4	5	3	7	15	12
E	Programming	B	2	6	15	30	20	21
F	GUI Design	D	5	7	8	15	10	11
G	Preliminary Operation Manual	Start E+2	8	9	2	4	3	3
H	Purchasing	Finish D+2	10	11	1	3	2	2
I	Receive Components	H	11	12	21	35	28	28
J	Maintenance Manual	I	12	13	5	8	6	7
K	Mechanical Assembly	Finish I - 10	14	15	8	18	12	13
L	Electrical Assembly	Finish I - 5	16	17	4	15	5	7
M	Pre-Testing	K,L	18	19	2	3	2	3
N	Shipping	M,J	19	20	20	50	25	29
O	Installation Preparation	D	5	22	15	20	18	18
P	Installation	N,O	20	21	15	35	20	22
Q	Testing & Debugging	P,E,F	21	23	3	12	4	6
R	Operation	Q	23	24	5	5	5	5
S	Taining	Start Q+2	25	26	1	1	1	1
T	Final Operation Manual	S,G	26	27	2	5	3	4
U	Acceptance		24	28	1	1	1	1



# Lindo Formulation using Excel



	Activity	Predecessor	Start Node	Finish Node	Best Time <days>	Worst Time <days>	Probable time <days>	Estim. Time <days>		
A	Flowsheet	-	0	1	5	15	8	9	(A)	T1 - T0 >= 9
B	Electrical Schematics	-	0	2	7	20	10	12	(B)	T2 - T0 >= 12
C	Plant Layout	-	0	3	2	5	3	4	(C)	T3 - T0 >= 4
D	Review	A,B,C	4	5	3	7	15	12	(D)	T5 - T4 >= 12
E	Programming	B	2	6	15	30	20	21	(E)	T6 - T2 >= 21
F	GUI Design	D	5	7	8	15	10	11	(F)	T7 - T5 >= 11
G	Preliminary Operation Manual	Start E+2	8	9	2	4	3	3	(G)	T9 - T8 >= 3
H	Purchasing	Finish D+2	10	11	1	3	2	2	(H)	T11 - T10 >= 2
I	Receive Components	H	11	12	21	35	28	28	(I)	T12 - T11 >= 28
J	Maintenance Manual	I	12	13	5	8	6	7	(J)	T13 - T12 >= 7

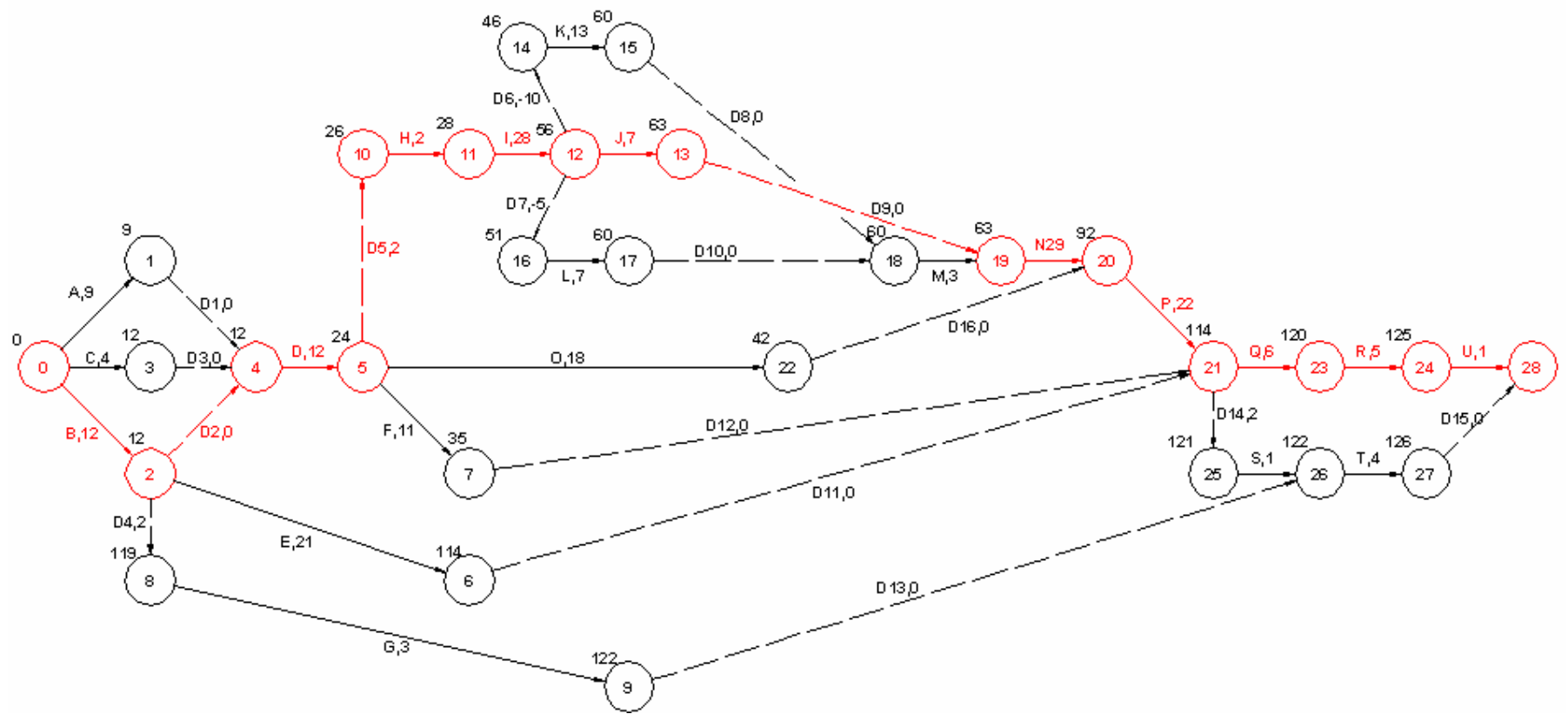
=CONCATENATE("(" ,A3,")")

=CONCATENATE("T",E3, " - T",D3," >= ",I3 )





# Activity on Arc Graph



# Project Review

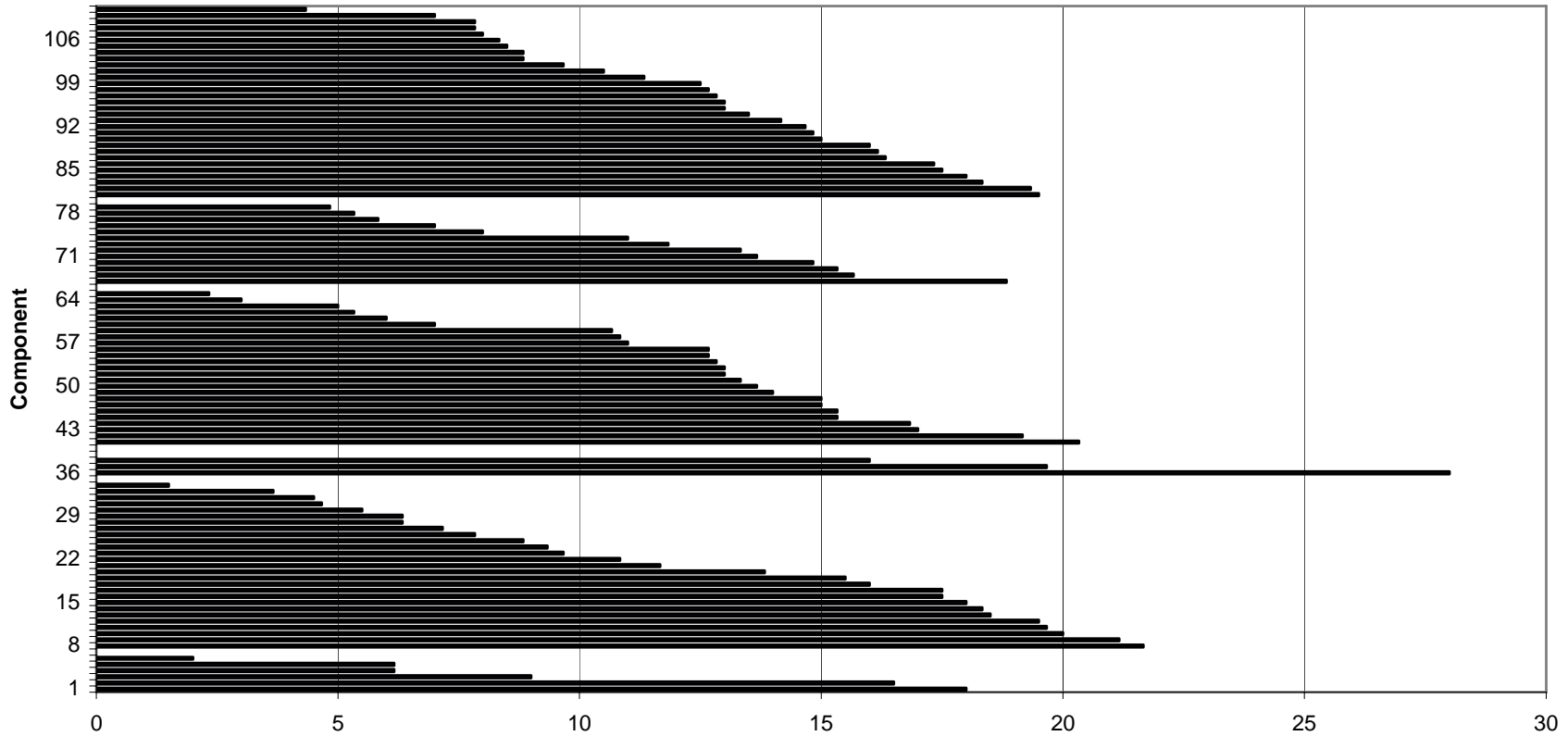


- **Critical Path**
  - *Electrical Schematics*
  - *Review*
  - *Purchasing*
  - *Receive Components*
  - *Maintenance Manual*
  - *Shipping*
  - *Installation*
  - *Testing and Debugging*
  - *Operation*
  - *Acceptance*
- **Estimated completion time: 126 days**



# Component Delivery Time

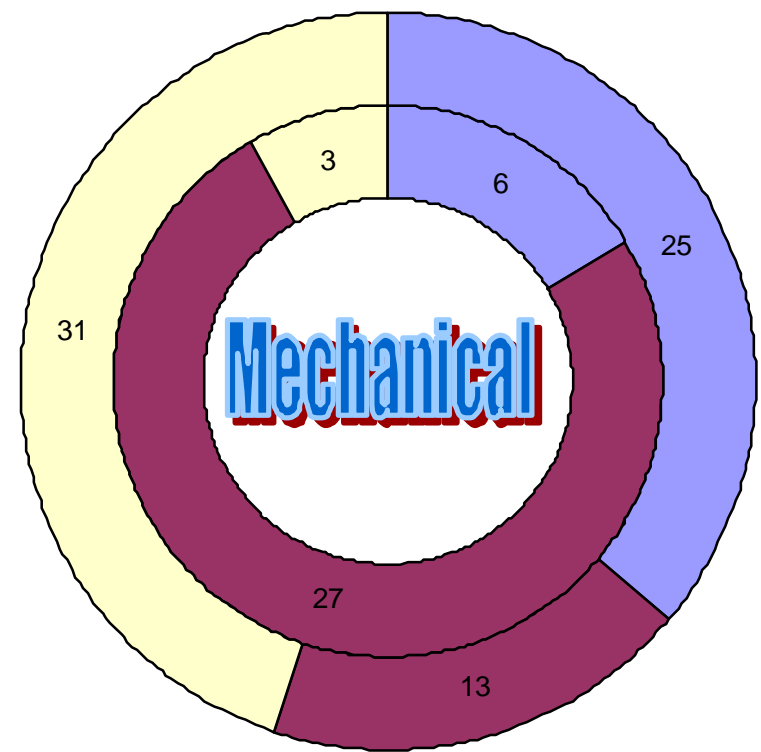
Equipment delivery graph



ID	Priority	Description	Days Best	Worst	Probable	Expected	P(x>Xo)
1		1 Square tubing, 2" x 2" , 304SS, polished, 11 gauge	13	23	18	18	0.5 57.14%
2		1 Square tubing, 4"x 4", 304SS, polished, .120" wall	12	19	17	16	0.071429
3		1 Feet, Swivel, leveling mount, SS 3/4" w/o bolt, 7200 lbs	6	12	9	9	0
4		1 Nuts finished, SS, 3/4"	4	9	6	6.333333	0
5		1 Nuts, SS, 3/4" "heavy"	4	9	6	6.333333	0
6		1 Consumables	1	3	2	2	0



# Component Breakdown Graph



**Electrical**

- 1
- 2
- 3

	1	2	3	
<b>Mechanical Components</b>	6	27	3	36
<b>Electrical Components</b>	25	13	31	69
				105





## What is the chance to finish on time?



**50%**  
**I want 95%**

$$P(T \leq T_o) = 0.95 \rightarrow P\left(\frac{T_o - 126}{\sqrt{49.3}}\right) = 1.65 \rightarrow T_o = 137.58 \approx 138 \text{ days}$$



# That's NOT on the critical path, but ...



- Sub Critical Paths**

$$\lambda = \left( \frac{\alpha_2 - \beta}{\alpha_2 - \alpha_1} \right) (100\%)$$

$\alpha_1$  = minimum total slack in the network  
 $\alpha_2$  = maximum total slack in the network  
 $\beta$  = total slack in the path that is been evaluated

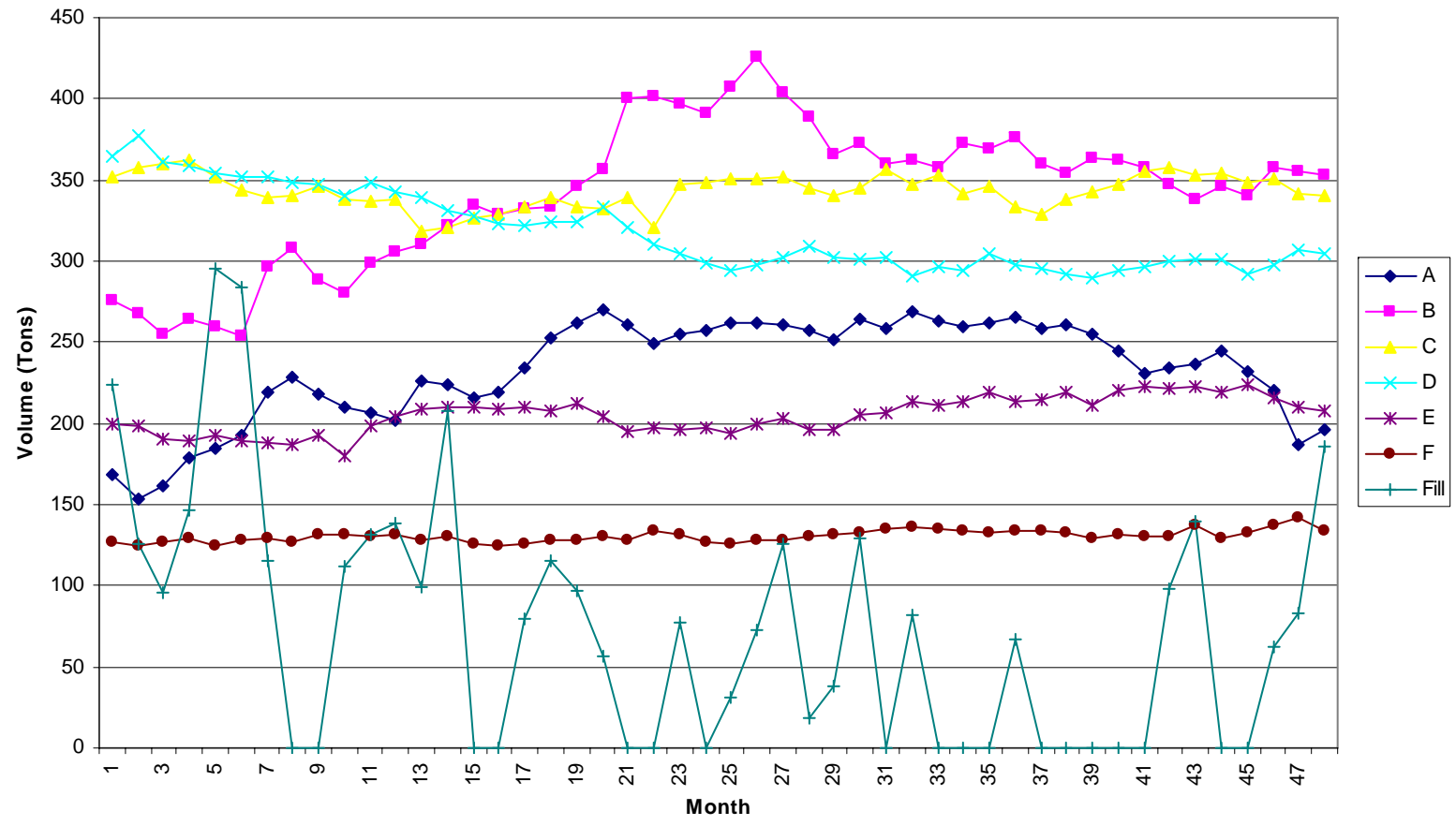
Path	Total Slack	$\lambda$
{B,D2,D,D5,H,I,J,D9,N,P,Q,R,U}	0	100.00%
{D6,K,D8,M}	2	98.10%
{A,D1}	3	97.14%
{D7,L,D10,M}	3	97.14%
{D14,S,T,D15}	5	95.24%
{C,D3}	8	92.38%
{O,D16}	50	52.38%
{F,D12}	79	24.76%
{E,D11}	81	22.86%
{D4,G,D13}	105	0.00%



# Will we exceed capacity?



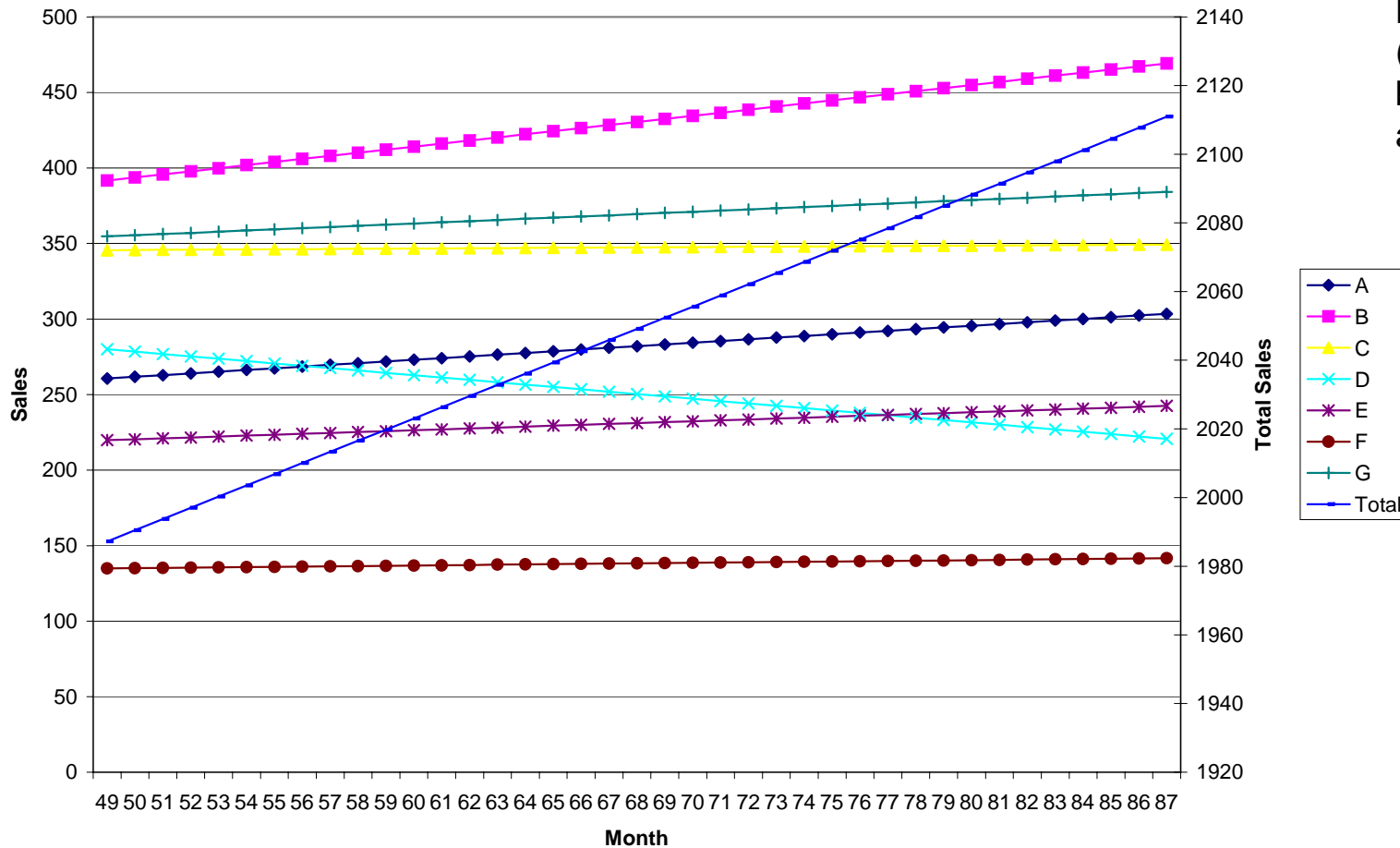
Juice Production per month



# Forecast



Forecasted Juice Production Chart



New Capacity (2100Tons) will be reached after 36 months





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## Lessons Learned



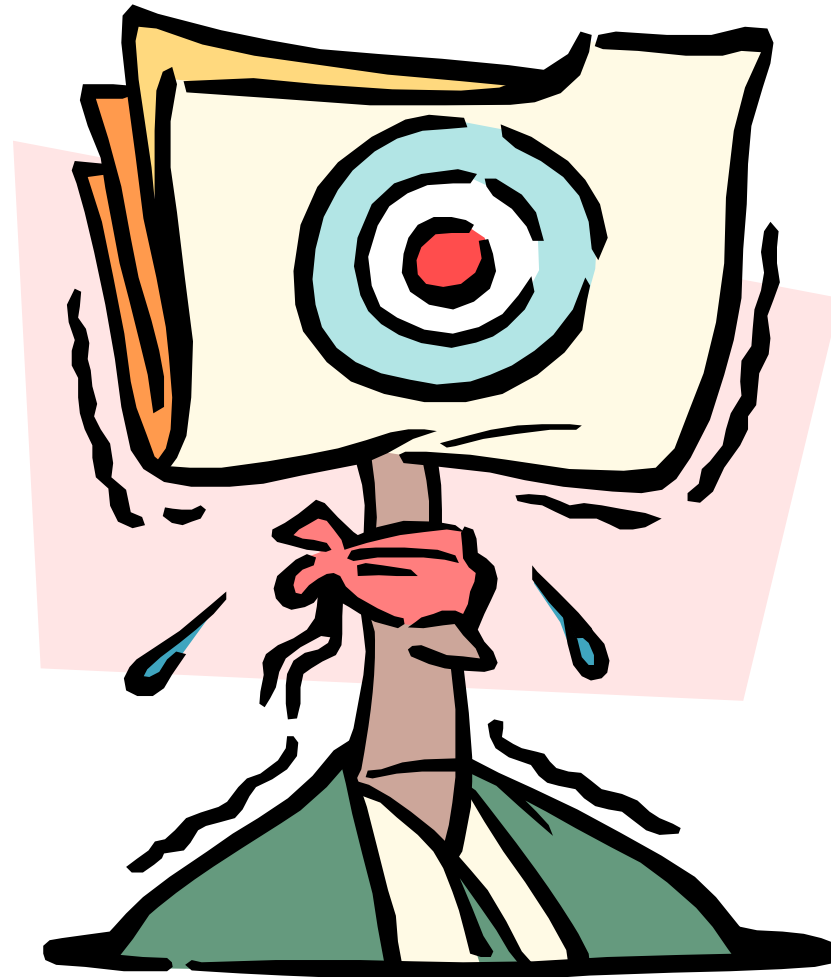
- Label Lindo's constraints same as activity name
- Use Excel to generate Lindo Formulation
- Pay attention to near-critical paths.
- Be careful with the Expected Time to Completion!



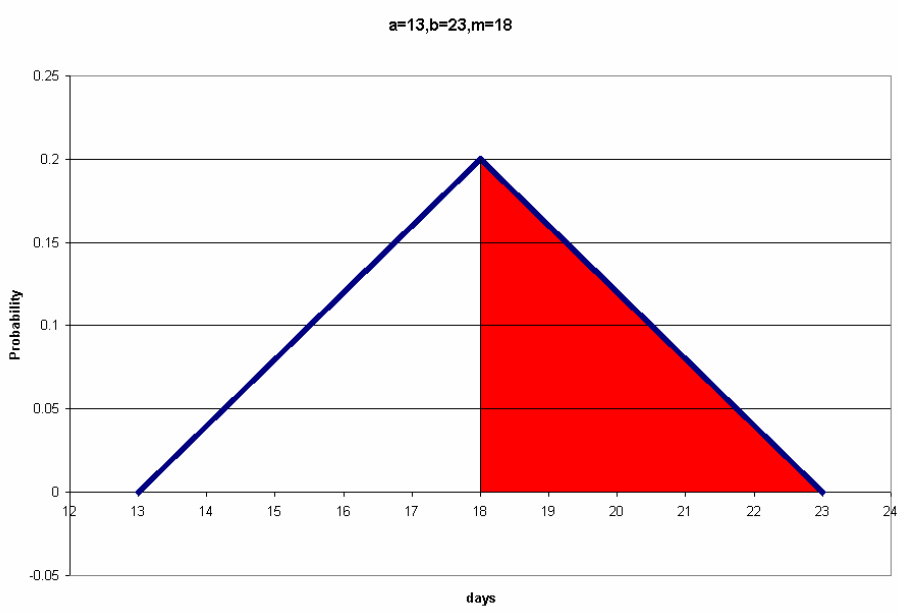
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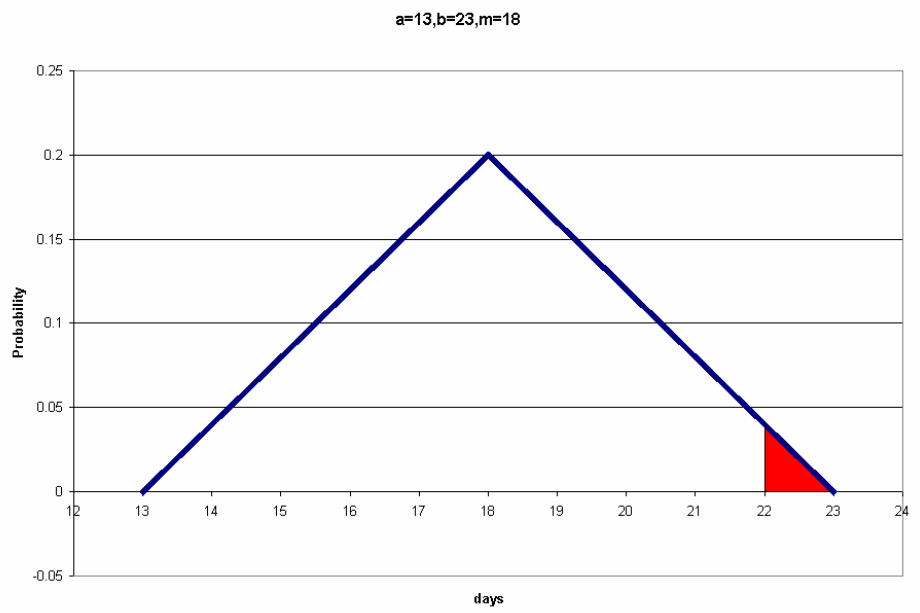
# Questions?



# Probabilities



$P(t > 18) = 50\%$



$P(x > 22) = 2\%$

Central Limit Theorem:  $T = T_1 + T_2 + \dots + T_n$

