performance indicator of manufacturing capability from those analysis presented by Burchand Jain[4] is shown in table 1 with four different categorization of manufacturing decision areas .

Performance indicator of the manufacturing activity also can be measured from operational manufacturing activity, the model of operational management in the production activity have been published by ISA 95[5] as shown in fig 2. The input of this model are product definition and production schedule , the output are production performance and production capability, which is measured in production floor. Starting data in this activity means picture of performance of manufacturing activity of the research object with input and output as modeled by ISA 95.

Table 1. Four Categorization of Manufacturing Decision Area as present by Burchand Jain et. al(4)

1. Hayes et.al[2]	2.Skinner[1]	3.Miltenburg[3]	4.Slack and Lewis[7]
1. Capacity(A1)	1. Plant and Equipment(A1,A2,A4)	1. Human resources(A5)	1. Capacity(A1,A2)
2.Facilities(A2)	2.Production design engineering(A3, A8)	2. Organization structure(A9, A10)	2.Process technology(A3)
3.Process Technologies(A3)	3.Labor and staffing(A5)	3.Sourcing(A4)	3. Supply network(A4)
4.Vertical Integration/Vendors(A4)	4.Production planning and control(A6, A7)	4.Production Planning and control(A7, A8)	4. Organization and development(A5-A10)
5.Human Resources(A5)	5.Organization and Management(A9, A10)	5.Process technology(A3,A6)	
6.Quality(A7)		6.Facilities(A1,A2)	
7.Production Planning/Materials Control(A7)			
8.New Product Development(A8)			
9.Performance measuremen and reward(A9)			
10.Organization/System(A10)			

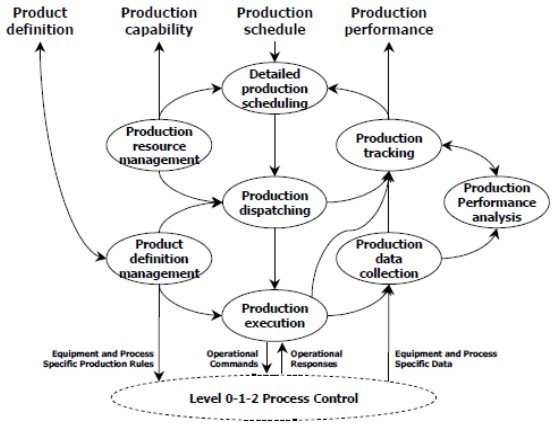

Fig 2: Model Activities in Production Operation Managements, ANSI/ISA-95.00.03[5]

IV. Systematic Approach and Establishing of Starting Data

In order to obtain the starting data which comply with the research need, the systematic approach methodology as introduced by Pahl and Beitz[6] was used. This approach can be illustrated as a black box (fig 3), which is connected directly with input and output. Generally as a system the input and output can be classified as energy, materials and signal, and in the box, the word function is written, which is statement of the function to be solved as the expected output of this approach.

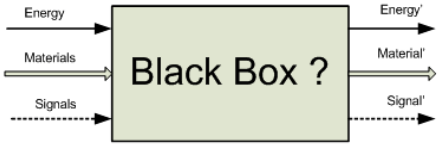

Fig 3. The conversion of energy, material and signals. Solution not yet known; task or function described on the basis of inputs an d outputs, Pahl and Beitz[6]

Begin with overall function and then deploy to the function structure, as shown in the fig 4. The function structure is a detailed description of any special functions which is arranged to meet the overall function. Every special function must be unique that can solve the function as focus as possible and the right solution could be proposed accurately as need by the design requirements. If a function in a function structure can't be define as unique function, it must be deploy again into sub function which consist of unique function.

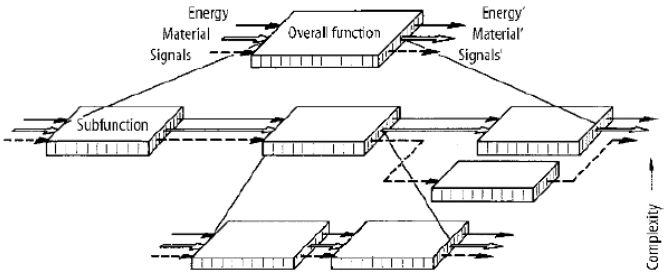

Fig 4. Establishing a function structure by breaking down an overall function into sub functions, Pahl and Beitz[6]

In this case study, the output of the research is production floor manufacturing performance as stated in the first research objective and black box consist of function measuring hospital bed production floor manufacturing performance as stated in the second research objective. The input to the system is operational management activities. The relation of input, black box and output is overall function of this case study is shown in fig 5.

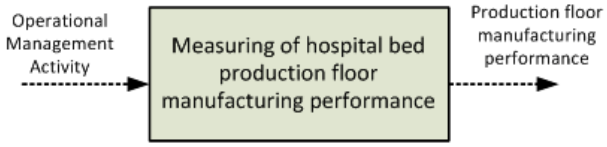

Fig 5. Overall function of Measuring of Hospital Bed Production Floor Manufacturing Performance

The black box of the overall function than deploy to function structure. This function structure is built in two stage function, the first stage consists of 3 functions and the second stage is one function. The function structure is shown in fig 6.

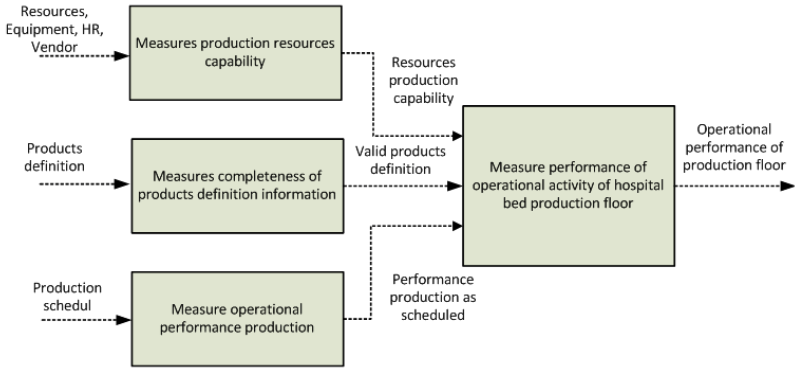

Fig 6. Function structure of input, function and output of production floor performance

From the breakdown of function to the function structure, three performance indicators in the first stage and one in the second stage can be described to build the main operational performance indicators objective(first objective questions). They are :

1. Resource production capability
2. Valid product definition
3. Production performance as production scheduled
4. Operational activity

When deploying each of those 4 items as main objective of the research in the more detail performance indicators, it gives:

A .Production Capability Information

Production Equipment availability

1. Availability of equipment(eg work station) which is meet with planned production capacity
2. Degree specialization of equipment compare with industrial standard
3. Extent of in-house modification/improvement/adaptation of equipment

Availability of Human resources and organization .

4. Workers availability in every work station.
5. Extent to which workers are involved in improving the company's process/production system.
6. Scope of workers' job .
7. Level of skill possessed by workers as compared industrial standard .
8. Frequency job training as compared industrial standard .
9. Philosophy of managing workers .
10. Level of integration among department and management hierarchy .
11. Level of authority of Line function relative to staff function

Vertical Integration of supplier in-house or outsource

12. Objective of sourcing decision .
13. Relationship with suppliers .
14. Frequency of assistance provided to supplier in meeting company objective.
15. Average number of supplier.
16. Level of components availability (components pull) from outsource which is meet production schedule .
17. Level of components availability (components pull) in-house which is meet production schedule .
18. Frequency of products inspections outsource supply.
19. Frequency of products inspections in-house supply.
20. Easily handling level of components supply in-house.
21. Easily handling level of components supply outsource.
22. Quality level of components supply in-house.
23. Quality level of components supply outsource.
24. Level of using visual information to show QCD supply.

B. Design Product Definition

Information ability of Product Design

1. Level of definition of product ID go to production line.
2. Level of validity of BOM used as reference activity of production.
3. Level of validity of routing used as reference activity of production.

C. Production Schedule

Information ability of production planning and scheduling.

1. Involvement of different parts of organization(eg, marketing, procurement, and production) in preparing production plans .
2. Way in which uncertainty of demand forecast is managed .
3. Level availability production schedule in each workstation.
4. Level of production activity producing product meet schedule.
5. Level visualization of production activity.

D.Operational Performance

Availability of production information realization.

1. The Purpose of " quality measurements" in organization .

2. The overall objective of "quality planning and control function" in organization.
3. While assessing performance the relative emphasis placed in organization.
4. Level of production activity can reach schedule .
5. Level of the products quality can be reached .
6. Level of visualization to show performance of production activity.

V. Questionnaire of Starting Data

A questionnaire was designed following the items as described in section 4, for every question set rank qualitatively in a five point likert scale. To investigate deeper for information, some questions were added and must be answered by person in charge in work station. The sample of the questionnaire shown in figure 7, this questionnaire model adopted from the model questionnaire used by Burchand Jain et. al(4).

21. Easily handling level of components supply outsource (shows percentage under different rating)

.....%	.....%	.....%	.....%	.....%
1	2	3	4	5
Very difficult deliver without R, T, B,P (rack, trolley, box, pallet)	←	Medium, deliver use R, T, B, P (rack, trolley, box, pallet) but the R,T,B ,P not standard	→	Very easy, deliver use R, T, B,P (rack, trolley, box, pallet) standard

22. Quality level of components supply in-house (shows percentage of the equipments under different rating)

1	2	3	4	5
Worst	←		→	Best

Fig 7. Sample of questionnaire

VI. Methodology to Analyses Data

The data from the questionnaire captured from production floor, was analyzed using value engineering method. Beginning with building break down tree of the end demand (purpose) of starting data as level 1, and then from the function structure as the level 2 and level 3.And also for every statement given in level 3 weight of the item was decided/The decision to give value of the weight is by the level of importance of the purpose of starting data. Total weights is set at 100, and details of the weight of this questionnaire is shown in table 2. From the feedback of the questionnaire the degree of capability can be calculated using the formula (1) :

$$C = \frac{\sum_{i=1}^{n} Wi.Vi}{\sum Wi} \qquad (1)$$

C = Level of Performance
W_i = Weight of parameters number i
V_i = Measured Value of parameter number i

Vi is chosen in a level only, use this value as the Vi value, if other level selected the value is based on formula (2):

$$V_i = \%.1 + \%.2 + \%.3 + \%.4 + \%.5 \qquad (2)$$

The probability of level performance can be between 1 and 5. Level 1 is the worst level, and the excellent level is 5. Between the worst and excellent, there is level 2 which is unsatisfactory, level 3 for average and level 4 for good .

Table 2, Breakdown tree of starting data and weight.

Level 1	Level 2	Level 3	Weight
Production floor manufacturing Performance	**1.Production Capability Information**	Production Equipment availability	
		1. Availability of equipment(e.g. work station) which is meet with planned production capacity	4
		2. Degree specialization of equipment compare with industrial standard	3
		3. Extent of in-house modification/improvement/adaptation of equipment	3
		Availability of Human resources and organization	
		1. Workers availability in every work station.	3
		2. Extent to which workers are involved in improving the company's process/production system.	1
		3. Scope of workers' job .	1
		4. Level of skill possessed by workers as compared industrial standard .	3
		5. Frequency job training as compared industrial standard .	1
		6. Philosophy of managing workers .	1
		7. Level of integration among department and management hierarchy .	2
		8. Level of authority of Line function relative to staff function	1
		Vertical Integration of supplier in-house or outsource	
		1. Objective of sourcing decision .	2
		2. Relationship with suppliers .	2
		3. Frequency of assistance provided to supplier in meeting company objective.	3
		4. Average number of supplier.	2
		5. Level of components availability (components pull) from outsource which is meet production schedule .	3
		6. Level of components availability (components pull) in-house which is meet production schedule .	3
		7. Frequencies of products inspections outsource supply.	2
		8. Frequencies of products inspections in-house supply.	2
		9. Easily handling level of components supply in-house.	2
		10. Easily handling level of components supply outsource.	2
		11. Quality level of components supply in-house.	3
		12. Quality level of components supply outsource.	3
		13. Level of using visual information to show QCD supply.	2
	2. Design Product Definition	Information ability of Product Design.	
		1. Level of definition of product ID go to production line.	4
		2. Level of validity of BOM used as reference activity of production.	5
		3. Level of validity of routing used as reference activity of production.	3
	3. Production Schedule	Information ability of production planning and scheduling.	
		1. Involvement of different parts of organization(eg., marketing, procurement, and production) in preparing production plans .	2
		2. Way in which uncertainty of demand forecast is managed .	2
		3. Level availability production schedule in each workstation.	4
		4. Level of production activity producing product meet schedule.	4
		5. Level visualization of production activity.	3
	4.Operational Production Performance	Availability of production information realization.	
		1. The Purpose of " quality measurements" in organization .	3
		2. The overall objective of "quality planning and control function" in organization.	3
		3. While assessing performance the relative emphasis placed in organization.	2
		4. Level of production activity can reach schedule .	5
		5. Level of the products quality can be reached .	5
		6. Level of visualisation to show performance of production activity.	3

VII. Result of Data Analysis

The data of the manufacturing activity have been captured using designed the questionnaire instrument, with the result shown in table 3 column number 6. Also using equation 1 and equation 2, the manufacturing performance of production floor was calculated, and the results shown in table 3 column 7, the level of manufacturing performance was found to be only 2.92.

This existing level has been contributed by the production capability, product design definition, production schedule and gproduction performance with the level of 3.06, 2.75, by 3.33 and 2.36 each for group performance. The distribution of value levels is shown in the form of a radar chart in fig 8.

The opportunity to improve manufacturing performance can be seen from table 3. Calculation of production floor manufacturing performance,is mainly influenced by poor product inspection, quality level of components supply, poor product definition, also poor in group production performance and poor visual management to inform numerous production aspects.

Information of product definition which is go to the production floor have average performance only, i.e. 2.75. With this performance level create problem in production process , and make real processing time higher than standard cycle time, the reason usually by BOM which is used in production floor occasionally not valid, or some time process interrupted by a product with the high level urgency has gone to the production floor but the Identity (ID) or definition of product not complete yet.

Table 3. Calculation of Production Floor Manufacturing Performance of Research Object

Level 1	Level 2	Level 3	Weight W	Total	Value V	W*V	Level 2 Total
Production floor manufacturing performance	1.Production Capability Information	***Production Equipment availability***		10			3,06
		1. Availability of equipment(e.g. work station) which is meet with planned production capacity	4		2,4	9,6	
		2. Degree specialization of equipment compare with industrial standard	3		3	9	
		3. Extent of in-house modification/improvement/adaptation of equipment	3		3	9	
		Availability of Human resources and organization		13			
		1. Workers availability in every work station.	3		5	15	
		2. Extent to which workers are involved in improving the company's process/production system.	1		4	4	
		3. Scope of workers' job .	1		4	4	
		4. Level of skill possessed by workers as compared industrial standard .	3		4	12	
		5. Frequency job training as compared industrial standard .	1		4	4	
		6. Philosophy of managing workers .	1		4	4	
		7. Level of integration among department and management hierarchy .	2		4	8	
		8. Level of authority of Line function relative to staff function	1		3	3	
		Vertical Integration of supplier in-house or outsource		29			
		1. Objective of sourcing decision .	2		3	6	
		2. Relationship with suppliers .	2		3,4	6,8	
		3. Frequency of assistance provided to supplier in meeting company objective.	2		3	6	
		4. Average number of supplier.	2		4	8	
		5. Level of components availability (components pull) from outsource which is meet production schedule .	2		3,4	6,8	
		6.Level of components availability (components pull) in-house which is meet production schedule .	3		2,15	6,45	
		7. Frequency of products inspections outsource supply.	2		2	4	
		8. Frequency of products inspections in-house supply.	2		2	4	
		9. Easily handling level of components supply in-house.	2		3,8	7,6	
		10. Easily handling level of components supply outsource.	2		2,9	5,8	
		11. Quality level of components supply in-house.	3		2	6	
		12. Quality level of components supply outsource.	3		2	6	
		13. Level of using visual information to show QCD supply.	2		2	4	

	2. Product Definition	***Information ability of Product Design***		12			
		1. Level of definition of product ID go to production line.	4		3	12	
		2. Level of validity of BOM used as reference activity of production.	5		3	15	2,75
		3. Level of validity of routing used as reference activity of production.	3		2	6	
	3. Production Schedule	***Information ability of production planning and scheduling.***		15			
		1. Involvement of different parts of organization(eg., marketing, procurement, and production) in preparing production plan .	2		5	10	
		2. Way in which uncertainty of demand forecast is managed .	2		3	6	3,33
		3. Level availability production schedule in each workstation.	4		4	16	
		4. Level of production activity producing product meet schedule.	4		3	12	
		5. Level visualization of production activity.	3		2	6	
	4. Production Performance	***Availability of production information realization.***		21			
		1.The Purpose of " quality measurements" in organization .	3		1	3	
		2. The overall objective of "quality planning and control function" in organization.	3		1	3	
		3. While assessing performance the relative emphasis placed in organization.	2		4	8	2,36
		4. Level of production activity can reach schedule	5		2,9	14,5	
		5. Level of the products quality can be reached .	5		3	15	
		6. Level of visualization to show performance of production activity.	3		2	6	
			Grand total	100		291.6	
			Total performance		2,92		

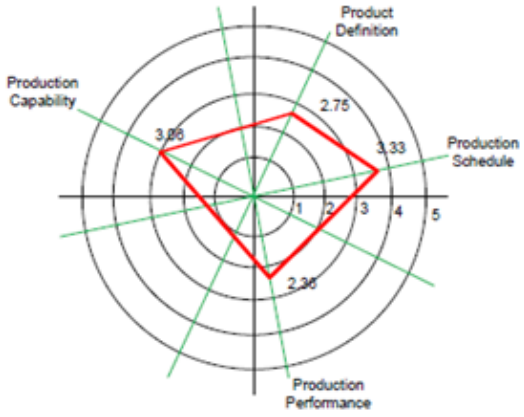

Fig 8. Production Performance of Production Floor

VIII. Conclusions and Future Research

The survey was able to capture data of existing production performance relating to the research objective. The following results were obtained :

1. Systematic approach method can be used to design production information in production floor, this system can be used as alternative method in production information system.

2. KPIs described by this approach in this research can be used to measure production performance of production floor.
3. Result of the existing performance measured is distributed under average to average level only.
4. The under average performance of the production floor was mainly influenced by poor product inspection, low quality level of components supply, poor product definition, also poor in group production performance and poor in visual management to inform all production aspects.
5. Information of product definition which is go to production floor occasionally not complete and create obstacle in the production process, the worst case jammed and in the top of that production stop.
6. The results from the survey show the production capability has many weakness mainly in vertical integration of supply chain system not only supply in house also outsource supply i.e. availability of complete components on time, and the right quality.
7. Production schedule information occasionally not available in the production floor and schedule achievement not comply as expected, it is make waste, the result is high loss of profit.
8. This data can be used as input to the next research activity,and to start focus from this evidence to define the detail and right data to complete phase 1.

The next phase of this will develop a production scheduling system that will be able to improve the poor performance experienced by the company.

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BIOGRAPHY

Susanto Sudiro is Lecture in Magister of Mechanical Engineering Program at Pancasila University, Jakarta Indonesia. He earned B.S. in Mechanical Engineering from National Institute of Science and Technology Jakarta Indonesia, Masters in Mechanical Engineering from Institute Technology Bandung, Bandung Indonesia. He joined Pancasila University in 1990 and currently supervising many research projects both at B.S. and master level in topics relating to Quality Management, New Product Development, Lean Manufacturing, and Machine Tools Design.
He has done research projects in new product development with some Hospital Bed Manufacturer e.g. MAK(Mega Andalan Kalasan) from Indonesia and Frenchbed from Japan. He spent more than 15 years implement Good Manufacturing Practices in Medical Devices base on ISO 13485 Quality System for Regulatory Purposes. He also has experience in regulation system to make hospital bed product comply with Indonesian National Regulation (SNI) and European Medical Devices Regulation (CE mark). His research interests include new product development, project management, jig and fixture design, manufacturing, simulation, optimization, reliability, scheduling, and lean.

Dr Sha'ri has a degree in Industrial Engineering from University of Miami and a Masters of Science in Integrated Quality Systems from University of Birmingham and Doctor of Philosophy with a focus on TQM for small manufacturing business from the University of Birmingham. He is a Registered Professional Engineer with the Board of Engineers Malaysia (BEM) and a Senior Member of the American Society for Quality (ASQ).
He is now a Professor of Quality Engineering and Management in UTM. Having graduated from the USA, he spent one year training in Body Assembling in Mitsubishi Motors Corporation, Japan. Upon completion of the training, he was involved in the beginning years in Proton (Malaysian National Car) in the Body Assembling Section, and later in the Quality Control Department. He joined UTM in 1990 and currently supervising many research projects both at PhD and master level in topics relating to Quality Management, Robust Quality Engineering, Sustainability, Lean Manufacturing, and Industrial Engineering.
Dr Sha'ri has published over 100 papers in national and international journals and conferences. Besides writing, he has been involved in training a number of organizations including Proton, IWK, Hitachi Chemical, Mitsubishi in various topics of Quality Engineering, ISO 9001, Industrial Engineering, and Project Management. He is currently heading a research project on developing a theoretical framework for lean adoption in Malaysian companies.