A Case Study to determine the most effective Production system for new Manufacturing Company-“Hassis Games”

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Instructor: Mr. Christopher Wishon

Project Team

Amrut Deshpande	1211537636
Novice Singh	1211407090
Shobhit Singhal	1211442866

Table of Contents

Company Background

Hassis Games is a new company which produces two types of traditional board games- Atlantic City and Reward. They have started their company with a Kickstarter Campaign which helps in building them a strong reputation in market.

Because of Campaign, Hassis Games got the yearly demand for their products - 130,000 boxes/year demands for Atlantic City and 195,000 boxes/year demands. Currently, Company has no manufacturing facility for theses product types and our team was contacted to assess the situation regarding the production/manufacturing facility in optimized way.

Details of Product types-

Atlantic city- Components involved in this product include Compressed Cardboard Player, Player Money, Player Cards, Metal tokens, Box. Each Component has some associated manufacturing operations with it. Operations include Printing, scoring, drying, polished, grinding, Heat shrinking and finally assembly by hand.

Assumptions

- We design and analyze the manufacturing system considering steady state in mind.
- We assume that the demand is deterministic.
- Designed facility must be able to accurately account for the provided yearly demand.
- We assume enough material handling equipment such as tote bins, forklifts; trailers and tow trucks are available readily at the plant.
- Every cell has designated workers and there is no mixing of workers within the cells.
- All the data given to us to perform the calculations are correct.
- Physical cell must be rectangular.
- Each cell is not completely wall off
- General office staff need not to be considered while calculating labor estimates
- All machines not operated by personnel (everything but the Assembly stations and the grinding stations) are subject to operational level failures only
- Two machines failing after the same cycle is not possible

- Each cell can support at most one internal buffer.
- Assume normal distributions and facility to be designed for alpha value 99%
- There are 260 working days per year
- There is no Inventory
- Boundary of layout is not rectangular
- Parts in each cell are produced one by one that is if a part passes printing stage, second part is loaded.
- Metal Token is isolated meaning that no machine is adjacent to it.
- Each assembly workstation has a single assembly worker assigned.
- Atlantic City is manufactured first and then Reward, so that change over takes place only once in a day. Next day onwards, First reward is manufactured and the Atlantic City cycle goes on.

Objectives

- To understand the bottleneck concept and to identify the bottleneck station for every component.
- To compute the yearly and daily demand of both the games to be manufactured in a day.
- To evaluate the Line availability by considering mean time to failure and repair and station availability.
- To perform the cost analysis considering area, labor and machine costs.
- To understand RPW Concept and balance the assembly line using the task time.
- To create facility layout using facility design conceptualization.

Executive Summary

We try to find the bottleneck station of each machining process of each component. After calculating the total production of single machine, bottleneck station is detected. Number of machines and total production per station was calculated.

Also calculated the Net production of each component per day .Considering the mixed product line , For player Board, Player card, Player Money, Boxes, Metal Tokens, and Plastic Tokens, net production is 1805,1455,1161,3150,534,and 756 respectively.

Initially, we go with mixed products line that is both Atlantic City and rewards, cost to company is found to $35.2 ,but when we go with the single product Atlantic City to produced ,cost to company is $ 46 and for Rewards , it is $38.
After justify all the facility requirements provided by Hassis games, Total area used for Facility layout us 5175 sq. ft. and total machine cost is $29883(in $1000).
If we produced single product Atlantic City, total area is 3270 sq. ft. and total machine cost is found to be $13786 (in $1000).For Rewards, total area is 2190 sq. ft. and total machine cost is $18709(in $1000).

We planned the total manpower schedule. Total number of workers is calculated for floor Supervisor, Assembly Worker, Metal Token Worker, Plastic token worker, General staff is 1, 12,4, 11, 3 respectively.

Machine utilization Area is calculated and it is 5175 sq. ft. and area cost is found as $11160000.

We used the line Availability and Rank Positional weight Techniques to calculate the net total production and to assignment the tasks to workstation respectively.

In cost Analysis, we have calculated the Total Machine Cost, Labor Cost and Area Cost.

While panning the Facility Layout, we have considered all the factors like hallway between department, metal token isolation, Hallway area calculated as 660 sq. ft. when considered both Product Atlantic City and Rewards, Hallway area for Atlantic City is 504 sq. ft. and Hallway Area for Rewards is 480 sq. feet.

It is better to produce both products simultaneously as its overall cost is less to manufacture the product instead of producing single game Atlantic City or reward.

Problem Statement

Hassis Games is a company which is set for the production of two board games Atlantic City and Reward. Having already known their yearly demand, the challenge is to access the situation and to determine the most effective production system to meet the deterministic demand of both the board games. In order to meet the yearly demand, the company needs to estimate several requirements.

Firstly, it needs to estimate the machines required for all the individual component manufacturing by using its process times and the quantity of machines within a cell. In the due course the inventory levels of the components also has to be calculated.

Secondly, the facility layout has to be designed by considering the given square footage of each machine, miscellaneous tools, storage, inventory and maneuvering space. The prorated financial cost of machine for a five year time period has to be keenly evaluated for a better layout.

Finally, the labor cost has to be calculated by keeping changeovers, inventory management and material transfer tasks in the cost analysis. Additionally machine cost and facility cost must also be calculated in order to have an overall cost estimate of the company.

Model Analysis

As mentioned before, for a manufacturing plant which caters to a variety of parts going through a variety of machines, an efficient way to come up with layout in the facility is the use of the concepts of cycle time and number of machines required. Here we plan to approach the problem using two models and select the model which performs better to the requirements of Hassis Game.

There are two product types Atlantic City and Reward which have yearly demand of 195,000 boxes and 1,30,000 boxes respectively. It's been given that there are 260 days in a year .Demand can be found of each product i.e. Atlantic City 500 components has to be produced each day and Rewards 750 components has to be produced each day. We are considering that both Atlantic City and Rewards have to be produced together.

Atlantic City has 5 Components Compressed Cardboard Player Board, Player Money, Player Cards, Metal Tokens, and Box. It's given that Player Board has three processes Printing, Scoring and Folding have cycle time 24, 5 and 5 respectively. Similarly, Player Cards has three processes Printing, Cutting and folding have cycle time 18, 10, 14 respectively. Player Money has three processes Printing, cutting and folding have cycle time 20, 10, 21 respectively.

Batch Size for player Board is 250. Number of batches for Atlantic and Rewards are Atlantic Demand (500)/ Batch size (250) is 2 and Rewards Demand (750)/ Batch Size (250) is 3 respectively. It is given that if both Reward and Atlantic City board games, the dies and printer rolls must be changed over in Player Board, Player Board, Player cards. This process takes 30 minutes .After Calculations and considers all the changeovers and setup timings, 7.5*60*60-30*60=25200 sec for each machining process of Player Board. Loading time is 600 sec.

Net Working time is Total working time – number of batches *Loading time.
For player Board component, Net working time is 22200.Similary with other components, we can calculate the Net working time. It is shown in below table.

Components	No. of batches		Loading Time per batch in secs	Net Working Time in secs
Player Board	Atlantic City	Reward		
Printing	2	3	600	22200
Scoring				
Folding				
Player Cards				
Printing	4	5	480	20880
Cutting				
Folding				
Player Money				
Printing	3	0	300	24450
Cutting				
Folding				

Fig. Net Working Time

Player Box-In order to manufacture this component, we have to consider two sheets from top and bottom, so demand is doubled. For Atlantic City, demand is 1000 and Reward is 1500.It is given cycle time is 24, 15, 10 sec for Processes Printing, Scoring and Drying respectively. Total Working time is 25200 sec for each machining process, as there is no number of batches to load, so new working time remains the same. Similarly, it goes with the other component Metal Tokens and Plastic tokens. In metal tokens, grinding process takes 30 sec per token and requirement is 6 tokens per game. Standard deviation is 3 secs. Melting/Cooling Process (Cycle Time) is for 100 games. In grinding process, Cycle time is calculated by this formula-

$$\sum_{i \in A_k} t_i + Z_\alpha \cdot \left(\sum_{i \in A_k} V(t_i) \right)^{1/2} \leq C$$

As we are taking Z=99% confidence, it can be calculated as 6*30+2.33*(3) ^.5 =184 sec. Total and Net working time is same i.e. 25200.

Similarly, In Rewards, plastic token component is manufactured not for Atlantic City. Demand for Plastic city is 350.As 5 sets, 40 pieces each are made. Cycle time is calculated by the same formula as indicated above .by this formula, we have calculated 5*(1.75*40+2.33*(0.2) ^.5) =355 sec. As batch size is 40, Total working time is 25200. Since, there is no loading for batch, net working time remains the same.

Boxes				
Printing	0	0	0	25200
Scoring				
Drying				
Metal Tokens				
Melting	0	0	0	25200
Cooling				
Grinding				
Plastic Tokens				
Molding	0	0	0	25200
Cooling				
Grinding				

Fig. Total Working ime

Total Production:

The volume of total production refers to the output manufactured by the company or its establishment during the calendar year. Volume of total production is the volume of output produced during the statistical reference year irrespective of whether it is produced for sale or further processing within the same legal unit.

The Total production for a single machine is calculated by Net-working time and Cycle time. The Net-working time gives us the total time available in a day for production and the Cycle time is defined as the time taken by a machine to complete one single process of one product.

$$\boldsymbol{Total\ Production(\ Single\ Machine) = \frac{Net\ WorkingT\ ime}{Cycle\ Time},in\ units}$$

Formula 5.1

Hassis Games has two games and each game consists of several components. The Total production is calculated for every manufacturing process of the components.

To Show,

In Mixed model Production, consider the Printing process of the Player board component. The Net-working time per day is found to be 22,200 seconds per day and the Cycle time is 24 seconds for the same. We get 925 products per day per machine.

$$Total\ Production(\ Single\ Machine) = \frac{22{,}200}{24} = 925\ units$$

Similarly, the Total Production per machine is calculated for every single process of every component of each game.

Calculated Values of Total production (Single Machine):

Components	Cycle Time-Seconds	Net Working Time-Seconds	Total Production
Player Board			
Printing	24		925
Scoring	5		4440
Folding	5		4440
Player Cards			
Printing	18		1160
Cutting	10		2088
Folding	14		1491
Player Money			
Printing	20		1260
Cutting	10		2520
Folding	21	25200	1200
Boxes			
Printing	24		1050
Scoring	15		1680
Drying	10		2520
Metal Tokens			
Melting	1200		2100
Cooling	1200		2100
Grinding	184		137
Plastic Tokens			
Molding	125		201.6
Cooling	100		252
Grinding	355		71

Bottleneck Station:

In production and project management, a bottleneck is one process in a chain of processes, such that its limited capacity reduces the capacity of the whole chain. The result of having a bottleneck are stalls in production, supply overstock, pressure from customers and low employee morale. There are both short and long-term bottlenecks. Short-term bottlenecks are temporary and are not normally a significant problem. An example of a short-term bottleneck would be a skilled employee taking a few days off. Long-term bottlenecks occur all the time and can cumulatively significantly slow down production. An example of a long-term bottleneck is when a machine is not efficient enough and as a result has a long queue.

Almost every system has a bottleneck, even if it is a minor one, if every system was running at full capacity, at least one machine would be accumulating processes. Identifying bottlenecks is critical for improving efficiency in the production line because it allows you to determine the area where accumulation occurs. The machine or process that accumulates the longest queue is usually a bottleneck, however this isn't always the case. Bottlenecks can be found through: identifying the areas where accumulation occurs, evaluating the throughput, assessing whether each machine is being used at full capacity and finding the machine with the high wait time.

In our System, we have Bottleneck station for every component manufacturing which are shown below:

Components	Bottleneck Stations
Player Board	Printing
Player Cards	Printing
Player Money	Folding
Boxes	Printing
Metal Tokens	Grinding
Plastic Tokens	Grinding

Machines Required and Total Production (Station-Wise)

Number of Machines required is calculated for every manufacturing process based on the yearly demand to be met. The daily demand is estimated by considering the yearly demand, working days in a year and cycle time of a product. The machines required for 1 manufacturing is identified through the daily demand.

The total production for each station is calculated by number of machines required for the product manufacturing and the total production of single machine

$$\boldsymbol{Total\ Production(\ Station - wise) =}$$
$$\boldsymbol{Total\ Production(Single\ Machine) * Machines\ Required, in\ units}$$

Hassis Games has two games and each game consists of several components. The Total production for every station is calculated for every manufacturing process of the components.

To Show,

In Mixed model Production, consider the Printing process of the Player board component. The Total production of single machine is 925 and the machines required is 2. We get 1850 products per day per station.

Calculated Values of Total production (Station-Wise):

Components	Machines Required	Total Production (Station-Wise)
Player Board		
Printing	2	1850
Scoring	1	4440
Folding	1	4440
Player Cards		
Printing	2	2320
Cutting	1	2088
Folding	1	1491
Player Money		
Printing	1	1260
Cutting	1	2520
Folding	1	1200
Boxes		
Printing	3	3150

Scoring	2	3360
Drying	2	5040
Metal Tokens		
Melting	1	2100
Cooling	1	2100
Grinding	4	548
Plastic Tokens		
Molding	4	806.4
Cooling	3	756
Grinding	11	780

Similarly, the Total Production per station is calculated for every single process of every component of each game.

Total Effective production at 100%

The total effective production at 100% is nothing but the minimum most production per station among all the manufacturing process of every component

For Mixed model,

Components	7. Total Effective production at 100%
Player Board	1850
Player Cards	1491
Player Money	1200
Boxes	3150
Metal Tokens	548
Plastic Tokens	756

Line Availability

Mean Time to Failure

In reliability analysis, MTTF is the average time that an item will function before it fails. It is the mean lifetime of the item.

With censored data, the arithmetic average of the data does not provide a good measure of the center because at least some of the failure times are unknown. The MTTF is an estimate of the theoretical center of the distribution that considers censored observations.

The MTTF can be used in several ways; for example:

- To determine whether a redesigned system is better than the previous system in demonstration test plans.
- As a measure of the center of the distribution when the distribution fits the data adequately.
- To compare selected distributions with a distribution ID plot.

Mean Time to Repair

Mean Time to Repair (MTTR) is a basic measure of the maintainability of repairable items. It represents the average time required to repair a failed component or device. Expressed mathematically, it is the total corrective maintenance time for failures divided by the total number of corrective maintenance actions for failures during a given period of time. It generally does not include lead time for parts not readily available or other Administrative or Logistic Downtime (ALDT)

Given that, all machines have an average failure rate of 2000 cycles (MTTF) between failures other than any printing machines which have an average failure rate of 3000 cycles (MTTF) between failures. Once broken, the average repair rate for all machines is 25 cycles (MTTR).

Station Availability

The station availability is found by using the Mean time to failure (MTTF) and the number of machines (n) required to manufacture a single product of different components.

$$\boldsymbol{Station\ Availability = 1 - \left(\frac{1}{MTTF}\right)^{n}, in\ Percentage}$$

MTTF: Mean Time to Failure

n: Number of machines required for per product manufacturing

The Station availability are found in terms of percentage and the values for every product manufacturing is between 99.95% and 100 in mixed model setup.

Line Availability

The degree to which a system, subsystem or equipment is in a specified operable and committable state at the start of a mission, when the mission is called for at an unknown, *i.e.* a random, time. Simply put, availability is the proportion of time a system is in a functioning condition. This is often described as a mission capable rate. Mathematically, this is expressed as 100% minus unavailability. The ratio of the total time a functional unit is capable of being used during a given interval to the length of the interval.

Availability of a system is typically measured as a factor of its reliability – as reliability increases, so does availability.

The most simple representation for availability is as a ratio of the expected value of the uptime of a system to the aggregate of the expected values of up and down time, or,

$$A = \frac{E[\text{uptime}]}{E[\text{uptime}] + E[\text{downtime}]}$$

If we define the status function X (t) as

$$X(t) = \begin{cases} 1, & \text{sys functions at time } t \\ 0, & \text{otherwise} \end{cases}$$

Therefore, the availability $A(t)$ at time $t > 0$ is represented by

$$A(t) = \Pr[X(t) = 1] = E[X(t)].$$

Average availability must be defined on an interval of the real line. If we consider an arbitrary constant c>0, then average availability is represented as

$$A_c = \frac{1}{c}\int_0^c A(t)\,dt.$$

Limiting (or steady-state) availability is represented by

$$A = \lim_{c\to\infty} A_c.$$

Limiting average availability is also defined on an interval [0, c] as,

$$A_\infty = \lim_{c\to\infty} A_c = \lim_{c\to\infty}\frac{1}{c}\int_0^c A(t)\,dt, \quad c > 0.$$

Therefore Line availability is,

$$A_0 = \frac{\text{Mean Uptime}}{\text{Mean Uptime + Mean Downtime}} = \frac{\beta^{-1}}{\beta^{-1} + b^{-1}} = \frac{1}{1 + \beta b^{-1}}$$

A_0 is effectiveness of a line with buffers of size 0

For Mixed Model,

$$\textbf{\textit{Line Availability}} = \frac{\mathbf{1}}{(\mathbf{1}+((\mathbf{1}-X)+(\mathbf{1}-Y)+(\mathbf{1}-Z))*\mathbf{25})}, \textbf{\textit{in percentage}}$$

X: Station Avalability of Manufacturing Process 1

Y: Station Avalability of Manufacturing Process 2

Z: Station Avalability of Manufacturing Process 3

MTTR: 25

Net Production

The Net Production is defined as the product of Total effective production for 100% and the Line availability. We calculate the Net production of Every component of both the games. The formula to find Net production is shown below:

$$\boldsymbol{Net\ Production} =$$
$$\boldsymbol{Total\ Effective\ Production}(\mathbf{100\%}) * \boldsymbol{Line\ Availability}$$

The calculated values of Line availability and Net production are listed in the table below,

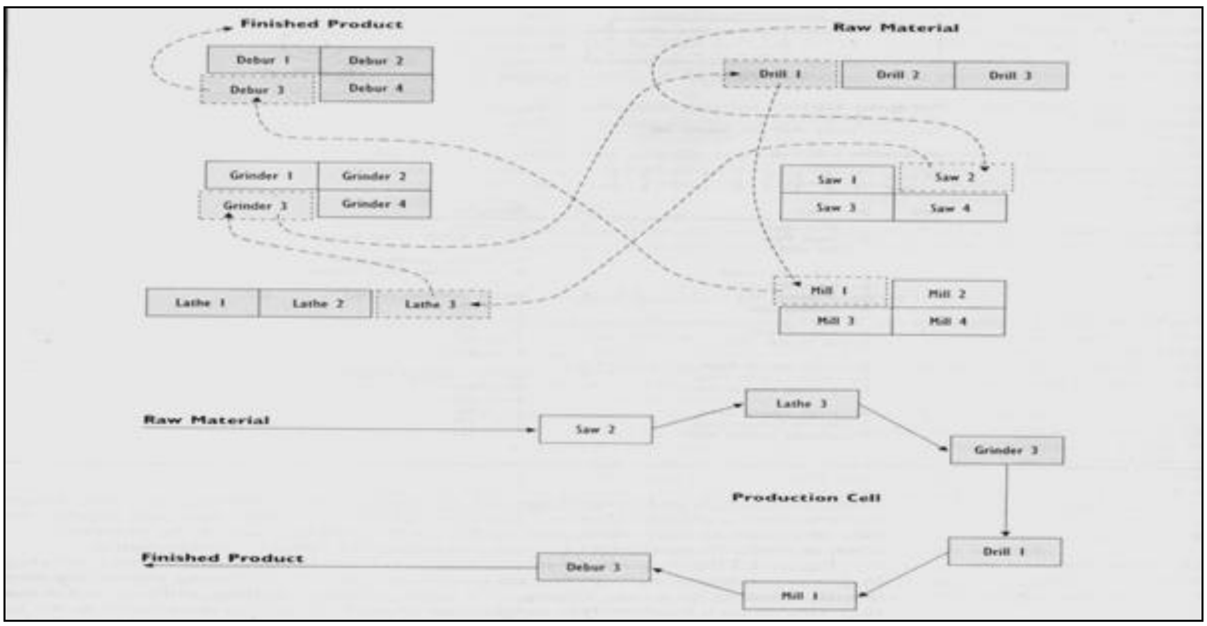
Components	**Line Availability**	**Net Production**
Player Board	97.561	1805
Player Cards	97.561	1455
Player Money	96.774	1161
Boxes	99.999	3150
Metal Tokens	97.561	534
Plastic Tokens	99.999	756

Facility Requirements

Facility layout and design is an important component of a business's overall operations, both in terms of maximizing the effectiveness of the production process and meeting the needs of employees. The basic objective of layout is to ensure a smooth flow of work, material, and information through a system. The basic meaning of facility is the space in which a business's activities take place. The layout and design of that space impact greatly how the work is done—the flow of work, materials, and information through the system. The key to good facility layout and design is the integration of the needs of people (personnel and customers), materials (raw, finishes, and in process), and machinery in such a way that they create a single, well-functioning system.

Some of the requirements for manufacturing operation layout are enough production capacity of machine, minimum handling costs, optimized space required for each machine and allow high labor, space utilization for machine, volume and product flexibility.

As machines are grouped into cells, each cell in a CM layout is formed to produce a single parts family (a few parts all with common characteristics),they require the same machines and have similar machine settings. CM layout would be attempted for these reasons-Machine changeovers are simplified, Training periods for workers are shortened, and Materials-handling costs are reduced, Parts can be made faster and shipped more quickly.



Area Requirements

It's been given that square footage requirements for each machine. Each component has different manufacturing process, so each machine area is given. For player board, Printer area is 50 sq. ft., so total area is number of machines * area of machine assigned =50 *2 *3=300.It's been assumed that square size is tripled to determine the minimum size of physical cell As space is needed for other miscellaneous tools, storage, inventory, and office space. Similarly, other area of each machine can be found. You can refer the other values in table provided below.

Components		Area per machine in sqft	Total Area (in sqft.)
Player Board			
Printing		50	300
Scoring		20	60
Folding		20	60
Player Cards			
Printing		50	300
Cutting		30	90
Folding		25	75
Player Money			
Printing		100	1230
Cutting		40	120
Folding		30	1290
Boxes			
Printing		75	675
Scoring		130	780
Drying		30	180
Metal Tokens			
Melting		250	750
Cooling		200	600
Grinding		10	120
Plastic Tokens			
Molding		25	300
Cooling		5	45
Grinding		10	330

Fig. Total Area

Assembly square ft. is 30.

Initial Block pan is produced showing the relative positioning of the departments. Drawings----------- and other details

After designing the initial Block pan, it is to assign the each department to a particular location in facility. The larger the value of department, more difficult it is to locate them. Also, the interactions between department's increases cause the flow of material complex. In order to define the order between the departments like Assembly and interactions among the various departments or flow between the materials, we have to measure the flow of materials through Flow Dominance.

Flow Dominance

Cost parameters have to be defined w_{ij} to be the weights for material flow between I and j.

$$w_{ij} = \sum_{k=1}^{N_{ij}} f_{ijk}\, h_{ijk}.$$

M: number of activities.

N_{ij}: number of different types of items moved between activities i and j.

f_{ijk}: flow volume between i and j for item k (in moves/time period).

h_{ijk}: equivalence factor for moving item k with respect to other items moved between i and j (dimensionless).

w_{ij}: equivalent flow volume specified in from-to chart (in moves/time period

$$f' = \frac{\left[\dfrac{\sum_{i=1}^{M}\sum_{j=1}^{M} {w_{ij}}^2 - M^2\overline{w}^2}{M^2 - 1}\right]^{\frac{1}{2}}}{\overline{w}}, \qquad \overline{w} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{M} w_{ij}}{M^2}$$

$$f_U = M\left[\frac{M^2 - M + 1}{(M-1)(M^2-1)}\right]^{\frac{1}{2}}, \qquad f_L = M\left[\frac{1}{(M-1)(M^2-1)}\right]^{\frac{1}{2}}$$

f' is the coefficient of variation.
f_L and f_U are lower and upper bounds on f', respectively ($f_L \le f' \le f_U$).
The upper bound f_U is only guaranteed to work when each process plan includes all activities. In this case, $0 \le f \le 1$.

Flow dominance measure=f= $\frac{f_U - f'}{f_U - f_L}$

Three cases :
1. $f \approx 0 \Rightarrow$ a few dominant flows exist. $\Rightarrow$ product layout.
$\Rightarrow$ can use operations process chart as starting point for developing layout and material handling system design.
$\Rightarrow$ quantitative measures principal source of activity relationship.
2. $f \approx 1 \Rightarrow$ many nearly equal flows exist.
$\Rightarrow$ any layout equally good with respect to flows .
$\Rightarrow$ qualitative measures principal source of activity relationship.
3. $0 << f << 1 \Rightarrow$ no dominant flows exist. $\Rightarrow$ difficult to develop layout.
$\Rightarrow$ process or product family layout .
$\Rightarrow$ both quantitative and qualitative measures important source of activity relationship.

Material Flow

	Plastic Board	Player card	Player Money	Plastic Tokens	Boxes	Assembly 1	Assembly 2
Plastic Board	-	-	-	-	-	500	750
Player card	-	-	-	-	-	500	750
Player Money	-	-	-	-	-	500	-
Metal Tokens	-	-	-	-	-	500	-
Plastic Tokens	-	-	-	-	-	-	750
Boxes	-	-	-	-	-	500	750
Assembly 1	-	-	-	-	-	-	-
Assembly 2	-	-	-	-	-	-	-

M=8

$$w = \frac{4 * 1250 + 500}{64} = 85.93$$

$f = [(5 * 250000 + 4 * 562500 - 64 * (85.93)^2)/63]$ ^.5/85.93 = 2.55

$f(u) = (8 * \sqrt{}(64 - 8 + 1))/\sqrt{}7.63$ = 2.87

F (L) =$(8 * \sqrt{}(1))/\sqrt{}7.63$ =.384

F' $= \frac{2.87-2.55}{2.87-.384}$ = .13

For Atlantic City only,

	Plastic Board	Player card	Player Money	Plastic Tokens	Boxes	Assembly 1
Plastic Board	-	-	-	-	-	500
Player card	-	-	-	-	-	500
Player Money	-	-	-	-	-	500
Metal Tokens	-	-	-	-	-	500
Boxes	-	-	-	-	-	500
Assembly 1	-	-	-	-	-	-

M=6

$$w = \frac{5 * 500}{36} = 69.44$$

$f = [(5 * 250000 - 36 * (69.44)^2)/35]$ ^.5/69.44 = 2.522

$f(u) = (6 * \sqrt{}(31))/\sqrt{}175$ = 2.52

F (L) =$\frac{6*\sqrt{1}}{\sqrt{5}} * 35$ =1.01

F' $= \frac{2.52-2.522}{2.52-1.01}$ =0

For Rewards Only,

	Plastic Board	Player card	Player Money	Plastic Tokens	Boxes	Assembly 2
Plastic Board	-	-	-	-	-	750
Player card	-	-	-	-	-	750
Plastic Tokens	-	-	-	-	-	750
Boxes	-	-	-	-	-	750
Assembly 2	-	-	-	-	-	-

M=5

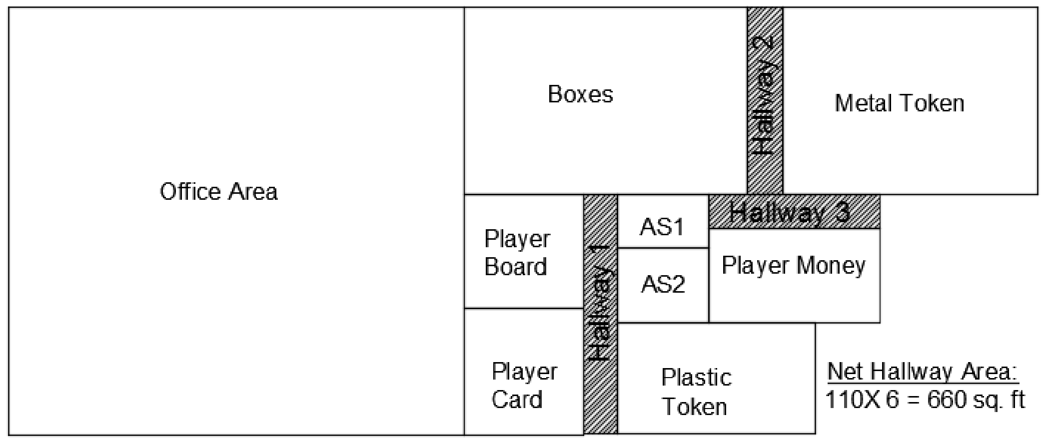
$$w = \frac{4 * 750}{25} = 120$$

$f = [(4 * 750^2 - 25 * (120)^2))/24]$ ^.5/120= .47

$f(u) = (5 * \sqrt{}(21))/\sqrt{}96$ = 2.33

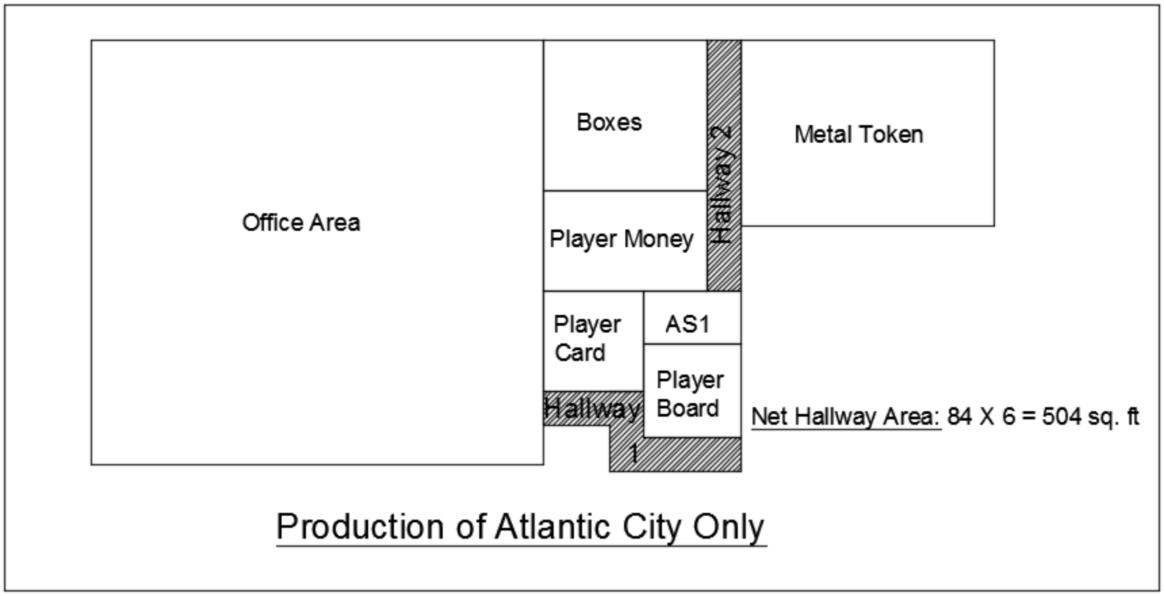
F (L) =$\frac{5*\sqrt{1}}{\sqrt{96}}$=.51

F' $= \frac{2.33-.47}{2.33-.51}$ =1.02

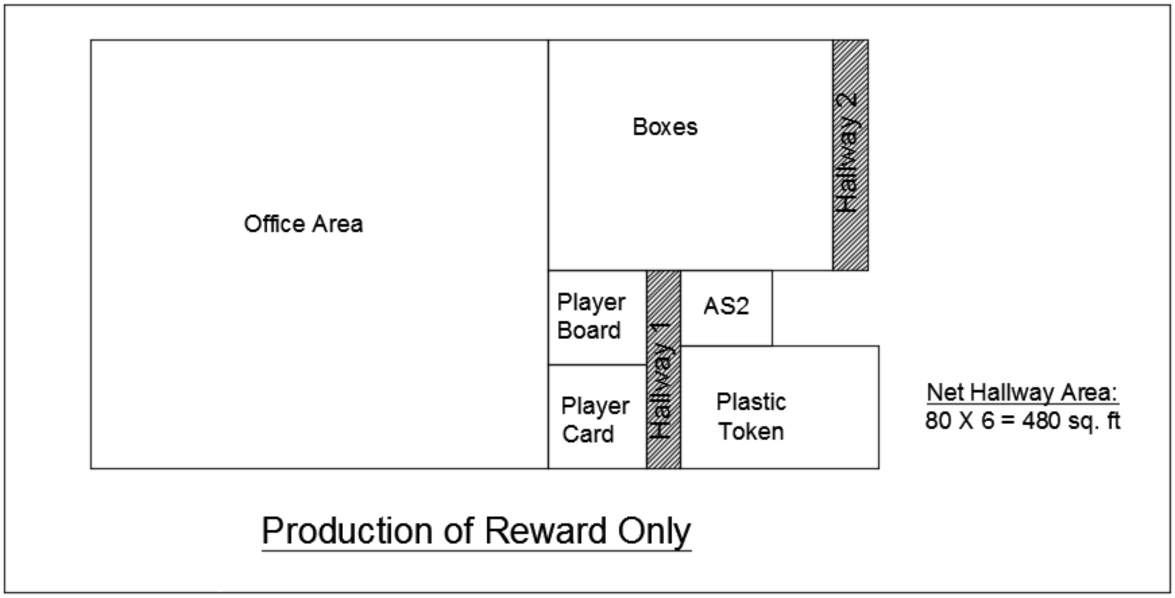


Production of both Atlantic City and Reward

In the given figure above, it is given that cell is 5 ft. long and at least 2.5 feet wide and at most 10 feet wide. All cells have access to hallway. Hallways must be 6 feet wide to permit adequate material handling and manpower movement. As shown in above sketch, metal token is assume to be high risk process, so it must be isolated as shown .Hallways are shown between the department with optimized calculation of hallway passage and three hallways are shown ,Hallway 1 ,hallway2 ,hallway3 .Assembly area are planned such that it can be easily accessible from all the departments. Boxes and Metal token use Hallway 2 and Player money use Hallway 3, and Plastic token, Player card and Player board uses hallway 1 for material handling. Office area is at corner of the facility so that it is undisturbed by the Assembly operations but at a minimum distance.



While production of Single product Atlantic City, Boxes and metal token use hallway 2 and Player board and player card uses hallway 1 and there is only one Assembly area which is connected to the entire machining department at a minimum distance through hallway passage. Metal token is isolated. Office area is given lot of space due to requirements.



For rewards, Facility layout is seen above .All the departments are connected through hallway to Assembly department. For component Boxes, a large space is required.

Assembly

It is given that Assembly is competed by hand and no use of any hand tools and semi automation on Assembly. All required components are available for assembly of product and workers place the things in box in correct ratios. All the precedence tasks are known so that worker knows the procedure of assembly the various components. There is two Assembly layers-Assembly1 and Assembly 2.Assembly1 assembles Player cards and tokens (Metal tokens in Atlantic City and Plastic Tokens in Rewards) and Assembly 2 assembles Money, Board and Top in case of Atlantic City and Board and Top in case of Rewards.

Using line balancing technique, tasks along the assembly line to workstation so that each line has approximate same amount of work.
By using Ranked positional weight (RPW), No. of stations can be found for Assembly1 and Assembly2.Through RPW technique, Number of station for Assembly1 and Assembly 2 are 5 and 7 respectively.

As there are five stations in an Assembly layer 1, there must be five workers each per station .Similarly, there are seven stations in Assembly layer 2, there must be seven workers each per station.

For Atlantic City, Metal Token Component has four machines for Grinding Process and for Atlantic City; Plastic Tokens Component has 11 machines required for same Grinding process. Machines required for grinding process is more as compared to other processes for both Atlantic City and Rewards.

Each worker is required for each workstation; number of Metal Token workers is 4 for Atlantic City and is Number of Plastic Token workers is 11 for Rewards.

As both products are producing in Assembly house, a supervisor is sufficient. As calculated above, total number of Assembly worker for both Atlantic City and Rewards is 12. For both products Atlantic City and Reward, 6 general staff is needed for both product types.

Cost Analysis

Cost analysis is a technique used to compare the total costs of a program with its benefits, using a common metric (most commonly monetary units). This enables the calculation of the net cost or benefit associated with the program.

As a technique, it is used most often at the start of a program or project when different options or courses of action are being appraised and compared, as an option for choosing the best approach. It can also be used, however, to evaluate the overall impact of a program in quantifiable and monetized terms.

In our case study, the cost analysis is done by breaking all the costs incurred. The main costs involved are

1) Machine cost

2) Labour cost

3) Area cost

Machine cost

The machine cost is calculated by considering the total area in square feet and and cost per machine in $1000's. The total machine cost is estimated by evaluating machine costs of every production process of every component.

The table below shows the total machine cost calculation:

Components	Cost per Machine(in $1000)	Total Area (in Sqft.)	Total Machine Cost(in $1000)
Player Board			
Printing	1200	300	2400
Scoring	520	60	520
Folding	423	60	423
Player Cards			
Printing	1670	300	3340
Cutting	619	90	619
Folding	1050	75	1050
Player Money			
Printing	1230	300	1230
Cutting	308	120	308
Folding	1290	90	1290
Boxes			
Printing	904	675	2712
Scoring	1210	780	2420
Drying	801	180	1602
Metal Tokens			
Melting	951	750	951
Cooling	1190	600	1190
Grinding	105	120	420
Plastic Tokens			
Molding	2010	300	8040
Cooling	104	45	312
Grinding	96	330	1056
Total Area/Cost		**5175**	**29883**

Labour Cost

The cost of labor is the sum of all wages paid to employees, as well as the cost of employee benefits and payroll taxes paid by an employer. The cost of labor is broken into direct and indirect (overhead) costs. Direct costs include wages for the employees that produce a product, including workers on an assembly line, while indirect costs are associated with support labor, such as employees who maintain factory equipment.

In our case study there are five different type of labors, Namely Floor Supervisor, Assemble worker, Metal token worker, Plastic token worker and General Staff.

Assembly worker is paid $80,000/year, Metal worker is earning 90,000/year and plastic token worker gets $65,000/year. Additionally for a game to be produced, a floor supervisor is needed at a yearly cost of $110,000. As the calculation shown is for both the games being produced, we would need only one supervisor. For each game produced in house, 6 general staff are needed and they charged $65000/year per head.

For any Production floor there is a supervisor. Assembly workers are found by the number of machines involved in the assembly lines, 5 in Assembly 1 and 7 in Assembly 2. We have 4 Metal token worker in assembly 1 and 11 Plastic token workers in assembly 2. Also, for the combined production floor we need 6 general staff.

Workers	No. Of Workers	Cost per unit ($1000)	Cost for 1st year ($1000)	Cost for 2nd year ($1000)	Cost for 3rd year ($1000)	Cost for 4th year ($1000)	Cost for 5th Year ($1000)
Floor Supervisor	1	110	110	117	120	124	128
Assembly Worker	12	80	960	1018	1049	1080	1113
Metal Token Worker	4	95	380	403	415	428	441
Plastic Token Worker	11	65	715	759	781	805	829
General Staff	3	65	390	414	426	439	452

The Yearly cost increases by 3% and is calculated by,

$$\boldsymbol{Yearly\ Cost = (Cost\ of\ 1st\ year)^n}$$

Where n is 2, 3, 4 and 5 for 2nd, 3rd, 4th and 5th year.

The Overall Labor cost is found by adding add the yearly cost, and is shown below,

1st year cost+2nd year cost+ 3rd year cost+ 4th year cost+5th year cost= ($ 2,555+ $ 2,711+ $ 2,792+ $ 2,962+ $ 2,876)* $1,000 = **$13895, 000.**

Area CosT

The cost which is associated with the space allotment of the facility is called the area cost. It consists of the consumed machine area, miscellaneous and office area and aisle area. It is calculated as shown below:

$$\boldsymbol{Area\ cost} = (\textbf{Total Machine area} + \textbf{Offices, Break room, miscellaneous area} + \textbf{Aisle Area}) * \mathbf{0.943, in\ \$1000s}$$

0.943($943) is the cost per square foot.

Area Cost=Total Area* Cost per square foot

The calculated machine utilization area is 5175 square feet. The miscellaneous area is given to be 6000 square feet and the aisle area is found to be 660 square feet.

Area Cost = (5175+6000+660)* 0.943= $11,160,000

Ranked Positional weight:

The ranked positional weight (RPW) technique is one of the best known heuristics. The procedure constructs a single sequence. A task is prioritized based on the cumulative assembly time associated with itself and its successors. Trasks are then assigned in this order to the lowest numbered feasible workstation.

RPW Calculation

ATLANTIC CITY

Precedence Diagram

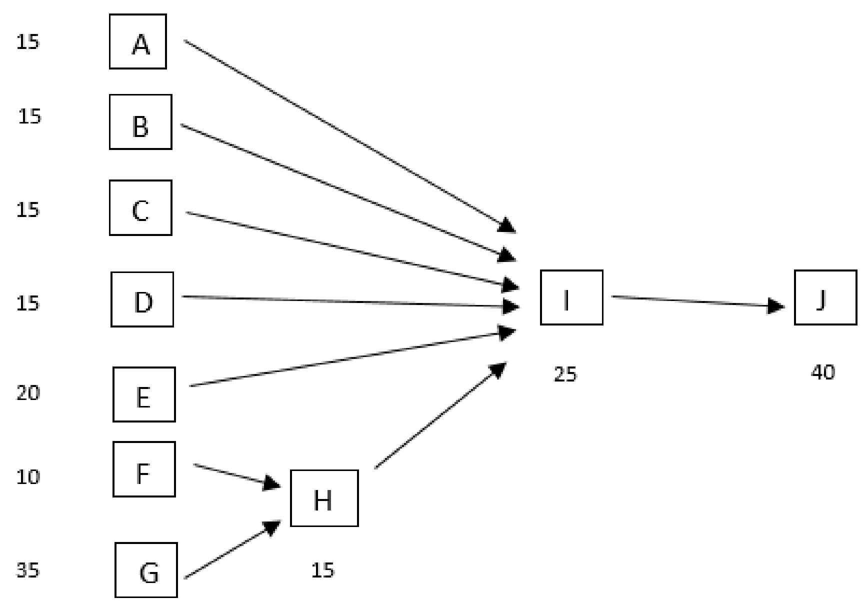


Fig. Precedence Diagram

Total Production

The total production of Atlantic City is found to be

$$\frac{130{,}000}{260} = 500\,per\ day$$

Lower Bound Calculation

The lower bounds are calculated to understand the workstations to be used in the layout. It is calculated by using below formula.

$$\boldsymbol{LB(0) = \frac{Total\ task\ time}{Cycle\ Time} = \ \epsilon \frac{t(i)}{C}}$$

Where, t(i) is the Random task time.

$$= \frac{244.7}{54} = 4.53 = 5$$

$$\boldsymbol{LB(1) = t(max) + t(min) > C}$$

=44.036+ 12.33=56.366>54

It hence states J requires an individual station,

Hence, LB (1)=254.7/54=4.7=5

$$\boldsymbol{LB(2) = Count\ of\ tasks\ which\ exceed\ half\ cycle\ time = 3}$$

The LB(2) is found to be 3.

$$\boldsymbol{LB(3) = \frac{1}{2} count\ of\ tasks\ which\ exceed \frac{1}{3} cycle\ time}$$

= (1/2)*9= 4.5= 5

Hence, we choose LB (3) as our lower bound considering all the Lower bounds which have been calculated based on the largest lower bound value theory. The Lower bound is 5, which states the number of workstation.

Ranked Positional weight

Tasks	Task Time	Standard Deviation	Random task time	Positional Weight	Ranked Positional weight
A	15	3	19.04	88.696	5
B	15	3	19.04	88.696	6
C	15	3	19.04	88.696	7
D	15	3	19.04	88.696	8
E	20	3	24.04	93.696	3
F	10	1	12.33	101.986	2
G	35	5	40.21	126.986	1
H	15	2	18.29	91.986	4
I	25	4	29.66	73.696	9
J	40	3	44.036	44.036	10

The total random task time is found to be **244.7.**

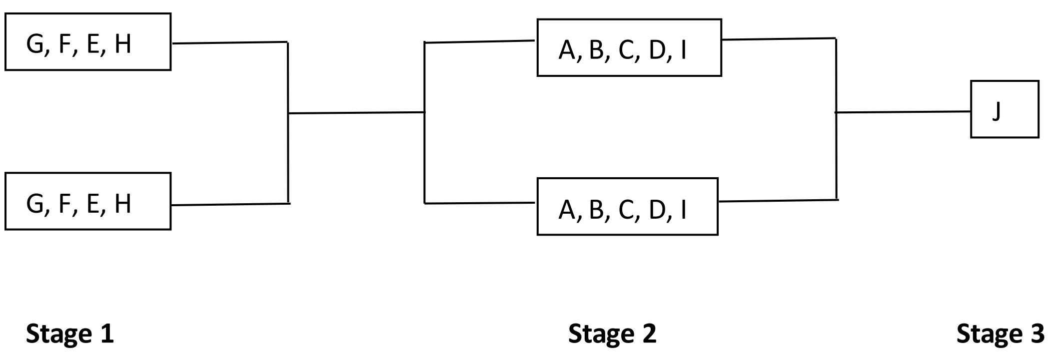
Sequencing

As per the precedence task we find the sequence to be,

G→F→E→H→A→B→C→D→I→J

Since, we have LB (0) =5, we require 5 workstations

Now, grouping the tasks (G, F, E, H) in one Work station and (A, B, C, D) into another workstation and designating it in parallel arrangement.



The throughput time of 54 seconds remains to be same in this case.

We have 5 workstations and 3 stages, the cycle time of stage 1 is **108** seconds and the throughput time is **54** seconds.

Now, checking for each workstation,
GFEH=40.21+12.33+24.04+18.29=**94.87<108 seconds.**

ABCDI=19.04*4+29.66=**105.82<108 seconds**

J=44.036<**54 Seconds**

Therefore the above solution for Atlantic city is accepted.

REWARD

Precedence Diagram

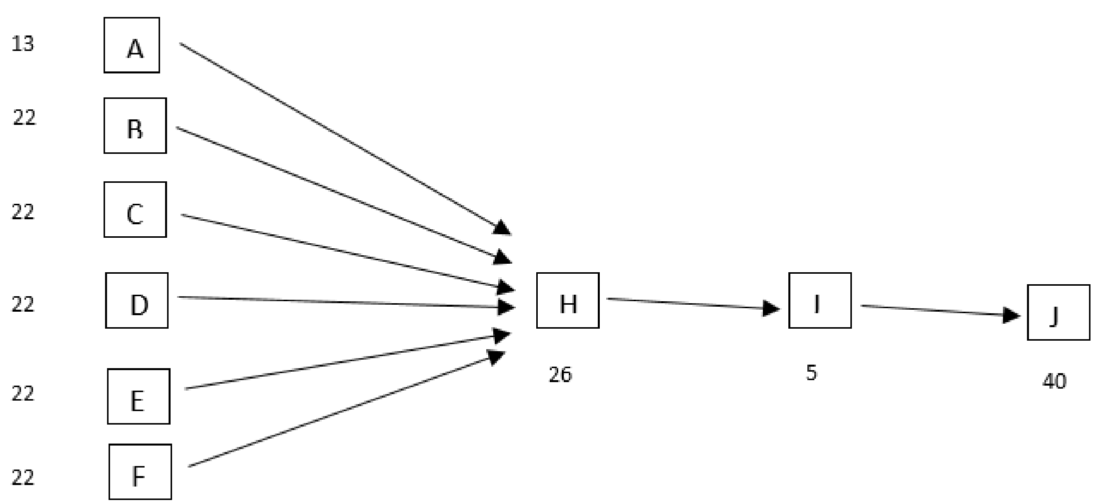


Fig. Precedence Diagram

Total Production

The total production of Reward is found to be

$$\frac{193{,}000}{260} = 750\, per\ day$$

$$\text{Cycle Time} = \frac{27{,}000}{750} = 36\, seconds$$

Lower Bound Calculation

The lower bounds are calculated to understand the workstations to be used in the layout. It is calculated by using below formula.

$$\boldsymbol{LB(0) = \frac{Total\ task\ time}{Cycle\ Time} = \text{€}\frac{t(i)}{C}}$$

Where, t (i) is the Random task time.

$$= \frac{228.29}{36} = 6.34 = 7$$

$$\boldsymbol{LB(1) = t(max) + t(min) > C}$$

=44+16.3=60.3>36

Hence J needs a single stage and has to be aligned an individual station,

Hence, LB (1)=254.7/54=4.7=5

$$\boldsymbol{LB(2) = Count\ of\ tasks\ which\ exceed\ half\ cycle\ time = 7}$$

The LB (2) is found to be 7.

$$\boldsymbol{LB(3) = \frac{1}{2} count\ of\ tasks\ which\ exceed \frac{1}{3} cycle\ time}$$

= (1/2)*8= 4

Hence, we choose LB (2) as our lower bound considering all the Lower bounds which have been calculated based on the largest lower bound value theory. The Lower bound is 7, which states the number of workstation.

Ranked Positional weight

Tasks	Task Time	Standard Deviation	Random task time	Positional Weight	Ranked Positional weight
A	13	2	16.3	98.3	6
B	22	3	26	108	1
C	22	3	26	108	2
D	22	3	26	108	3
E	22	3	26	108	4
F	22	3	26	108	5
H	26	4	30.66	81.96	7
I	5	1	7.33	51.3	8
J	40	3	44	44	9

The total random task time is found to be **228.29.**

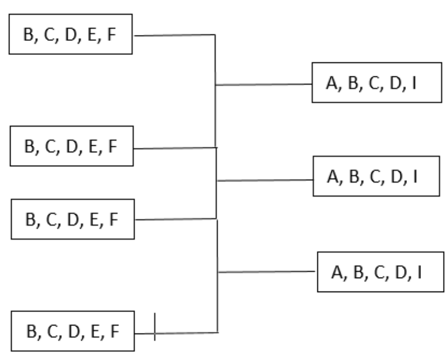
Sequencing

As per the precedence task we find the sequence to be,

B→C→D→E→F→A→H→I→J

Since, we have LB (0) =7, we require 7 workstations

Now, grouping the tasks (B, C, D, E, F) in one Work station and (A, H, I, J) into another workstation and designating it in parallel arrangement.



Stage 1 **Stage 2**

The throughput time of 54 seconds remains to be same in this case.

We have 5 workstations and 3 stages, the cycle time of stage 1 is **108** seconds and the throughput time is **54** seconds.

Now, checking for each workstation,

BCDEF=5*26=**130<144 seconds.**

AHIJ=16.3+30.66+7.33+44=**98.29<108 seconds**

J=44.036<**54 Seconds**

Therefore the above solution for Reward is accepted.

Appendix

Atlantic City

Total Production Yearly 130,000
Daily 500 (in units)

Total Working hour: 7.5 hrs
25200 secs

Components 1. Player Board
Manufacturing Process

a) Printing Process time: 24 secs per sheet

Single Printing Machine if used can produc 1050 (Which is less than our daily requirement of 1250)

Therefore the number of printing machines required: 2

b) Scoring Process time: 5 secs per sheet

Single Printing Machine if used can produc 5040 (Which is more than our daily requirement of 1250)

Therefore the number of scoring machines required: 1

c) Folding Process time: 5 secs per sheet

Single Printing Machine if used can produc 5040 (Which is more than our daily requirement of 1250)

Therefore the number of scoring machines required: 1

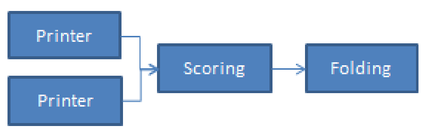
Reward

Total Production Yearly 195,000
Daily 750 (in units)

Batch Siz 250

No of Batches:
Atlantic City 2
Reward 3

Loading Batches 10 mins



Player Board

Atlantic City

Total Production Yearly 130,000
Daily 500 (in units)

Total Working hour: 7.5 hrs
25200 secs
20880

Components 2. Player Cards
Manufacturing Process:

a) Printing Process time: 18 secs per sheet

Single Printing Machine if used can produce 1160 (Which is less than our daily requirement of 1250)

Therefore the number of printing machines required: 1

b) Card Cutting Process time: 10 secs per sheet

Single Printing Machine if used can produce 2088 (Which is more than our daily requirement of 1250)

Therefore the number of cutting machines required: 1

c) Folding Process time: 14 secs per sheet

Single Printing Machine if used can produce 1491.4 (Which is more than our daily requirement of 1250)

Therefore the number of folding machines required: 1

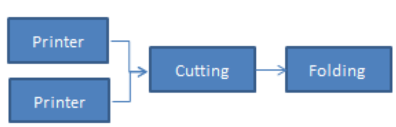
Reward

Total Production Yearly 195,000
Daily 750 (in units)

Batch Size 150

No of Batches: 8.3333 9
Atlantic City 4
Reward 5

Loading Batches 8 mins 72
4320



Player card

Atlantic City

Total Production Yearly 130,000 Total Working hours 7.5 hrs
Daily 500 (in units) 27000 secs

Components 3. Player Money
Manufacturing Process:

a) Printing Process time: 20 secs per game

Single Printing Machine if used can produce 1350 (Which is more than our daily requirement of 500) Batch Size 200

Therefore the number of printing machines required: 1

No of Batches:
Atlantic City 2 Day 1
3 Day2

b) Cutting Process time: 10 secs per game

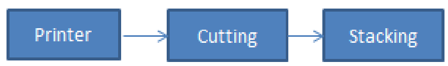
Single Printing Machine if used can produce 2700 (Which is more than our daily requirement of 500) Loading Batches 5

Therefore the number of scoring machines required: 1

c) Stacking Process time: 21 secs per game

Single Printing Machine if used can produce 1285.71 (Which is more than our daily requirement of 500)

Therefore the number of scoring machines required: 1



Player money

Atlantic City **Reward**

Total Production Yearly 130,000 Total Working hour 7.5 hrs Total Production Yearly 195,000
Daily 500 (in units) 25200 secs Daily 750 (in units)

Components 4. Boxes
Manufacturing Process 25200

a) Printing Process time: 24 secs per sheet

Single Printing Machine if used can prod 1050 (Which is less than our daily requirement of 2500) Batch Si 250

Therefore the number of printing machines required: 3

No of Batches:
Atlantic City 2
Reward 3

b) Folding/Scoring Process time: 10 secs per sheet

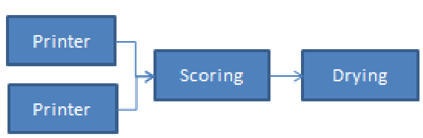
Single Printing Machine if used can prod 2520 (Which is more than our daily requirement of 1250) Loading Batches 10 4800

Therefore the number of scoring machines required: 1

c) Drying Process time: 15 secs per sheet

Single Printing Machine if used can prod 1680 (Which is more than our daily requirement of 1250)

Therefore the number of scoring machines required: 2



Boxes

Atlantic City

Total Production Yearly 130,000 Total Working hou 7.5 hrs
Daily 500 (in units) 27000 secs

Components 5. Metal Token
1anufacturing Process

a) Melting Process time: 20 mins per 100 games

Total time 100 mins for 500 games

Therefore the number of printing machines required: 1

b) Casting Process time: 20 mins per 100 games

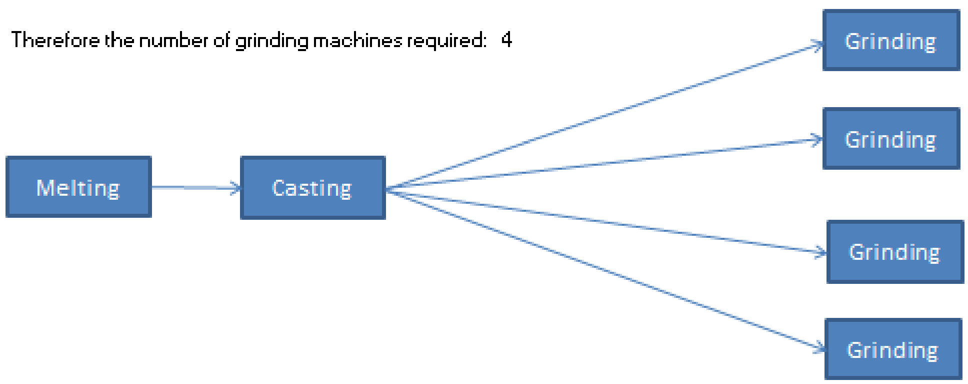
Total time 100 mins for 500 games

Therefore the number of scoring machines required: 1

c) Grinding Process time: 180 secs per game

Single Grinding Machine if used can proc 150

Therefore the number of grinding machines required: 4



Metal token

Reward

Total Working hour: 7.5 hrs Total Production Yearly 195,000
27000 secs Daily 750 (in units)

Components 1. Plastic Token
Manufacturing Process:

a) Molding Process time: 125 secs per game(25sec*5sets)

Single Molding Machine if used can produce 216 (Which is less than our daily requirement of 750)

Therefore the number of printing machines required: 4

b)Cooling Process time: 100 secs per game(25sec*5sets)

Single Printing Machine if used can produce 270 (Which is less than our daily requirement of 750) 8

2.828427125

Therefore the number of cooling machines required: 3 6.590235201

32.951176

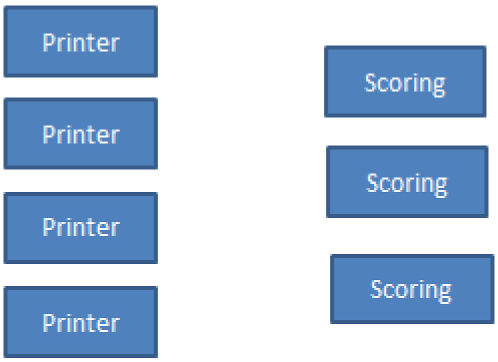
c) Grinding Process time: 350 secs per game(1.75sec*200pieces)

382.951

Single Printing Machine if used can produce 70.5051 (Which is less than our daily requirement of 750)

Plastic Token

Therefore the number of scoring machines required: 11



Plastic Token

Assembly 1	Total Volume	130000	Assembly 2	Total Volume	195000
	Total Working hours	260*7.5		Total Working hours	260*7.5
	Cycle time	0.015 hrs		Cycle time	0.01 hrs
		54 secs			36 secs

Assembly

Assembly 1	Quantity	Cost per unit	Total Cost
No of Station	5	182	910
No of Assy Workers	5	80	400
No of Metal Token Workers	4	95	380

Assembly 2	Quantity	Cost per unit	Total Cost
No of Station	6	182	1092
No of Assy Workers	7	80	560
No of Plastic Token Workers	11	65	715

	Length	Breadth
Aisle	155	6
Total Area		930

Total Number of Workers		Cost for the 1st Yr	Cost for the 5th Yr
Floor Supervisor	1	110	128
Assembly Worker	12	960	1113
Metal Token Worker	4	380	441
Plastic Token Worker	11	715	829
General Staff	6	390	452

Cost Breakup	
Machine Cost	31885
Labour Cost	13895
Area Cost	11415
Total Cost	57195

Cost to Company(per product in $)	35.2

Cost for the 2nd Yr	Cost for the 3rd Yr	Cost for the 4th Yr
117	120	124
1018	1049	1080
403	415	428
759	781	805
414	426	439

Atlantic City and Rewards

Sl No.	Components	Demand		Cycle	Batch	No of Batches		Total Working	Loading Time Per	Net Working time(in	Total Production-
1	Player Board	Atlantic	Reward	Time	Size	Atlantic	Reward	time(in secs)	batch (in secs)	secs)	Single Machine
a)	Printing	500	750	24	250	2	3	25200	600	22200	925
b)	Scoring			5				25200			4440
c)	Folding			5				25200			4440
2	Player Cards										
a)	Printing	500	750	18	150	4	5	25200	480	20880	1160
b)	Cutting			10				25200			2088
c)	Folding			14				25200			1491
3	Player Money										
a)	Printing	500		20	200	3	0	25200	300	24450	1260
b)	Cutting			10				25200			2520
c)	Folding			21				25200			1200
4	Boxes	Note: Demand is doubled as there are two sheets for both Top and Bottom									
a)	Printing	1000	1500	24	0	0	0	25200	0	25200	1050
b)	Scoring			15				25200			1680
c)	Drying			10				25200			2520
5	Metal Tokens	Note: Grinding process takes 30 secs per token. Requirement is 6 tokens per game. Standard Deviation is 3 secs. Melting /Cooling proces									
a)	Melting	500	0	1200	100	5	0	25200	0	25200	2100
b)	Cooling			1200				25200			2100
c)	Grinding			184				25200			137
6	Plastic Tokens	Note: 5sets/40 pcs each,									
a)	Molding	0	750	125	40	0	0	25200	0	25200	201.6
b)	Cooling			100				25200			252
c)	Grinding			365				25200			69

Bottleneck Station	No of Machines required	Total Production-Stationwise	Total effective production at 100%	MTTF	MTTR	Station Availability	Line Avaliability	Net Production
Printing	2	1850	1850	3000	25	1.0000	0.975607112	1805
	1	4440		2000	25	0.9995		
	1	4440		2000	25	0.9995		
Printing	2	2320	1491	3000	25	1.0000	0.975607112	1455
	1	2088		2000	25	0.9995		
	1	1491		2000	25	0.9995		
Folding	1	1260	1200	3000	25	0.9997	0.967741935	1161
	1	2520		2000	25	0.9995		
	1	1200		2000	25	0.9995		
Printing	3	3150	3150	3000	25	1.0000	0.999987499	3150
	2	3360		2000	25	1.0000		
	2	5040		2000	25	1.0000		
ss(Cycle Time) is for 100 games								
Grinding	1	2100	548	2000	25	0.9995	0.975609756	534
	1	2100		2000	25	0.9995		
	4	548		2000	25	1.0000		
Grinding	4	806.4	756	2000	25	1.0000	0.999999997	756
	3	756		2000	25	1.0000		
	11	760		2000	25	1.0000		

Area per machine(in Sqft.)	Cost per Machine(in $1000)	Total Area(in Sqft.)	Total Machine Cost(in $1000)
50	1200	300	2400
20	520	60	520
20	423	60	423
50	1670	300	3340
30	619	90	619
25	1050	75	1050
100	1230	300	1230
40	308	120	308
30	1290	90	1290
75	904	675	2712
130	1210	780	2420
30	801	180	1602
250	951	750	951
200	1190	600	1190
10	105	120	420
25	2010	300	8040
5	104	45	312
10	96	330	1056
	Total Area/Total Cost	5175	29883

Atlantic City

Assembly 1	Quantity	Cost per unit	Total Cost
No of Station	5	182	910
No of Assy Workers	5	80	400
No of Metal Token Workers	4	95	380

Assembly 2	Quantity	Cost per unit	Total Cost
No of Station	0	182	0
No of Assy Workers	0	80	0
No of Plastic Token Workers	0	65	0

	Length	Breadth
Aisle	84	6
Total Area		504

Total Number of Workers		Cost for the 1st Yr	Cost for the 5th Yr	Cost for the 2nd Yr	Cost for the 3rd Yr	Cost for the 4th Yr
Floor Supervisor	1	110	128	117	120	124
Assembly Worker	5	400	464	424	437	450
Metal Token Worker	4	380	441	403	415	428
Plastic Token Worker	0	0	0	0	0	0
General Staff	3	195	226	207	213	219

Cost Breakup	
Machine Cost	14696
Labour Cost	5901
Area Cost	9217
Total Cost	29814

Cost to Company(per product in $)	46

Sl No.	Components	Demand		Cycle	Batch	No of Batches		Total Working	Loading Time Per	Net Working time(in	Total Production-
1	Player Board	Atlantic	Reward	Time	Size	Atlantic	Reward	time(in secs)	batch (in secs)	secs)	Single Machine
a)	Printing	500	0	24	250	2	0	27000	600	25800	1075
b)	Scoring			5				27000			5160
c)	Folding			5				27000			5160
2	Player Cards										
a)	Printing	500	0	18	150	4	0	27000	480	25080	1393
b)	Cutting			10				27000			2508
c)	Folding			14				27000			1791
3	Player Money										
a)	Printing	500		20	200	3	0	27000	300	26100	1350
b)	Cutting			10				27000			2700
c)	Folding			21				27000			1286
4	Boxes	Note: Demand is doubled as there are two sheets for both Top and Bottom									
a)	Printing	1000	0	24	0	0	0	27000	0	27000	1125
b)	Scoring			15				27000			1800
c)	Drying			10				27000			2700
5	Metal Tokens	Note: Grinding process takes 30 secs per token. Requirement is 6 tokens per game. Standard Deviation is 3 secs. Melting /Cooling proce									
a)	Melting	500	0	1200	100	5	0	27000	0	27000	2250
b)	Cooling			1200				27000			2250
c)	Grinding			184				27000			147
6	Plastic Tokens	Note: 5sets/40 pcs each,									
a)	Molding	0	0	125	40	0	0	27000	0	27000	216
b)	Cooling			100				27000			270
c)	Grinding			365				27000			74

Bottleneck Station	No of Machines required	Total Production-Stationwise	Total effective production at 100%	MTTF	MTTR	Station Availability	Line Availability	Net Production
Printing	1	1075	1075	3000	25	0.9997	0.967741935	1040
	1	5160		2000	25	0.9995		
	1	5160		2000	25	0.9995		
Printing	1	1393	1393	3000	25	0.9997	0.967741935	1348
	1	2508		2000	25	0.9995		
	1	1791		2000	25	0.9995		
Folding	1	1350	1286	3000	25	0.9997	0.967741935	1244
	1	2700		2000	25	0.9995		
	1	1286		2000	25	0.9995		
Printing	1	1125	1125	3000	25	0.9997	0.967741935	1089
	1	1800		2000	25	0.9995		
	1	2700		2000	25	0.9995		
ss(Cycle Time) is for 100 games								
Grinding	1	2250	587	2000	25	0.9995	0.975609756	572
	1	2250		2000	25	0.9995		
	4	587		2000	25	1.0000		
Grinding	0	0	0	2000	25	0.0000	0.013157895	0
	0	0		2000	25	0.0000		
	0	0		2000	25	0.0000		

Area per machine(in Sqft.)	Cost per Machine(in $1000)	Total Area(in Sqft.)	Total Machine Cost(in $1000)
50	1200	150	1200
20	520	60	520
20	423	60	423
50	1670	150	1670
30	619	90	619
25	1050	75	1050
100	1230	300	1230
40	308	120	308
30	1290	90	1290
75	904	225	904
130	1210	390	1210
30	801	90	801
250	951	750	951
200	1190	600	1190
10	105	120	420
25	2010	0	0
5	104	0	0
10	96	0	0
	Total Area/Total Cost	3270	13786

Rewards

Assembly 1	Quantity	Cost per unit	Total Cost
No of Station	0	182	0
No of Assy Workers	0	80	0
No of Metal Token Workers	0	95	0

Assembly 2	Quantity	Cost per unit	Total Cost
No of Station	7	182	1274
No of Assy Workers	7	80	560
No of Plastic Token Workers	11	65	715

	Length	Breadth
Aisle	83.5	6
Total Area		501

Total Number of Workers		Cost for the 1st Yr	Cost for the 5th Yr
Floor Supervisor	1	110	128
Assembly Worker	7	560	649
Metal Token Worker	0	0	0
Plastic Token Worker	11	715	829
General Staff	3	195	226

Cost Breakup	
Machine Cost	19983
Labour Cost	8593
Area Cost	8196
Total Cost	36771

Cost to Company(per product in $)	38

Cost for the 2nd Yr	Cost for the 3rd Yr	Cost for the 4th Yr
117	120	124
594	612	630
0	0	0
759	781	805
207	213	219

Sl No.	Components	Demand		Cycle Time	Batch Size	No of Batches		Total Working time(in secs)	Loading Time Per batch (in secs)	Net Working time(in secs)	Total Production-Single Machine
		Atlantic	Reward			Atlantic	Reward				
1	**Player Board**										
a)	Printing	0	750	24	250	0	3	27000	600	25200	1050
b)	Scoring			5				27000			5040
c)	Folding			5				27000			5040
2	**Player Cards**										
a)	Printing	0	750	18	150	0	5	27000	480	24600	1367
b)	Cutting			10				27000			2460
c)	Folding			14				27000			1757
3	**Player Money**										
a)	Printing	0	0	20	200	0	0	27000	300	27000	1350
b)	Cutting			10				27000			2700
c)	Folding			21				25200			1200
4	**Boxes**	Note: Demand is doubled as there are two sheets for both Top and Bottom									
a)	Printing	0	1500	24	0	0	0	27000	0	27000	1125
b)	Scoring			15				27000			1800
c)	Drying			10				27000			2700
5	**Metal Tokens**	Note: Grinding process takes 30 secs per token. Requirement is 6 tokens per game. Standard Deviation is 3 secs. Melting /Cooling proce									
a)	Melting	0	0	1200	100	0	0	27000	0	27000	2250
b)	Cooling			1200				27000			2250
c)	Grinding			184				27000			147
6	**Plastic Tokens**	Note: 5sets/40 pcs each,									
a)	Molding	0	750	125	40	0	0	27000	0	27000	216
b)	Cooling			100				27000			270
c)	Grinding			365				27000			74

Bottleneck Station	No of Machines required	Total Production-Stationwise	Total effective production at 100%	MTTF	MTTR	Station Availability	Line Avaliability	Net Production
Printing	1	1050	1050	3000	25	0.9997	0.967741935	1016
	1	5040		2000	25	0.9995		
	1	5040		2000	25	0.9995		
Printing	1	1367	1367	3000	25	0.9997	0.967741935	1323
	1	2460		2000	25	0.9995		
	1	1757		2000	25	0.9995		
Folding	0	0	0	3000	25	0.0000	0.013157895	0
	0	0		2000	25	0.0000		
	0	0		2000	25	0.0000		
Printing	2	2250	1800	3000	25	1.0000	0.975607112	1756
	1	1800		2000	25	0.9995		
	1	2700		2000	25	0.9995		
ss(Cycle Time) is for 100 games								
Grinding	0	0	0	2000	25	0.0000	0.013157895	0
	0	0		2000	25	0.0000		
	0	0		2000	25	0.0000		
Grinding	4	864	810	2000	25	1.0000	0.999999997	810
	3	810		2000	25	1.0000		
	11	814		2000	25	1.0000		

Area per machine(in Sqft.)	Cost per Machine(in $1000)	Total Area(in Sqft.)	Total Machine Cost(in $1000)
50	1200	150	1200
20	520	60	520
20	423	60	423
50	1670	150	1670
30	619	90	619
25	1050	75	1050
100	1230	0	0
40	308	0	0
30	1290	0	0
75	904	450	1808
130	1210	390	1210
30	801	90	801
250	951	0	0
200	1190	0	0
10	105	0	0
25	2010	300	8040
5	104	45	312
10	96	330	1056
	Total Area/Total Cost	**2190**	**18709**

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