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Lean Production and its Implementation at Helsinki Metropolia UAS Digital Printing Lab

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The aim of this thesis was to offer recommendations on how to implement lean production at Digipaino, the digital printing lab of Helsinki Metropolia University of Applied Sciences. The research was conducted while working in the printing lab for five months.

The study was carried out by investigating and mapping the work processes of different products that are most typically produced in Digipaino. It was found that current production activity in Digipaino includes aspects that according to lean philosophy are defined as waste and need to be removed. Proposals for changes were made and an activity plan was created, which can be used as a guiding line on the way of implementing lean production in Digipaino. A new floor plan was produced, suggesting an improved machine layout and workflow in the lab.

As a conclusion, it was found that, while Digipaino maintains a role as a study unit, certain aspects of lean production could be implemented in the digital printing lab of Helsinki Metropolia UAS.

Keywords	Lean, digital printing, workflow, process planning, process management

Contents

1 Introduction

This thesis explores lean management and its practical usage at Helsinki Metropolia University of Applied Sciences' digital printing lab Digipaino. Digipaino functions as a printing shop and as a study lab at the same time. Lean production plan will be prepared for Digipaino, in order to make the production more effective. The topic was chosen after encouragement by Digipiano's management who is interested in implementing lean production.

The objective of the thesis is to analyse the current situation in Digipaino and offer practical recommendations for changes following the lean principles. A further goal is to create a new layout for the printing lab and present an activity plan for the future.

For the purpose of this thesis the author has investigated and made workflow schemes that map the routes of different production stages for the main products in Digipaino. Suggestions are presented about turning work processes lean. This includes a layout plan, which can be used as a starting point on the process of becoming lean. All the schemes and plans can be found in the appendices.

2 Lean production

Lean production is a philosophy of how a manufacturing company manages and operates its business by using many of highly efficient manufacturing techniques. [1,339;2] The methods of lean production aim to combine the flexibility and quality of craftsmanship with the low costs of mass production [2].

The central idea of lean is the elimination of all waste and the continuous development of production. [1,340] Waste is manufacturing activities or actions that add no real value to the product or service [3]. Waste reduction allows making quick responses to markets demands and makes a company more competitive. [1,340] Continuous development, on the other hand, makes it possible to react to constantly changing views of the customer as well as to the new standard requirements. [4,453]

The key idea of lean is the elimination of waste. Anything that does not add value from the customer's perspective to the production is called waste. Adding value to the production does not mean increasing the production cost. It means that something value adding happens in the unit, for example, it is being processed. Waiting time is considered as waste, because during that time nothing happens in the unit. Every unit should flow through the system smoothly. [5,24] Overproduction is a waste of resources and the inventory that is followed by it is also a form of waste, because of the extra handling and space it requires. Transportation between different production phases and movement of workforce are waste and have to be kept to a minimum. Processing waste is an inevitable part of every production, but like the unnecessary motion, so should the production waste be kept as minimal as possible. Waste from product defects, on the other hand, has to be eliminated from the production, because it requires time and recourses to fix and replace the defective products. Product defects indicate that there are problems somewhere in the production that need investigation. Activities that do not add value and increase the cost are considered as waste and should be removed from the production cycle. [1,340-341;4,449-450;6] According to research conducted by the Lean Enterprise Research Centre, fully 60% of production activities in a typical manufacturing operation are waste – they add no value at all for the customer [6].

Lean is based on the way people of the company think. In order to apply lean tools and skills, the company has to share a common philosophy and a common set of principles. [7,32] In lean thinking the organisation has to be managed as one big system. Dividing production into separate processes and applying lean to only few processes under focus will not bring any success. The employees, the management, the production line and the workplace, all have to follow the lean philosophy. Otherwise lean cannot be fully implemented and the efforts will not carry wanted result. [1,340]

2.1 History of lean production

Lean production originates from Japan. In 1937 Kiichiro Toyoda founded Toyota Motor Corporation that produced cars for the local Japanese market. After the Second World War Japan had to rebuild its industries. There was a shortage of raw materials due to the overseas high transportation costs and the whole country was in crises. The Toyota Motor Corporation got into difficulties, because it could not find an institution that could provide financial resources for the expansion of Toyota's car industry. [5,68-69]

In Japan, the technology and machines were not as developed as those in the Western world. So, Toyota Motor Corporation sent its representatives to United States, to get ideas on how to turn their business into a successful car industry. The representatives noticed the huge stocks in US factories and the amount of products, which required repairing after the production. That did not fit the situation of Toyota – they had to be efficient, because they had no resources to overproduce nor did they have resources to do things twice. That gave the push to a new kind of approach to efficiency. [5,68-69]

Toyota decided to concentrate on flow efficiency. [5,69] Flow efficiency captures the idea of products moving through the manufacturing process as efficiently as possible from the products viewpoint. [5,13] The product is produced only if the customer has ordered it and it moves from one production stage to another without having to wait between different stages. That minimizes the necessity of a storage space. If there are any problems in manufacturing, the line will be stopped and the problem fixed immediately. That way it is possible to save resource materials and it also reduces significantly the number of units that need repairing. All in all, flow efficiency reduces cost and that was exactly what Toyota Motor Corporation was looking for. [5;8]

2.2 Lean production nowadays

Toyota Motor Corporation created a concept of lean, which is known under the name of Toyota Production System (TPS). Its creator is Taiichi Ohno. [8,10] Lean production was fully developed in the 1980s and early 1990s, when it spread wide across western world [2]. TPS is based on two pillars: Just-in-time and Jidoka [8,11]. Just-in-time (JIT) is a quantity control tool where product is produced at the right time in right quantity and in the correct location, in other words, JIT is a pull system. [8,11;1,340] Jidoka, a quality control tool, is a partially automated method of detecting system weaknesses and fixing them [8,303;6].

Lean method works best in competitive free-market environment with a clear customer focus. [8,33] A product has to be produced with the smallest necessary number of operations, motions and materials and must include everything that the customers expect from the product they have paid for. [1,341] In Finland, lean philosophy is followed in Nokia Solutions and Networks' factory in Oulu. [9,7] Elsewhere in the world lean production is used for example by Heidelberg Druckmaschinen AG, Honda, Nike, Intel, John Deere, Caterpillar Inc. and of course by Toyota. [10;11,224;12] Lean can be used in many different fields – from health care systems to customer service. For example Virgin Atlantic offers services for their clients that base on lean ideology. [5,23]

3 How lean methods affect production

Lean production, in case it is properly integrated, has a positive effect on production. It has to be noted that it takes a lot of time to implement lean management, and it will not be easy either. It is not enough if the production lines and environment are changed and set up by lean principles, because the change must also happen inside the organisation, in the minds of people who are working in the company. The organisation must have willingness to change. [8,3]

Lean production is based on pull production. In pull production the product is produced only when it is needed, for example when the customer makes an order. That way overproduction is avoided. While machines do not run excessively, the line can be used in production of another product. Without inventory, there is no need for big stor-

age rooms. This means that the company can rent smaller rooms and save costs. Time and recourses are saved when there is no storage room, because then products do not need to move constantly between the production room and storage room. [8,13-14;1,353]

In lean production the designers work closely together with production workers. It helps designers to design the product to be suitable for the production line. In turn, the production workers can give immediate feedback to the designers in case there are manufacturing problems caused by design. [2;1,344] As for example in Marimekko, the design team is in the same building as the textile printing production line. [13] Textiles can be designed immediately according to the requirements of the production line, which eliminates fixes and adjustments later in the production phase.

The employees working in lean environment are usually organized into teams. The workers tasks are less narrowly specified and they are expected to be able to do all the tasks required from the team. With this system the employee gets variety in his or her everyday work and the work does not get boring and monotonous. When an employee has a wider range of skills, it eliminates the situations where only one worker has the skills to perform a specific task and whose absence would mean a stoppage in the production. [2] Multiskilled workers add flexibility to production. Work becomes more dynamic, because workers can quickly move over from one product to another and they have the skills to carry out problem solving by themselves. [8,60;1,345-346]

Implementing lean methods improves reacting time, which can be achieved by high throughput time. Throughput time is the time that it takes for the product to move through the whole production process from start to finish. [5,22] When lean workflow is first introduced to the production, the number of stoppages increases. Stoppages show the weak points in the production line and they give the opportunity to improve the system and make it more robust. After the causes of stoppages are solved, the mature lean production line stops less frequently than a mature mass production line. [8,60] Workers are encouraged to stop the production as soon as they discover a mistake in the production. A mistake is found easily, because the worker is constantly present during the process. Fixing is done immediately. That makes the delay of the production shorter. Mistakes are not considered as worker's fault, but a chance to improve the current system into a better, well organized system by changing and developing constantly. Lean method has to be treated as a tool, not as a target. [2]

A so called 5S approach is used in organizing work area:
Sort stands for eliminating everything that is not needed in the work area. Set In Order urges to organise the remaining necessary items. Shine means cleaning and inspecting the work area, so that it will not turn back into its previous state. Standardising has to be done for example by writing standards for previous phases. Sustain advises to apply the standards regularly, in order to keep the work area organized. [6]

Lean production works best in competitive free-market environment, because that makes the company struggle for its profits and has a better stimulus for applying lean philosophy. Speed of reacting time compared to competitors on a market is important. [2] A clear customer focus helps the company to find and meet the customer's needs. By using a lean process, running a workflow requires less investment, doing fewer inventories, consuming less space and using less people. The money saving aspect gives a push to eliminate all the existing waste in the production. [8,9-33]

4 Situation at Metropolia's Digital Printing Lab

Digipaino, also known as digital printing lab, locates at Helsinki Metropolia University of Applied Sciences' Leppävaara campus. It is part of the University's organisation and all the business is regulated by Metropolia UAS. Digipaino does not compete on commercial market. Its main customer is Metropolia UAS, which orders many of its printed products from Digipaino. Other significant customer groups are students and university staff. Outside customers do find their way to Digipaino, but only in small numbers. They usually find their way to Digipaino through someone who is, or has been related to the Metropolia UAS.

4.1 Staff

In Digipaino there are three workers: a senior lecturer, a lab engineer and a trainee. Senior lecturer uses Digipaino as a study lab. Besides courses, he or she manages the purchase of the new equipment and keeps the programs and software up to date.
Lab engineer is responsible for the production. He or she checks that all the orders are full-filled correctly and customers are happy. Because he/she knows the possibilities

and limitations of the machinery, he/she is the one who can give the agreement on printing something that differs from Digipaino's ordinary products. Price calculations, new material orders and invoicing are also duties of the lab engineer as well as supervising the trainee.

Trainees are students of Metropolia UAS who have applied or otherwise expressed their wish to accomplish their internship period in Digipaino. The trainee changes every six months. The previous trainee teaches the new trainee during the period of three days up to two weeks. The level of training depends on the trainer. There is no specific method how the teaching is done. Only guidance provided to the trainer by the workplace is a Trainee Orientation Checklist that is attached as appendix 1. From the list the student who is acting as a trainer, can check if he/she has gone through all the main topics.

Communication between Digipaino staff members is verbal. The work area is relatively small, so it is easy to walk up to another person and forward the information. Errors in communication happen easily, especially when machines are working and making loud noise. In these cases one has to stop the work while conversation takes place. Sometimes it happens that information is not forwarded properly or one forgets to forward it at all. Communication can also be done via email. In case of emergency, the absent worker is contacted by phone. Those cases are rare, and done only during work hours.

Staff communicates with customers mostly via email. Digipaino has also a website. When problems occur and it is difficult or time consuming to solve them through emailing, and, therefore, the customer is contacted by phone. For the customer it is possible to visit Digipaino for example to choose the paper, discuss about prices, printing methods, e.g. before placing the order. Customers who place an order in Digipaino have to give their contact information.

4.2 Work environment

Digipaino printing lab covers an area of about 550m^2. The floor plan is illustrated in appendix 2. Appendix 2 is not an accurate floor plan. Its meaning is to give a rough understanding about the layout and dimensions of Digipaino. There are about 20 machines in Digipaino, from which about 7 are used on daily bases. A list of Digipaino's machines is in appendix 3. There are three exits, two that open into the other parts of

this Metropolia UAS building, and one door that opens to outdoors. Only deliverymen and maintenance use the door that opens to the outdoors. One can enter Digipaino only if he/she has an access card, for example workers, students and university staff. Customers who do not have an access card have to ring a doorbell, which is found only at one door, on the side of the main entrance of the university.

In Digipaino there are the offices of the senior lecturer and the lab engineer. Besides the offices there are two storage rooms. In the smaller storage room there are mainly packages and envelopes for packing. In the other storage room, illustrated in figure 1, there are all kind of materials from papers to a car bonnet. There are also offset printing materials, even though Digipaino does not have an offset printing machine anymore.

Figure 1. View to the storage room.

While performing a task, it takes time to find the correct tools. Even though some tools do have their own specific place, like the knife in figure 2, they still tend to get lost or lend to be used in other tasks. Returning the tool to its correct location is usually forgot-

ten and remembering where it was left is always a tricky question. The problem multiplies when all the three workers are forgetful. Some tools are kept in a drawer, so that it would be easier to find at least some kind of a tool. The drawer situates in the centre of Digipaino, which means that worker has to walk to the drawer and back to the machine during one operation, for example cutting the material from the roll of Epson StylusPro GS6000 that is illustrated on the left hand of figure 2.

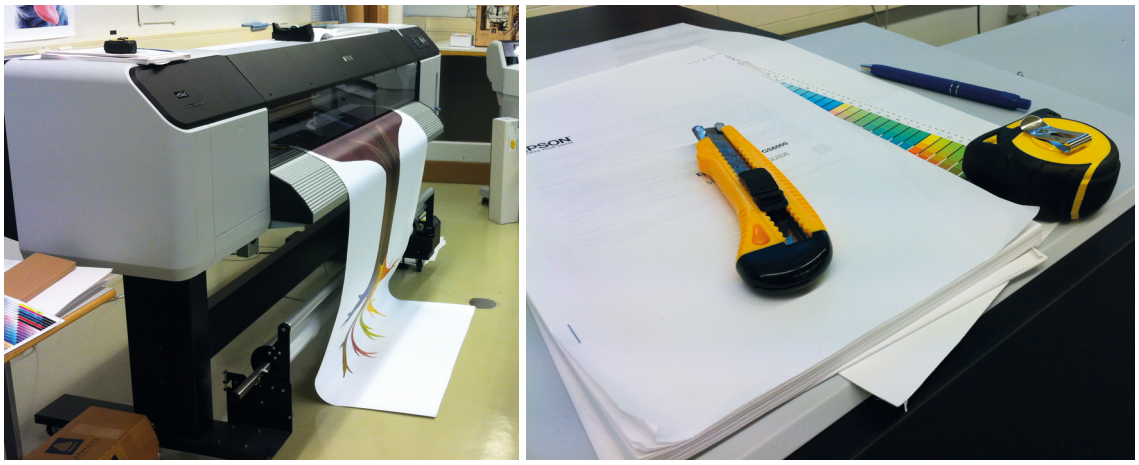

Figure 2. Printout that needs to be cut with the knife which correct location is on top of Epson StylusPro GS6000.

Working process quite often needs empty surfaces where to put the printouts to wait for the next work phase. Unfortunately surfaces are rarely empty, so in order to put the printouts on the surface, the worker has to clean the mess that is on the way. There is not always time to clean the mess, so the worker just piles the things on top of one another and uses the quickly created free space. When the pile is there for long enough, it becomes part of the environment and nobody takes any notice of it.

4.3 Workflow

Basic workflow is mapped and viewable in appendix 4. Digipaino's workflow processes are depicted in the form of a swim lane diagram. It illustrates the flow of the process, and shows the responsible parties at the point of the process in which they are involved. [14] Workflow paths visualise the routes on which a worker has to move in order to complete the work. The basic workflow path is illustrated in appendix 5.

Orders are mainly received by email to Digipaino's mailbox. Digipaino uses Microsoft Office Outlook like the rest of the university. Mailbox can be read by all of Digipaino's workers. When an email order is received in Digipaino, as seen in figure 3, it is firstly checked if it includes all the necessary information to handle the job and if the file attached is suitable for printing. For example if the file is in a format that does not open with Digipaino's software or if there are visible defects in the design (file is corrupted), the customer is contacted in order to fix the problem and send a new version of the file. When the received file seems to be fine, the work is added to the Wiki work list. Orders made on spot have the same workflow; except that then the trainee might forget to ask all the necessary questions, like what kind of paper the client desires or the final size of the printout, because no checklist exists.

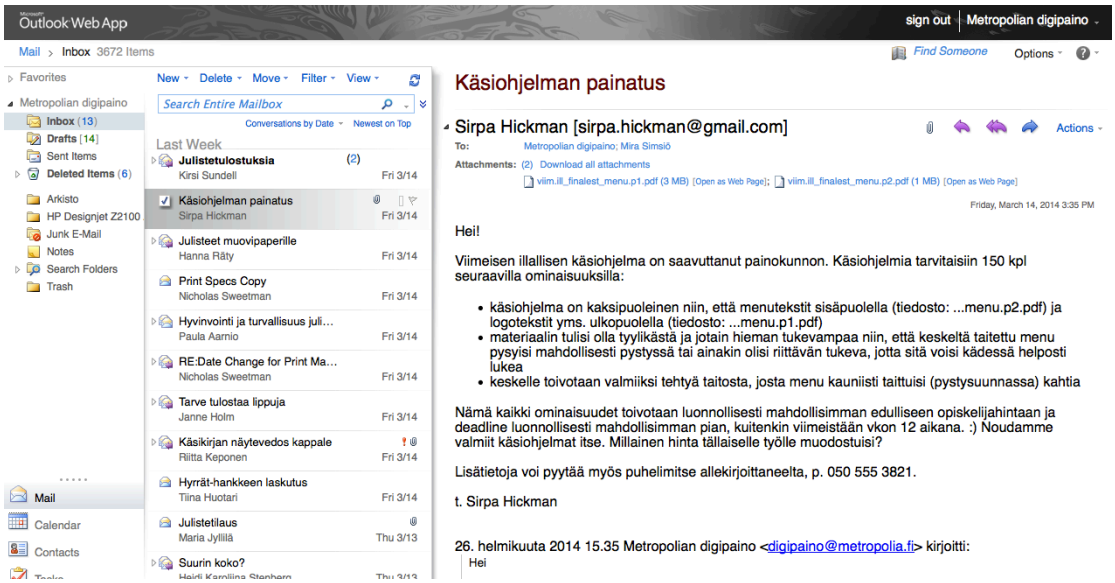

Figure 3. Digipaino's email system.

Checked orders are saved to Wiki system that works as a ticketing system. Inadequate entries are common and sometimes it even happens that a worker forgets to add the order to the ticketing system, e.g. the name of the file is missing. The name of the order is either the name of the email, as figure 4 illustrates, or if order has arrived by some other way, a general name like "business cards", "posters", e.g. is given. Behind the order name the name of the customer and date of arrival are marked. Proper naming makes it easier to find the order when necessary, for instance during invoicing process, when one needs to find the original email for rechecking the information.

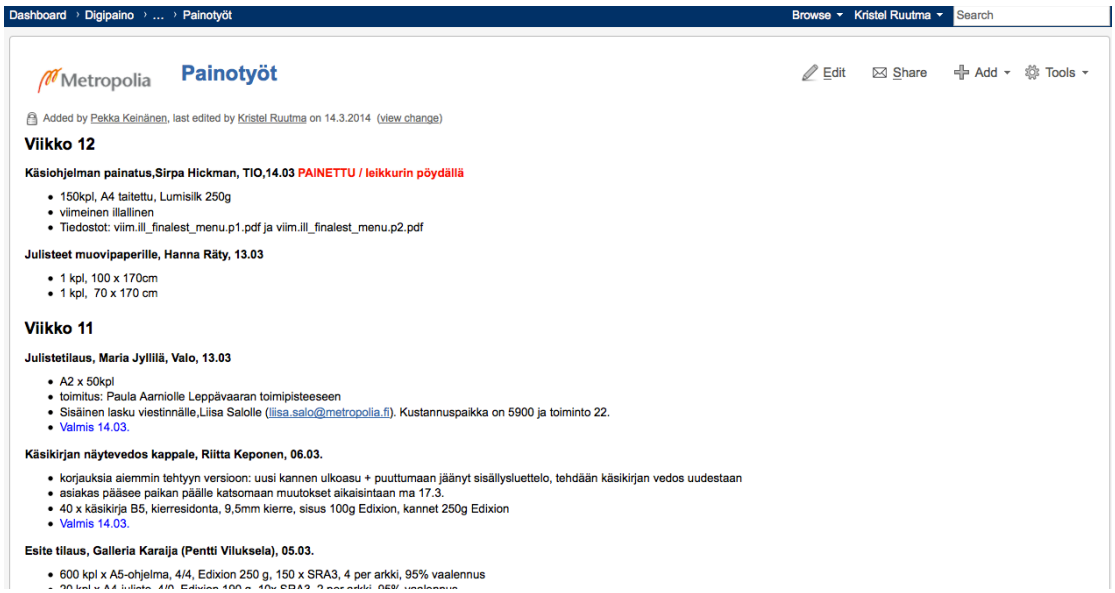

Figure 4. Orders are stored as tickets in Wiki system.

The accepted file is imported to the RIP software of the printer with which the file will be printed after setting the file properties. Problems may occur during printing. The trainee informs the lab engineer about the problem, unless he/she can fix it. In Digipaino there is no specific work division, because the place is so small and all the three workers might not be at work at the same time. That is the reason why they have overlapping tasks. It is common for the lab engineer to work together with the trainee on the same task. There are cases when the trainee does not manage with the task, but the lab engineer is not around. In that situation the trainee has to wait for the return of the lab engineer.

Sometimes it is necessary to perform some tasks before printing can start. First it has to be checked if there is correct paper in the machine. If the job has to be printed on a different material, the correct material has to be changed into the machine. Sometimes material has to be cut before changing can be done. Secondly, machine has to be switched on and working properly. Most of the machines are on all the time, but some need to be switched on or waken up from sleeping mode. Nozzle check is performed to some of the ink-jets, to be sure that the nozzles are not clogged.

The problems during printing process can be divided into two different categories: file problems and machine problems. If the file problem is self-fixable, fixing attempts will be made. Some fixing can be done for example in Adobe Photoshop, where the image file has to be flattened and saved again. With Microsoft Word files the file has do be

saved in a format that will include the font information, etc. There is no standardised way to fix the file problems. Each case is analysed separately and the method of achieving the desired solution may vary significantly from each other. If the problem cannot be fixed, the customer will be contacted and a new version of the file is requested.

Machine problems are usually solved by the staff. If not, then maintenance is contacted. Only one machine in Digipaino has a service agreement, where the maintenance can be contacted any time during working hours. That machine is the Ricoh Pro C751 printer, and the maintenance service should arrive during the next four working hours. If the service call is made in the afternoon, then it is possible that the service does not arrive before the next morning, which has to be taken into account when dealing with a high importance order. Other printers in Digipaino do not have that kind of service contract. In their cases the representative of the product has to be contacted if the printer's warranty is still in use. Some level of machine knowledge is needed to understand if the machine problem is self-fixable or not. Tacit knowledge is helpful, and is achieved during a long period of time, but for a trainee this knowledge has not yet developed. Then one has to rely on the tolerance bearings set by the manufacturer.

Printing phase is followed by finishing, where the printouts are either bound, stapled, cut clean or have another form of finishing which can be done in Digipaino. Packing follows finishing, and packed products are transported to post. When the order has been posted, ticket is marked as done to Wiki system and waits for the lab engineer to write an invoice based on that information.

Proposal:
Basic workflow contains considerable amount of waste as seen in appendix 6. Shapes filled with yellow mark the steps that stay the same in the workflow. Shapes that have only the outline stroke as yellow indicate a step that stays, but with modified content. The red arrows between different steps show the new order of the workflow.

Most of the unnecessary work is caused by file problems. Either the files are in wrong format, or they are missing bleed area, crop marks, etc. In the print proof there might appear stripes or boxes that were not visible on computer screen. One way of eliminating the file problems is to inform the customer already on the product-creating phase about the proper formats and requirements of the printing lab, as printing companies in

commercial market do. For example, figure 5 illustrates instructions for the client on Kopijyvä Oy's website.

Figure 5. Kopijyvä Oy prepress instructions for the customer on Kopijyvä's website. [15]

Faultless files that arrive to printing lab can be printed as soon as the machine has finished with the current work in progress. A file that needs fixing generates a stoppage in the workflow. Fixing can be time consuming and other works have to wait. Waiting time is a typical form of waste. With a staff of three people, time cannot be spent on fixing files that their creator could easily do right in the first place. Further option to solve this problem is to consider offering prepress services in Digipaino, or to have a closer co-operation with Metropolia UAS graphic design department's design studio Valo.

Incoming files should go through preflight software that checks the quality of files before they get processed. Preflight checks whether the characteristics of those files are in sync with desired output [16]. If the problems are caused by RIP software, the software has to be updated, so that it will be compatible with all kinds of files.

Printing machines are always kept ready for printing. Machines that are not used on daily bases can be switched off, but the most used machines have to be on standby. All the machines have to be maintained at least weekly by Digipaino's workers. That

ensures faultless operation when needed. Changing the substrate is an inevitable part of printing in a printing lab that produces mainly short runs and that is the reason why it is not marked in proposed new workflow.

Training the workers well eliminates some of the machine problems. The machine operator has to be able to distinguish between a fixable problem and a problem that needs maintenance. Operators usually know their printing machine well and during the years they have developed a know how on machine and its specific faults and performance. The lab engineer has this knowledge, but for the trainee a proper training session must be given. There is a small problem though, as Digipaino acts as a workplace for the trainee's internship period. Internship lasts for 20 weeks and it is a compulsory part of the studies. The trainee might not have had any previous experience with work in the print shop, except in a theoretical form and through excursions done during courses. It might be difficult to learn to know every machine well enough as required. During 20 weeks, the trainee has to operate about 15 machines in Digipaino, which are listed in appendix 3. For that reason it is questionable, if the trainee should know everything about the machines. Nevertheless, the lab engineer has to be well trained and able to fix every machine related problem that does not require the involvement of maintenance.

Packing needs to be standardised. For example all the jobs should be packed, no matter what the product is. It simplifies the workflow, because a worker does not have to check it from the Wiki system, if the work is going to be posted or is the customer coming to pick it up personally from Digipaino. It also makes it easy to distinguish the works that are ready. If the range of packing materials is wider, it helps to pack products quicker, because the worker does not have to build the package out of a wrong sized box. All the works that are packed should be kept in the same place, for example on a shelf that is meant for outgoing, ready jobs.

Invoicing should be automated and sent to the customer at the same day on which the product has left the printing lab or on the following workday the latest. Automation requires changing of the Wiki system, which is used now, to something that allows the invoice to fetch data from the ticketing system. That makes invoicing faster and gives the lab engineer more time to spend on Digipaino's shop floor.

4.3.1 Multiple copies per page

Current situation:

The process of making multiple copies per page is illustrated in appendix 7 and it starts by dropping a file into Fiery Command WorkStation 5 software window. After that, worker checks if the Ricoh Pro C751 is on, and if not, switches the machine on. Waiting time for the printer is 5 minutes. Paper is loaded to the machine's paper tray, unless there is already a suitable paper type in the machine. In case the paper is size SRA4 or smaller, the paper might run through the machine with its short edge first. That means that the fusing unit has to be changed to an older fusing unit, in order to minimize later defects while printing on SRA3, which is bigger in size. After the SRA4 (or smaller) short edge first job has been printed, the fusing unit has to be changed back to the new fusing unit. If the fusing unit is not changed, ugly stripes will start to appear on printing papers bigger than the short edge of SRA4 and they cannot be removed unless the maintenance comes and replaces the fusing unit to a new one. Waiting for maintenance may take time from a few hours up to a day. During the waiting time nothing can be printed. All in all, changing the fusing units according to the need increases the flow efficiency.

When machine setup is done, the file will be imposed in the Fiery RIP software. During imposing the layout of the sheet will be defined, crop marks added if necessary, cutter and bleed distance adjusted, duplex or not, etc. Paper type, paper profile and the brightness are set in work properties. When settings are set, the print proof will be taken. Based on the print proof the registration is checked and if registration marks are not aligned properly, the image shift is set in work properties. Also the imprint quality is checked. Yet another print proof is taken and the cycle goes on until the print proof is accepted. When the print proof is accepted, the job will be printed.

The original file, the RIP software or the printing machine can cause problems on the imprint quality. Digipaino cannot always fix the original files; usually the customer is contacted and asked to deliver a new file. RIP software has an option to flatten the file before print, so that has to be done and tested before contacting the customer. If the problem is not in the file, but in the machine, the maintenance is contacted, because there is not much that the worker can do alone to fix the problem, even if the cause of the problem is known.

Workflow path is marked onto appendix 8. It covers most of Digipaino, and the distances are relatively long, especially if a worker has to carry pile of papers. Distances consume time. For example, the printout has to be checked if it is similar to the file on the computer screen. Just a small check requires for the worker to walk across the room, compare the file with the one on the screen, and walk back to the machine to make the needed changes.

Proposal:
In order to change and make the workflow of multiple copies per page lean, as seen in appendix 9, the file problem has to be solved already before the file is sent to Fiery RIP software. The customer has to be informed about the standards Digipaino follows. Extra work with a file that does not follow the standards will increase the cost for the customer. That should be made clear on Digipaino's website. Preflighting the received files removes file related problems such as transparency issues.

Ricoh Pro C751 printer should be switched on in the morning, which reduces the waiting time of the machine setup down to 1 minute. Papers should be cut beforehand to the correct size, so that there is always enough paper to be used when needed. Papers have to be cut carefully; if they vary in size, the difference will be visible in the registration of duplex printouts. In these cases image shift does not help in aligning the registration, because for example after ten sheets the paper size might change again. As a result, badly cut raw sheets cause problems in all the following work phases.

Figure 6. Paper trays on the operation side of Ricoh Pro C751.

Ricoh printing machine has six paper trays as seen in figure 6. Most used paper types can be kept in the trays all the time. Some trays can be left for papers that are not needed so often, so the content of the tray changes according to the job. During printing a LED light indicates which tray is in use, so another tray can be refilled ready for the next print job [17] or in case of a long print run, another tray can be filled with the same paper. That way the flow is more efficient and the printing does not have to stop during refilling of the tray.

The imposing and work properties phases can be partly automated. With the software it is possible to create and save specific pre-sets, that can be applied to jobs by simply choosing the suitable pre-set from a dropdown list. In paper settings there are a lot of paper profiles that are not used in Digipaino. Those profiles should be erased from the paper profile list, because unnecessary profiles make the list long and make it difficult to find the correct profile. Searching for the right profile eats away time that can be used elsewhere.

Fiery RIP reveals all kind of transparencies in the file, unless the file has been saved in a correct way or flattened before sent to print. To avoid transparencies from appearing to the printout, the file has to be flattened in the RIP. Flattening should become a standard, in order to stop printing printouts with transparency problems, unless preflight software is purchased.

It is not wise to remove the print proof phase. Print proof shows a worker's layout mistakes immediately. That is good, because workers are trainees, students of Metropolia UAS, who do their internship in Digipaino. Print proof helps them to learn. Besides that, it is part of quality control to make sure that printouts are acceptable, so print proof is a proof of that. In a later phase mistakes might not be possible to fix, and the whole batch would have to be printed again.

Registration problems, as well as printouts being slightly too red, should be fixed by maintenance. The machine has a tight registration tolerance of +/-0.5mm [17], but it is not a surprise to see registration misalignment of +/-1.5mm. Registration problem should be investigated properly. If the printouts are too red, it means that magenta profile is out of place. The machine should be calibrated regularly.

4.3.2 Business cards

Current situation:

The workflow of the business cards is dependent on the size of the business card. The normal size of business cards printed in Digipaino is 50 x 90mm. Digipaino has purchased a special business card cutter Uchida BC-10, illustrated in figure 7, which cuts the cards out from the inserted A4 pages. The business card cutter has fixed cutting dimensions, which are commonly 50 x 90mm. Sometimes a client orders business cards with a different size, for example 50 x 80mm. This size cannot be cut with Uchida, it has to be cut with Wohlenberg MCS-2TV guillotine, as visualized in appendix 10. Cutting with Wohlenberg guillotine is more time consuming, even when using a pre-programmed program. The preparation time of the guillotine is long compared to the Uchida cutter. Turning on takes time and then it has to be set on the right program. A positive thing is that with guillotine it is possible to cut also the SRA4 size; Uchida uses only A4, because SRA4 does not fit into the feeder.

Figure 7. Uchida BC-10.

Uchida machine has to be switched on each time a job starts. Paper is placed into the feeding unit and start button is pressed to start the process. Usually only one sheet of business cards is cut to make sure that machine is cutting from correct places, e.g. crop marks are not visible. If crop marks are visible on the cut-out business card, the sheet pile has to be turned around so that the other end of the sheets are fed to the cutter. In case that does not help, Uchida has a possibility to move the place of the first cutting. When the cutting result passes the visual quality control performed by the

worker, the whole batch is cut. Packages are fetched from the small storage as visualised on appendix 11 and business cards are packed.

When the Wohlenberg guillotine is off, the machine has to be turned on. It takes about a minute for the machine engine to be in working condition. When guillotine is ready, the worker chooses a program from the guillotine's memory and starts cutting. Last cut has to be adjusted manually, because the program is old and made for 50 x 90 cm business cards. Packing takes place after business cards are cut to desired size.

Business card cutting workflow does not take into consideration the contact with maintenance. Usually machines are working properly. Settings do not need adjusting, because the programs on both machines are never changed, so the result produced is always the same. Only the change in paper type may affect the end result.

Proposal:
Standardisation of the incoming jobs correspondingly makes the business cards workflow leaner, as seen in appendix 12. There is no need to cut with the Wohlenberg guillotine, if all the incoming business cards are in size 50 x 90mm. Informing the customers about the required size helps them to create the file in the needed size. Of course, production of business cards that vary from the standard size is still possible, however, then it is not considered as an ordinary business card order, and it should be reflected in the price of the product.

4.3.3 Bound products

Current situation:
The binding process is illustrated in appendix 13. After printing, the material needs to go through a preparatory cut, where the book pages and covers are cut to the suitable form to be able to have a correct, faultless end product. Books are bound with Horizon perfect binder BQ-270. The set-up time of Horizon is relatively long – about one and a half hours – due to the gluing unit in which the glue needs to melt properly before machine can run. Job related settings are set in the machine after the glue is melted.

It is important to make test runs before the actual production. It reduces the number of errors and stoppages during production. If test binding goes wrong, the settings are changed according to the test piece. This process is repeated until a perfect result is

reached. Feeding the book blocks to the binder is simplified by placing the book blocks onto the transportation trolley in a way that the operator does not have to rotate the book block and check where the front sheet of the book block is or where the back sheet is. The operator simply takes the block and feeds it into the binder. In case of an unfixable machine problem maintenance is contacted.

When the batch is bound, the glue has to set before it can move on to cutting process. That takes one to two hours or even a day, depending on the work situation in Digipaino. A program for cutting is set up in Wohlenberg guillotine. Placing maximum five copies on top of each other while cutting makes the cutting process faster. Cutting can be done only on one side of the guillotine, because right-handed side leaves an ugly end result to the book's spine. Cut books are packed for the client. During cutting and packing, the tables next to the guillotine are used. Lack of space in the working area is a typical problem in Digipaino and visible in figure 8.

Figure 8. Lack of space around Wohlenberg MCS-2TV guillotine.

Binding workflow route is seen in appendix 14 and it does not include printing process. The route is relatively simple. Only the distances between the machines are long and

the table layout around the Wohlenberg guillotine makes the access to the guillotine a bit difficult with a trolley.

Proposal:
The lean binding process does not differ from the current workflow as illustrated in appendix 15. There are no phases that can be removed or done differently. Digipaino's new machine layout could make a difference in the workflow route. The work area has to be organised in a way that working is efficient. Surfaces have to be clean, so that cleaning and reorganizing do not interrupt working. Horizon perfect binder has to be maintained after every job. Maintenance done by Digipaino's workers ensures that the machine is clean and does not spoil the final product. Outside maintenance is needed only if the machine gets broken.

4.3.4 Folding workflow

Current situation:
Folding as a process is already quite simple. A defined step is followed by another necessary step, as visualised in appendix 16. The route, seen in appendix 17, among which the worker has to move during the process, is accordingly simple and clear. Folding is done with Morgana Digifold. Before the worker starts folding, he/she usually brings a trolley next to the folding machine in order to use it as a packing surface. Otherwise there is no fixed table surface on which the printouts or folded products can be placed.

First of all, the printed material needs to go through cutting that is done with Wohlenberg guillotine. Cut material is transported to Morgana Digifold that has been turned on already before, because it takes time for the machine to be ready for use. When the machine is properly on, the worker sets the machine up. Worker measures again the width and length of the material and inserts the information to the machine. Folding is tested and if it is not satisfying, the settings are adjusted until the outcome is acceptable. Because sheets are fed to the machine automatically, the worker has time to start packing the folded products as soon as they come out from the folding machine. Products are counted and packed in e.g. sets of 10.

If the machine causes a lot of spoilage during the folding, machine has to be checked. The problem can lie in incorrect settings, but if changing the settings does not help, it is

better to call the maintenance. Sometimes when there is a hurry with filling the order, the customer is contacted and asked if the folding job can be replaced with creasing, which is done on a different machine. That means the customer has to fold the products by hand from the creasing lines.

Proposal:
In lean folding workflow, which is illustrated in appendix 18, the spoilage can be minimized by training the worker well enough to be able to fix machine problems by changing the settings of the machine. Some of the machine's problems cannot be self-fixed. Perhaps a regular check by maintenance man will keep the machine up and running properly without causing any unnecessary stoppage in the production.

4.3.5 Stapling workflow

Current situation:
Stapling workflow is similar to folding workflow as seen in appendix 19. The preparatory cut material is fed to Morgana DocuMaster Pro, which has been set up according to the size of the fed material. Morgana DocuMaster Pro setup requires also the information about the final size of the stapled product. That information is inserted manually. Even though there is a possibility to create and save your own programs, saved settings are not used. Some of the settings are made inside of the physical machine, not only in the software. Those settings cannot be saved and they have to be changed according to the job. Changeover time is fast, in case the worker knows what he/she is doing.

Test runs are done and settings changed if the stapling does not hit to the correct location, or the booklet is folded on wrong place, etc. When everything is fine and passes the visual quality control done by the worker, the whole batch is run. Packing happens usually simultaneously with stapling and is done by the worker. During packing it is easy to spot the faulty products, and the machine can be stopped when a problem is noticed. A trolley needs to be transported next to Morgana DocuMaster Pro, so that there is a surface where ready products can wait for packing. Workflow path is mapped to appendix 20.

Stapling process can have machine problems that cannot be fixed by the worker. The lab engineer knows more about the machine, and usually he manages to fix the ma-

chine, so that at least the ordered amount of products can be stapled, even if the quality is not as high as it should be. Maintenance can be reached by phone and they give advice and product support by phone.

Proposal:
The workflow of stapling can be made leaner by automatisation. Lean workflow diagram is visualised in appendix 21. The Morgana DocuMaster Pro has the possibility of using ready-made programs. Digipaino could either inform the customer about the sizes suitable for stapling, or create programs for most common products. In that case programs have to be made in all the machines, in order to have some kind of standardisation and matching registration throughout the whole process.

4.3.6 Banner workflow

Current situation:
Banner's workflow is visualized in appendix 22 and starts from reception, where the checked file is transferred to a USB memory stick. Memory stick is then attached to another computer a few meters away, as seen in workflow path in appendix 23, and file is transferred from the stick to desktop. From the desktop the file is dropped to RIP software. Meanwhile worker checks the printer and performs required tasks, like changing proper substrate to the machine. The settings of the file are adjusted in the RIP. When everything is ready, the file is printed. Sometimes the file does not import into the RIP software. The problem lies probably in the file and it is attempted to be fixed by Digipaino's workers. If file fixing does not help, the customer is contacted and asked to deliver a new file.

Printed work is always checked. If the printout passes the quality requirements, it will be left to dry. Sometimes it happens that the printout does not pass the quality requirements, for example the ink can have scratches from bad handling. In that case the file will be printed again. If the problem's cause lies in the machine, the machine is fixed or cleaned, depending on the cause, by workers. In case the problem is not self-fixable, maintenance is contacted.

Depending on the customer's wishes, dried banner can be attached to KAPA board or it can be eyelet. Suitable piece from KAPA board is cut and the banner is attached to the piece. The result is cut clean. Eyeleting is done after the banner is cut clean. If

none of the finishing options are wanted, the banner is simply cut clean and packed for the customer.

Proposal:
In order to make the banner workflow lean, the files have to be standardised and run through preflight software before they reach the RIP software. Lean workflow is seen in appendix 24. Informing the client about the file standards that are used in Digipaino helps to solve at least some of the problems. Reception computer has to have a connection to the RIP software or a connection to the computer in which the RIP is operated. The current system of putting the file onto a memory stick and moving it physically to another computer is time consuming and also increases the risk of the file problems, e.g. the file is corrupted due to the transferring process. The printer is ready all the time, only the substrate needs to be changed according to the order.

In case a file is standardised and run through preflight, there should not be any problems in importing it to the RIP software. Print settings are adjusted faster and without mistakes if the job information is written onto a paper from which the worker can easily check the amounts and measures of the work in progress. There is always a possibility that something happens to the printer, and it has to be fixed either by a worker or ordered maintenance. The worker has to be trained well enough so that he/she could fix simple problems independently. The machine has to be maintained regularly by Digipaino's staff. For that there is a specific time assigned during the working hours, for example every Friday two of the last working hours are devoted to machine maintenance. Not every machine needs to be maintained thoroughly every week. There can be a division like basic maintenance to all of the machines, but one machine per week gets a deeper maintenance. List of the machines is kept for example on the notice board, so that all the workers are able to keep track on what is going on with each machine and if the worker who is supposed to do the maintenance is absent, another worker replaces him/her. Workers in Digipaino have to have overlapping knowledge and skills, so if one is absent, the other one can still perform the task.

Drying takes time, unless the printer is slow enough that the ink dries already during the printing process. If not, then the printout is laid on a table surface to dry. The table surface is kept clean and the arrangement of the work area has do be designed in a way that it is simple and easy to work. It should be also simple to keep places tidy and clean. During drying, the worker is able to prepare the next step. KAPA board is meas-

ured and cut ready for the banner or the eyeleting equipment is set up. When the banner does not need any special finishing, it will be cut clean and packed for the customer.

It is important to inform the customer about the file standards of Digipaino. On Digipaino's website customer should be able to find answers to all the questions he/she has. There is always a possibility to call to Digipaino and ask more questions if necessary. However, incoming phone calls should not disturb working, so it is better if the lab engineer answers customer calls. He also knows all the answers to the questions that a trainee does not know. That way customer service is smoother and there is no need for the trainee to pass the client over to lab engineer when things get difficult. Many handovers during one process generates defects. [5,57]

4.3.7 Poster workflow

Current situation:
Poster's workflow diagram is illustrated in appendix 25 and its trajectory is marked in appendix 26. Poster files are first opened and checked in the reception computer of Digipaino. The accepted files are transferred onto a USB memory stick and moved to a computer that has the RIP software, which operates with the printer used in poster printing, in this case Epson SureColor T3000. The printer is checked and prepared. In most of the cases the paper does not need changing, because there is one type of paper that is the cheapest production paper for that machine and if possible, posters are printed on that material. The machine has to be switched on every time the process starts. It even happens that when there is a longer gap between switching the machine on and printing, the machine goes into sleeping mode. Then the machine has to be waken up and the process can continue. Before printing nozzle check is done, unless it has not been performed earlier in the day.

The file is imported to Mirage RIP software. That is simple – the file can be dragged and dropped onto the Mirage window. When there is a problem with the file, for example fonts are not embedded to the file, the Mirage RIP software informs about it immediately. Updating the software and adjusting the settings can solve software issues. File problems are solved in the main computer and brought back to the computer where the Mirage RIP is. This causes a lot of unnecessary movement and the file can have many versions that are difficult to distinguish from each other. Depending on the worker, the

file naming might have some logic in it that helps to understand which fixed version it is, but in most of the cases only the worker who is carrying out the file fixing knows what he/she is doing to which file.

In Mirage RIP software print settings are adjusted and the file is printed. Before that, a correct paper profile has to be chosen from a dropdown list. Names of the papers in the machine differ from the names on the paper profile list. Sometimes the name on the paper package is totally different. Sometimes workers mark on the package the paper name used in the printer as illustrated in figure 9. The worker has to rely on his/her memory, unless he/she has jotted it down on a piece of scrap paper or a post-it note. Different names cause mistakes. Sometimes the profile errors are not even noticed.

Figure 9. Paper packages with paper information written on them by Digipaino's workers.

Print settings are adjusted and the file is printed. Even if it is made sure before printing phase that file is ready for print, in big orders it is sensible to make first one printout and ensure that machine problems do not exist. When there is an unfixable machine problem, the worker informs the lab manager who contacts the maintenance. If the printout is fine, it will be left to dry. Stripes appear on the printout if the printing has been too fast. In that case print settings are changed and the printer is set to print slower. If there is a problem in the file, it is fixed in Digipaino. In case the file is unfixable, the customer is contacted. When the printer is causing a problem that is not typical

for the machine, workers try to solve the problem themselves. Should no solution be found, then Epson maintenance is contacted.

Depending on customer's wishes, the dried poster can be attached to a KAPA board, in which case the KAPA board is cut and the poster is applied to the sticky surface of the KAPA. When the poster is attached, the edges are cut clean. In the situations where posters do not need to be attached to KAPA, the posters are cut clean after drying. It is easier and less time consuming to cut posters with Wohlenberg guillotine, but that requires to have a number of posters, lets say more than ten.

Proposal:
When a standardised file reaches the reception it will go through preflight software, where the worker makes sure that file is acceptable for print. If the file is not acceptable, the customer is contacted to send a new file. If the changes are made in Digipaino, the price is higher, because file fixing is considered as an additional service. A standardised and preflighted file does not cause delays or stoppages in production. The workflow is smooth and the flow efficiency is maximised. A poster's lean workflow is visible in appendix 27.

A connection has to be created between the main computer and the computer where Mirage RIP is to avoid using the USB stick. For example, the computers could share the same hard drive, so that when something is dropped to a "Print" folder in the main computer, the file is found also from RIP computer's "Print" folder. Print folder is situated on the desktop, where it is easily accessed. The RIP computer should be considered as a RIP computer, it should not be used for any other reason. On the so-called RIP computer there are other licenced software and plug-ins that are needed for other machines, like cutters Summa and Graphtec Cutting Pro. Cutters' software should be operated from a third computer, which eliminates the fact that if something happens to the RIP computer, half of Digipaino's equipment cannot be used. Dividing programmes between computers gives a chance for many workers to work on different tasks simultaneously. That is needed in case Digipaino plans to expand to competitive market and gets more orders or if more workers are hired.

In the finishing phase, the posters are cut clean either by hand or, if there are several with Wohlenberg guillotine. Cutting process can be made leaner when the Mirage software is adjusted so that the printer cuts both the front and back end of the printout

clean. This way cutting process is made faster. When the poster needs to be attached to KAPA board, the process of cutting KAPA can be eliminated by having pre-cut KAPA boards in storage. The client is informed beforehand about the standardised KAPA sizes that can be ordered from Digipaino.

5 Discussion and recommendations

Proper planning has do be done before lean production can be implemented. [18,53] Planning helps to apply lean methods smoothly to the production and to identify problems that might not be known before. Building process maps and making workstation plans are a good way to start the change. It has to be noted that applying happens while production is running. It is not possible to shut the company down for making the changes. On the other hand, implementing lean during production shows immediately mistakes and helps to make adjustments as soon as problems occur. Implementing lean methods in Digipaino is going to be easy because production is relatively small and the number of workers is also small. [1,433-345]

Typical production problems in Digipaino are absence of workforce, productivity/ efficiency problems, machine downtime, quality problems, poor communication and lack of raw material, just like in any other production. [1,353] In Digipaino employee involvement can be improved by teaching lean philosophy to the workers and training them properly in their work. Workers should consider themselves as one team and they should develop a sense of responsibility in their work. Workers should feel that they are part of Digipaino and that their work also represents them as individuals. [19,191] Workplace layout can be changed, in order to remove waste from production cycle. Quality control is possible if workers are trained well enough to recognize and distinguish quality problems. It is also vital to train workers to maintain machines. A weekly schedule should be planned to make it easier to remember the processes to be done in Digipaino. For example, on Fridays last two working hours are reserved for over-all machine maintenance and cleaning the work areas. Ideally, cleaning and organising the work area should be done immediately after the job with the machine is done, e.g. binding machine is cleaned from glue right after binding has finished. Standardisation of the processes is a way to set rules on how job has to be done. [19,190-197]

The management decides how broad and specialised the product line is. The greater the diversity of products, the more complex the manufacturing process becomes, and the more difficult it is to plan and control [1,341]. Standardisation of products simplifies the production. A job is always done in the same way and some of the production processes can be automated. At the moment it is not possible, because either the product's final size is different from previous one or the registration is not reliable, so it cannot be trusted. Standardisation makes it easy for the trainee to know what and how he/she has to do, and it also eliminates the need to wait for instructions. Standardisation of product range also standardises prices. [1,341]

Quality control can be applied in Digipaino by training and developing the skills of the workforce. All processes have to be stable and capable of meeting customer's needs. [8,59] Problem solving cannot create more work. [8,60] In ideal, there should not be situations where machines are not functioning well enough to produce such products that do not meet the quality requirements. If quality problems still exist, a proper investigation has to be made and the problem must be solved. Lean is a dynamic state characterized by constant improvement. So, it is normal to face problems, but the idea is to overcome them. Each product should flow through the system smoothly. [5,149] Stoppages lead to stockpiling and therefore to waste [20].

In lean management, operators and machinery must be flexible, and the system must be configured to be changed over quickly from one product to another [1,345-345]. Small batch sizes and large product range means short production runs, which in turn means that machines must be changed over frequently. [1,341-342] It can be performed well with proper training program and standardization of work process. It is good to ask from workers what they think about the current situation and to pay attention to what they say about improvements. [18,61] Flow efficiency and resource efficiency have to go hand in hand. [5,127] Resource efficiency shows how much a resource is utilised in relation to a specific time period and how much a machine is used during work hours. [5,10] If resource efficiency is less than 100%, there is free capacity on hand in order to be able to deal with unexpected events. [5,123] Material should flow uninterruptedly from one operation to the next without any delays. Bottlenecks have to be removed from the system. [1,347] Collaboration between workers, management and customer should help reduce overhead costs and maximise effective interaction. [21] The benefits of a good-quality program are less scrap, less rework,

less inventory (inventory just in case there is a problem), better on-time production, timely deliveries, and more satisfied customers [1,346].

5.1 Staff training

Lean philosophy has to be forwarded and taught to all the members of the company in order to implement it. Lean production requires everyone in the organization to be involved, which is a custom in Japanese culture. Workers have to co-operate with each other in order to develop and exchange knowledge. Co-operation helps to solve problems that might not be possible to solve alone. Everyone in the organization must take responsibility, but if a mistake is made, no one is blamed personally. A mistake gives a possibility to learn and it should not be hidden. [7,43] A mistake means that there is a problem in the process that needs solving and solving it also improves the process and helps it to become leaner. [1,350]

The leader's roll is to teach and guide the employees. Digipaino's staff number is so small that there is no reason to divide employees into groups, but they can be considered as one group. The group leader is responsible for developing a training plan, which can be used for training the employees. Training involves teaching and coaching the workers in their jobs. Training is not meant to be full time training, because the workers should be able to manage with the tasks themselves. The leader has to be aware of what is going on in the production and support and guide the workers always when necessary. [18,63-64] A good leader should also provide conditions for new improvements. [1,350]

Each worker has a responsibility to make suggestions on how working processes could be made more efficient. For example, a worker can made a suggestion of shortening the screwdriver in order to facilitate its use in a specific work phase. These kind of small remarks can be quite significant – better tools help the workers to perform their work faster. If the entire workforce has ideas on how to improve the process, it can increase the performance of the whole production line. [9,7.] In lean terms these suggestions are called Kaizen. Kaizen is a concept of making continuous improvements in a product and process. Kaizen can be made by anyone who is related to the work process. [8,304.] Managers should listen and reward those suggesting good improvements. [22] Rewarding creates an atmosphere of approval and it thrives workers to think actively about their work and challenges for new improvements.

The leader must provide emotional safety to the workers who bring forward a new idea, which might not work in practice. Otherwise workers get the message that bringing out ideas, even if they are excellent, should be avoided at any cost. [7,38] That kind of mentality is not good for working environment. It might happen that an idea about something that needs to be improved will be kept in the knowledge of the worker only: improvement idea is not passed on. It takes a lot of time for the next worker to come up with the same solution. In the worst case the employee passes the mentality on to the following employee, and that makes it difficult to change the way workers think.

Training of the workers while implementing the new production method might be the key for surviving and it has to be taken seriously. [9,7]. Workers have to be well trained and they should not only be trained in their own jobs but cross-trained in other existing skills and problem solving techniques. [1,346] That creates variety and variety enables the worker to escape from the soul-destroying repetition of line production. [2] A group leader has a huge responsibility: it is not easy to develop a training system for workers, especially a system in which the trainee is changing during every six months. It means that the system has to be efficient and it has to include everything but not too much at the same time. Probably it would be best to standardize every process and teach the trainee those standardized working processes. When the trainee has acquired those skills, new and deeper knowledge can be taught. Basic training has to be carried out immediately and after one or two months advanced training can be carried out. The reason for two different levels of training comes from the fact that learning takes time. It is known that people experience tension when they sense a gap between the current reality and the ideal state that is why it is better to keep the standards realistic for a trainee. [7,33] After trainee has been working for a while, he/she starts to have questions and feels the need to develop further. The group leader has to be around all the time and also an active member of the work group, because he/she is the one who checks if the standards are maintained. [18,63-68]

5.2 Improving communication

Checklist for works received has to be made in order to get required information immediately. It would help communication between Digipaino's staff members, if there was a system to track the job's current state. For example, a kanban system can be used for marking the job, amount, stage, situation, etc. [8,68] Common rules must be set for file

naming. Preflight software can be used so that files could be standardised and errors found before files reach the production stage. Digipaino could consider hiring a trainee for prepress purposes. It would remove file problems that cause stoppages in production. A prepress trainee's position is a good chance for a student to get acquainted with print production and the problems that are caused by files. An alternative idea is to instruct the customers on preparing files for print.

5.2.1 Website

Digipaino has a website, but it is not in proper use. There is a plan to make a new website instead of the existing one. Screenshot of the current website is visualised in figure 10 and as can be seen, the website is not informative. For example, it is not mentioned where Digipaino locates or not even how to make orders.

Figure 10. Digipaino's website under construction. [23]

The website should have a price list for simple jobs, in case that is in accordance with Metropolia UAS regulations. If not, then the price list should be in Digipaino, so that a worker can answer price related questions without waiting for the lab engineer to be around. The site should also have directions to Digipaino and how to find the door that has the doorbell. It is also good to have opening hours on the website. The most im-

portant information on the site has to be the instructions of files and in which format they have to be delivered to Digipaino. For example Erweko Oy has instructions on their website as seen in figure 11 and so does Kopijyvä Oy, illustrated in figure 5. Instructions guide the customer step by step in file creating process and ideally, it ensures that files that reach the reception are already standardized. In addition, this lowers the chance of file errors and reduces waste. Unfortunately file creating in a proper way is not a skill that everybody has, so money has to be invested in preflight software.

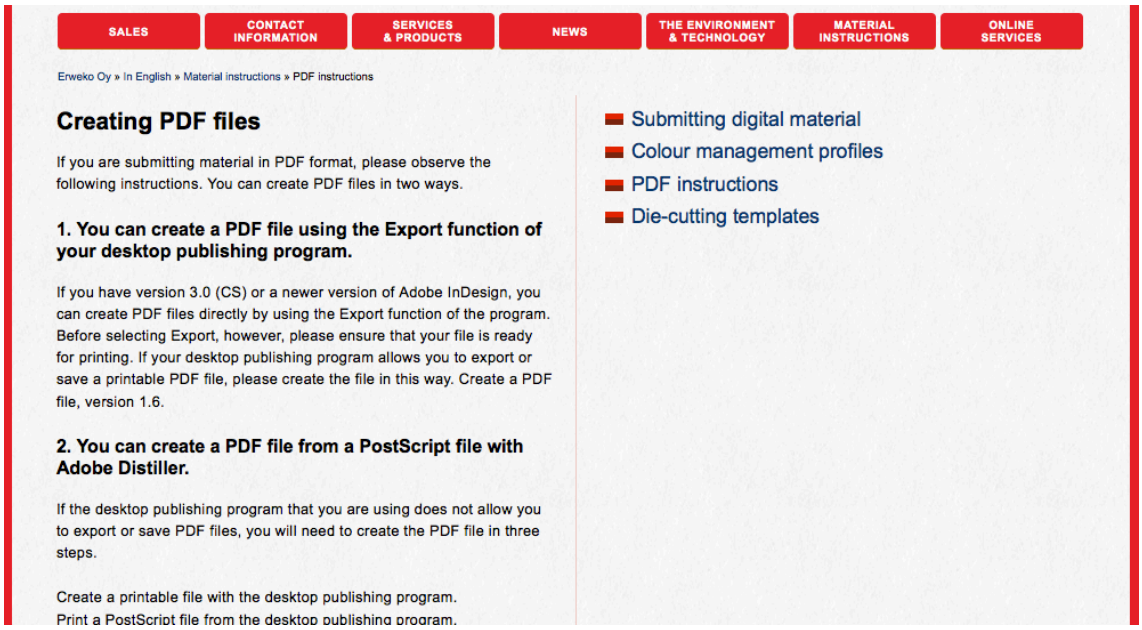

Figure 11. PDF creating instructions on Erweko Oy's website. [24]

The website has to contain information that has relevant and informative information for customer. On the website there must be a list of product types that Digipaino produces, information about job sizes, materials, etc. The customer should be able to find answers to his or her questions from the site. That removes some of unnecessary emails and phone calls, not to mention visits to Digipaino, which require worker's attention and disturb the work in progress. The website has to be updated regularly.

5.3 Waste reduction

Different workflows contain various forms of waste. There are seven types of waste: transportation, waiting, overproduction, defective parts, inventory, movement and excess processing. [8,25] Recommendations on how to tackle waste in Digipaino in accordance with lean philosophy are introduced below.

The transportation waste can be addressed by changing the layout of Digipaino. When the materials and equipment are close to each other, there is no need to transport material out from the storage and back to the storage. Jobs should be done immediately from start to finish, which removes the need for a buffer storage and again the transportation between storage and machine. Of course, the layout can still change even after applying a new layout, because lean is a constantly changing process.

Waiting time extends the time when the client receives the product. Each task should be dealt with as soon as they appear. [8,62] Unless the waiting is caused by mail delivery time, which cannot be regulated by Digipaino, the waiting is a serious form of waste and has to be removed from Digipaino. Waiting means that workers are not working for whatever reason. If the reason lies in machines, for example a machine is waiting for outside maintenance, a worker can start doing the next job. If there are no jobs at all, the worker should use time in cleaning the workspace, answer emails or find some other useful activity. Coffee breaks are not considered as part of work, so it should be done during predefined breaks or on worker's spare time. At the moment the guideline for break is 15 minutes for a coffee break and 30 minutes for lunch. If there is not enough work to be done during work hours, maybe it is better to shorten workdays, or make an organized program for the workers which tells what they can do with the "free time" during working hours. The group leader is responsible to maintain the order and guide the workers in their work. The solution for reducing excessive free time during working hours is to decrease opportunity cost, that is, the loss made by not utilising resources to the fullest. [5,11] Digipaino should make itself visible on the commercial market in order to get more orders and be able to keep the machines, as well as its workforce working. Sometimes waiting time is part of the process; in such case it is value adding. For example, a wide format printouts dry before they can be cut. Without drying time the ink surface might get damaged and instead of saving time, correcting defective products would take up further time. [8,24]

Superfluous work, defined as work devoted to taking care of secondary needs, is also a form of waste. Secondary needs are needs that we think are adding value but in reality they are not. For example chatting with a client can be categorized as superfluous work. Giving information about the product and having a job related discussion is part of work, but everything else, like talking about life in general is already superfluous work, because it is not adding value from product's point of view. [8,59] Good customer

service, on the other hand, is one of the features on which client makes the decision to place an order. To keep a good level in customer service and at the same time run a lean production based Digipaino, a sales personnel has to be hired. That of course raises expenses, but it will eliminate the situations where production workers have to solve customer related problems instead of filling orders and keeping production running. Sales personnel could also be in charge of registering all the incoming work.

Another type of waste is defective parts. In the case of Digipaino this refers to defective end products. Faults can be reduced when the machines are working properly. This requires a skilful workforce who knows how to do things correctly immediately. Quality at the source means doing things right the first time and, if something goes go wrong, stopping the process and fixing it [1,346]. A mistake should never reach the customer. [8,74]

Overproduction stands for products that are made too early and cannot be sold. In Digipaino overproduction is minimal. The printing lab functions totally on pull production system. Product is produced only if an order is made. Because of that, there is no need for huge storage rooms to keep the ready-made products that are waiting for the client. So, it can be said that inventory is already minimal.

Excess processing happens from time to time, especially in customer service and in packing process. Packing is not standardised and it takes a lot of time for the worker to think which is the best way to pack the product. Too much time and effort is put into making a custom sized package. To solve the problem there should be a wider variety of packages and packing materials. Standardisation makes the process faster and similar packing forms a positive image about Digipaino to the customers.

All the movement that is not value adding is waste and has to be removed from workflow. When workers are walking around and not staying at their workstation, it indicates that there is a problem caused by work design and workstation design. In Digipaino there is always going to be movement, because a worker is basically performing the tasks alone, and has to be able to move away from one workstation to another. The work area can be designed according to lean principles to reduce the need of unnecessary movements.

5.4 New layout

Production layout is restricted by print shop's past history. This has to be taken into account when planning a new layout. [19,197] Lean production environment requires a good planning and a proper control system. [1,361] Standardization of the work area helps to create a well-organized work environment. Well-organized workplace reduces the situations where time has to be spent on looking for what you need. [5,143] Every workstation has to have proper tools and those tools cannot be moved and used in some other workstation. If there are not enough tools to have every workstation provided, an investment has to be made. Moving tools around the shop floor will cause the situation where tools are missing. The workstation has to be designed as simple as possible. In ideal, any other printer may enter Digipaino and be able to work in lean environment without any guidance.

New layout of Digipaino aims to follow the lean principles. The suggested layout is seen in appendix 28. It is important to note that the plan is laid by trying to use as little financial resources as possible. In case it becomes evident that some workstation needs better equipment it is good to invest in it. The new layout is changed until it feels that the machines and tables are in the best position in order to reach the best possible workflow for Digipaino. After all, lean is a dynamic state.

New layout can be divided into four work areas, as seen in appendix 29: basic work area, ink-jet area, student area and classroom area. The idea is to simplify workflows and optimize material flow. [19,197]

Basic work area, marked with green colour, contains the electrophotographic printer Ricoh Pro C751 and finishing units: Wohlenberg MCS-2TV guillotine, Morgana DocuMaster Pro and Digifold, Horizon perfect binder BQ-270, wire binding unit, Graphtec Cutting Pro and a clamshell heat press. Workflows are illustrated in appendix 30.

Ink-jet area is marked with blue colour and it aims to gather ink-jets and their needed materials onto same location. All the Epson printers are operated from the same computer as well as Summa cutter.

The third area, a classroom area, is in the old storage, and the area is marked with red colour. Classroom area contains all the small machines that are not used in production,

but during lab lessons. Machines are on top of cupboards that can contain equipment or materials that are used for study purposes as well as the shelf-structure that stores study related material.

In student area, which is marked with yellow colour in appendix 29, there are computers and a sofa set, where students can work on their own or with a group. Also courses can be held in that room – there is enough table room for 10 computers and two sets of simulators. That means small groups are able to work well in the student area. Sofa set includes a television, which can be used as a screen for classroom purposes. In case Digipaino is not too noisy, due to working printing lab machines, the sofa set can be utilised as a meeting room.

The reception desk is located in the centre of Digipaino, so that the distance to different workstations is roughly the same. The small storage room is the only storage room. It can contain special papers that are used only in rare orders. Otherwise all the materials are stored next to the machines where they are used. In places where production is still done the traditional way, a buffer storage is needed to store products that are waiting for the next production phase. [19;25] The total absence of surplus stock or labour can become a serious liability when there is even the slightest disturbance in normal processes or procedures [2]. To avoid disturbance, there should always be enough material to deliver the order, but no more. A proper stock checking system needs to be developed in order to have necessary material right on time for the order.

Visual management is easily achieved in the new layout. It is possible to survey the status of the entire production process with one glance. This way workers and managers can quickly intervene if problems arise, which reduces the risk of mistakes. [20] Inspection of work can be done in every work phase. [1,339-366]

The layout was made keeping in mind the need of machine maintenance. Now it is possible to move around the machines that need to have the possibility of being accessed from every angle. Printers, like for example most of the ink-jets, do not need access from the backside, but if there is a need, they can be moved easily – they are on frame with rolls. [1,346]

Although lean production theory suggests marking work areas with tapes and label on the floor [26,139-141], this is not recommended for Digipaino. The reason is that

Digipaino has very few employees and the aim is to keep the printing lab so easy to understand that there is no need for labeling. Also, it is better to concentrate in applying lean production and making the workflow efficient, instead of spending time on none-value adding activities, like taping the areas. The emphasis has to be on a clean, tidy and organized workplace. [5;20] A recommendation is to label the tools, such as scissors and paperknives, in order to know which tool belongs to which work area.

5.5 Plan for Digipaino

- First, Digipaino's management should make a training plan for the workers. Workers have to be taught the basics of lean production and adapt the lean philosophy. Work division has to be made. Every process has to have "an owner" in order to understand what task belongs to whom. Also work areas can have an appointed owner whose responsibility is to maintain order in the area.

- Secondly, management should make a plan on how to proceed in implementing lean, for example how much resource can be spent in applying lean, weather there are possibilities to make investments in new equipment, etc. Necessary equipment and software that improve flow efficiency and remove waste from processes have to be purchased, for example preflight software.

- Workers, as a team, have to clean the work area and they have to be involved in changing the layout according to lean principles and how it can be most sensible for workflow. Appendix 28 can be used as a starting point. Workers should be helping in organizing the new work area.

- Tools and equipment have to be marked in order to know which tool belongs to which workspace.

- Management has to coach and guide the staff even after the training period has finished. The new system needs supervising and constant maintaining. New standards and schedules have to be introduced to the staff. Schedules have to be followed and rules must be obeyed. Implementing lean is a process that takes a long time. It has to be remembered that lean is not a target, but a tool to create a good, organized workplace.

6 Conclusion

The aim of this thesis was to offer recommendations on how to implement lean production at Digipaino, the digital printing lab of Metropolia University of Applied Sciences. A thorough study was carried out while working in the printing lab for five months. Close connection to the work gave a good insight to the production and processes of Digipaino.

Lean production is a production method and philosophy mixed together and it can be achieved by reducing waste from the production cycle. For the purpose of this thesis, the current workflows for different products at Digipaino were investigated and mapped in order to distinguish waste. Analyzing the workflows, a new layout plan was made. The new layout significantly decreases waste from workflows, as is visible from new workflow schemes. This new lean layout should be used as a starting point when implementing lean in Digipaino. Furthermore, the thesis contains numerous recommendations and offers a guideline for future action.

A suggestion for further study is to follow the process of implementing lean production at Digipaino and analyze the progress. In addition, the current study can be supplemented by consulting an outside human resources specialist. Such professional could provide recommendations on how to tackle possible psychological obstacles among the staff to implementing lean philosophy.

The current thesis has significance for the client because it contains practical proposals on how to start implementing lean and to improve the work at the printing lab. This is important because it will make work more efficient and hence the company more successful. All in all, implementing lean production into a digital printing lab is a long process and the workers should not be discouraged if positive results are not achieved immediately. Changes cannot be done over night, but by making small steps and using correct methods, a company will find its way into a circle of constant improvement, that is called lean production.

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Trainee Orientation Checklist

Harjoittelijaperehdytyksen tarkistuslista | Trainee orientation checklist

Harjoittelija | trainee: .....

Aloituspvm | starting date: .....

Yleiset | General

- ❑ Työaika | Working hours
- ❑ Avaimet ja kulkuoikeudet | Keys and access rights
- ❑ Sairaspoissaolot | Sick days
- ❑ Vapaapäivät & lomat | Days off & holidays
- ❑ Työsuhde-edut & rooli |Perks & role

Toimintatavat | Procedures

- ❑ Sähköposti ja puhelin | Email and phone
- ❑ Wikin käyttö ja töiden listaus | Using Wiki and listing jobs
- ❑ Koneen valinta työlle | Choosing the correct machine for the job
- ❑ Materiaalin valinta työlle | Choosing the correct material for the job
- ❑ Työtiedostojen tallennus, siirto ja arkistointi | Saving, transferring and archiving files
- ❑ Painettujen töiden arkistointi | Archiving printed jobs
- ❑ Salasanat | Passwords

Prepress | Prepress

- ❑ Töiden esitarkistus | Job preflight
- ❑ PDF:n tekeminen | Creating PDF files
- ❑ Käyntikorttien ladonta | Business card layout
- ❑ Asemointi Indesignilla | Imposition with Indesign

Tulostaminen Ricohilla | Printing with Ricoh

- ❑ Töiden tulostaminen | Printing
- ❑ Paperialustojen käyttö | Using paper trays
- ❑ Asemointi | Imposition
- ❑ Kohdistaminen | Registering
- ❑ Jälkikäsittelyoptiot | Finishing options
- ❑ Kalibrointi ja profiilien käyttö | Calibration and profiles
- ❑ Paperiasetusten teko |Making custom papers
- ❑ Erikoisalustat| Special paper trays

Tulostaminen mustesuihkuilla | Printing with inkjets

- ❑ Töiden tulostaminen ja arkistointi | Printing and archiving jobs
- ❑ Koneiden päivittäinen käyttö ja huolto | Daily use and service of the inkjets
- ❑ Paperien käyttö ja säilytys | Using and storing papers
- ❑ Töiden monistus ja keräys | Step and repeat & nesting
- ❑ Tulosteiden leikkaus koneesta | Cutting the print out
- ❑ *Materiaaliprofiilien tekeminen| Creating ICC profiles*
- ❑ *Suurkuvien ositus| Tiling LFP prints*

Jälkikäsittely | Finishing

- ❑ Giljotiinin käyttö| Using guillotine
- ❑ Nuuttaus, taitto ja nidonta - käsin | Creasing, folding and stitching - manual
- ❑ Nuuttaus ja taitto - Morgana | Creasing and folding - Morgana
- ❑ Stiftatut tuotteet - Documaster | Stiched products - Documaster
- ❑ Liimanidotut tuotteet - Horizon | Perfect bound products - Horizon
- ❑ Wire-sidotut tuotteet | Wire binding
- ❑ *Kuvakirjat | Photo books*
- ❑ Suurkokotulosteiden leikkaus | Cutting the LFP prints
- ❑ *Suurkokotulosteiden yhdistäminen | Joining the LFP prints*
- ❑ *Teippaus ja purjerenkaat | Taping and using eyelets*
- ❑ Pakkaus ja postitus | Packaging and delivery

Kursiivilla merkityt kohdat eivät kuulu perusteisiin.
Points written in italics are not part of the basics.

Perehdytys valmis | Orientation done: .....

Allekirjoitus | Signature: .....

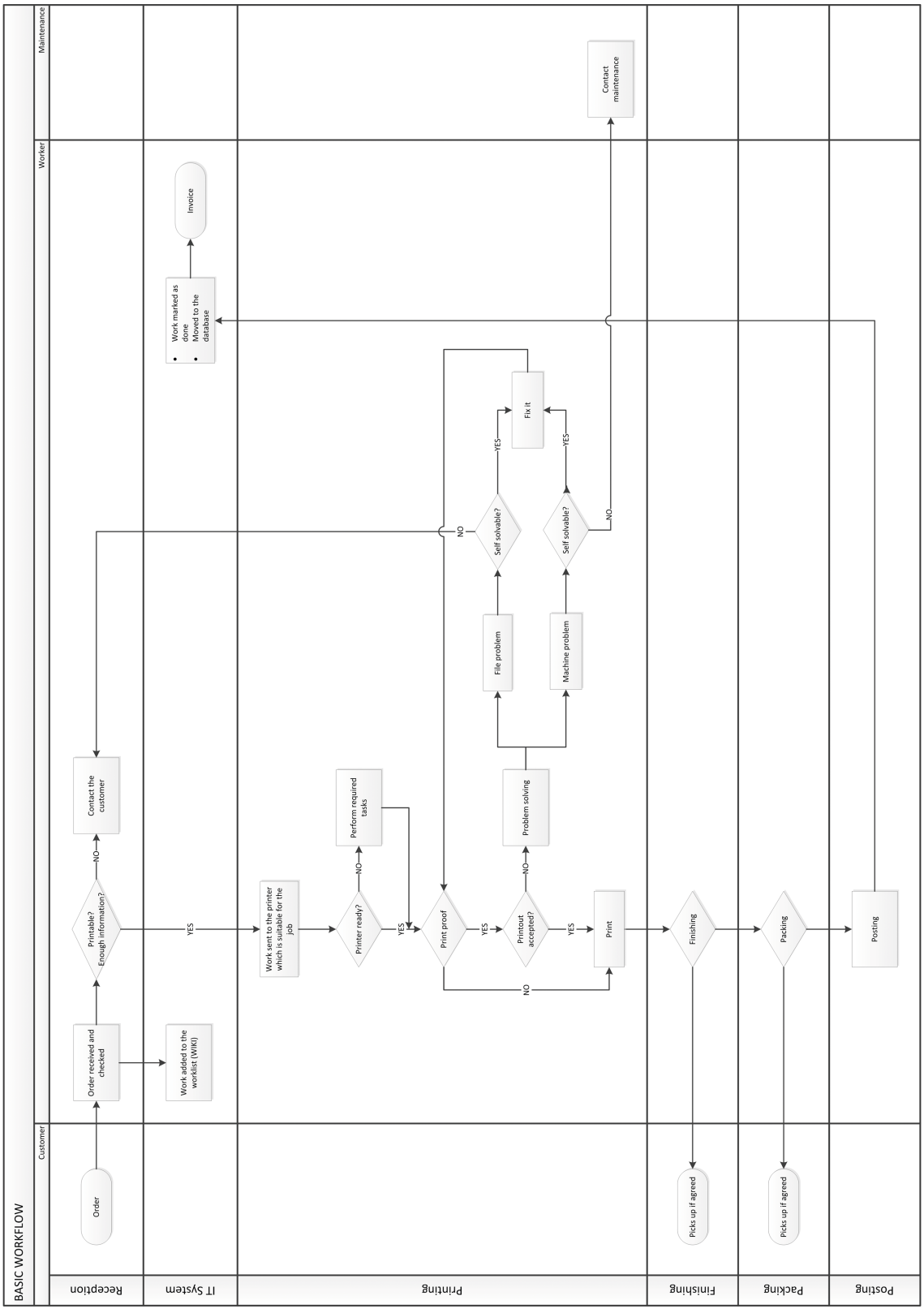
Digipaino's Floor Plan

Machines are numbered and definitions are listed in appendix 3.

List of Digipaino's Machines

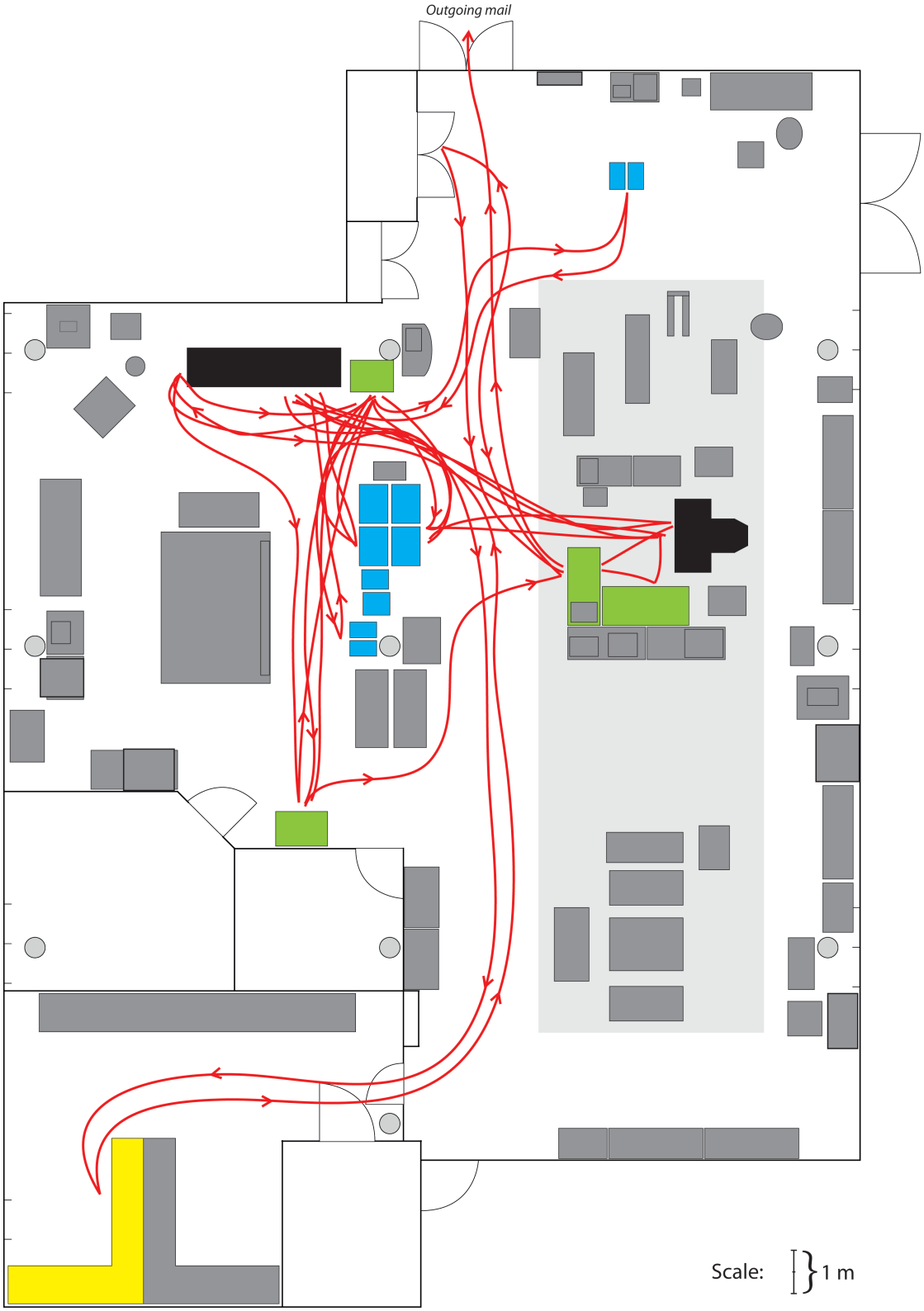
Number on appendix 2	**Machine**
1.	RENZ WBS 360 and closing bar (wire binding equipment)
2.	Horizon perfect binder BQ-270
3.	RICOH Aficio MP C2051 (copy machine)
4.	EPSON SureColor T3000 (ink-jet)
5.	RICOH Pro C751 (electrophotography)
6.	EIRI small light table
7.	Morgana Documaster Pro (greasing, folding, stapling)
8.	Morgana Digifold (folding machine)
9.	Kasfold HCS 2000 Bookletmaker
10.	Paper shredder
11.	EPSON Stylus Pro GS 6000 (ink-jet)
12.	EPSON Stylus Pro 9900 (ink-jet)
13.	EVOLUTION 310cm-124 wide format cutter
14.	EIRI big light table
15.	UCHIDA BC-10 business card cutter
16.	Wohlenberg MCS-2TV guillotine
17.	Hand guillotine
18.	Linea DH-360 (lamination machine) and Fastbind (hard cover binding machine)
19.	Clamshell heat press
20.	Gretag macbeth calibrator
21.	EPSON Stylus Pro 4900 (ink-jet)
22.	GRAPHTEC cutting pro FC 4510-60 (flatbed cutter)
23.	HP Designjet Z2100 Photo (ink-jet)
24.	Summa D60R (cutter)

Basic Workflow

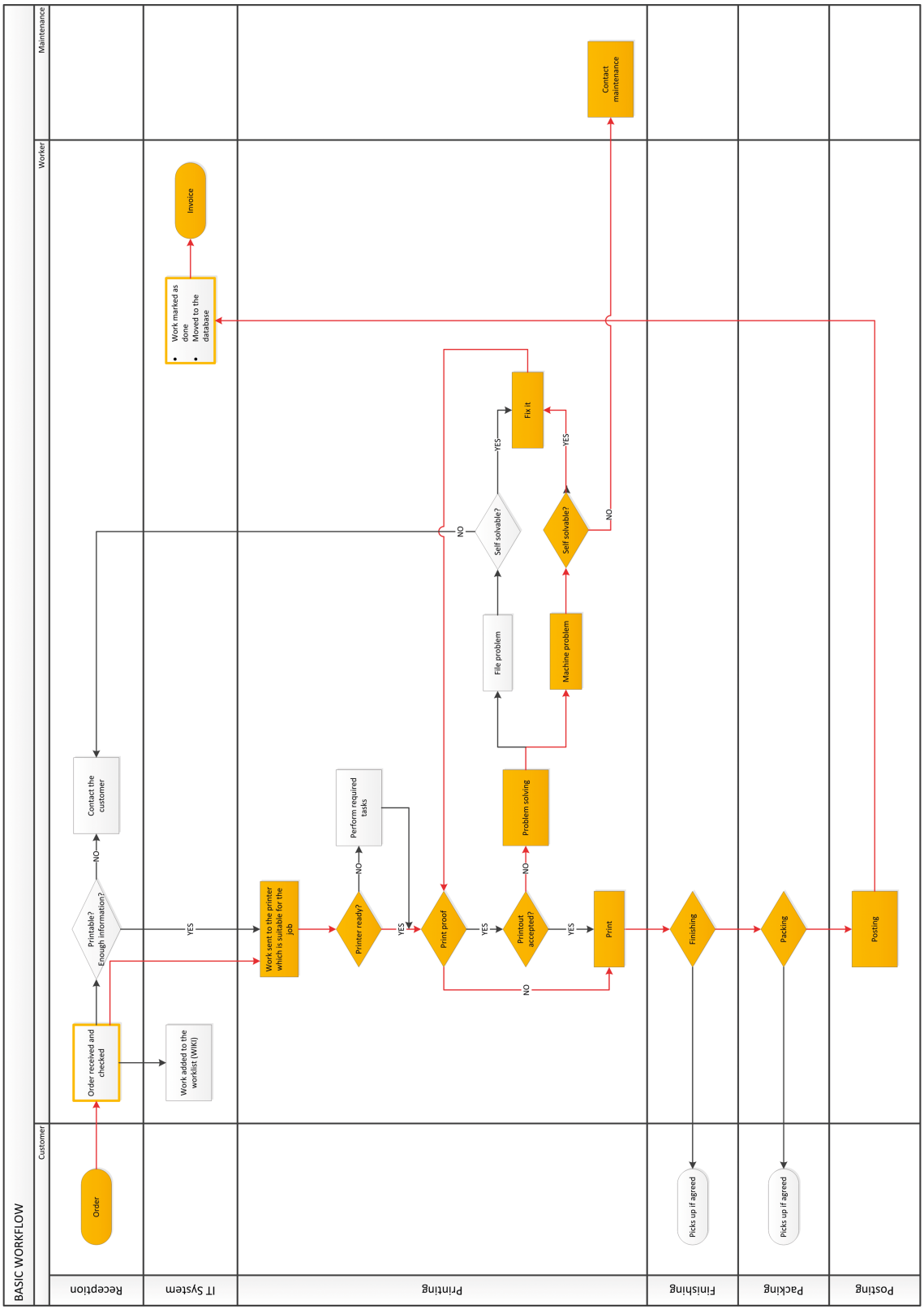


Path of Basic Workflow

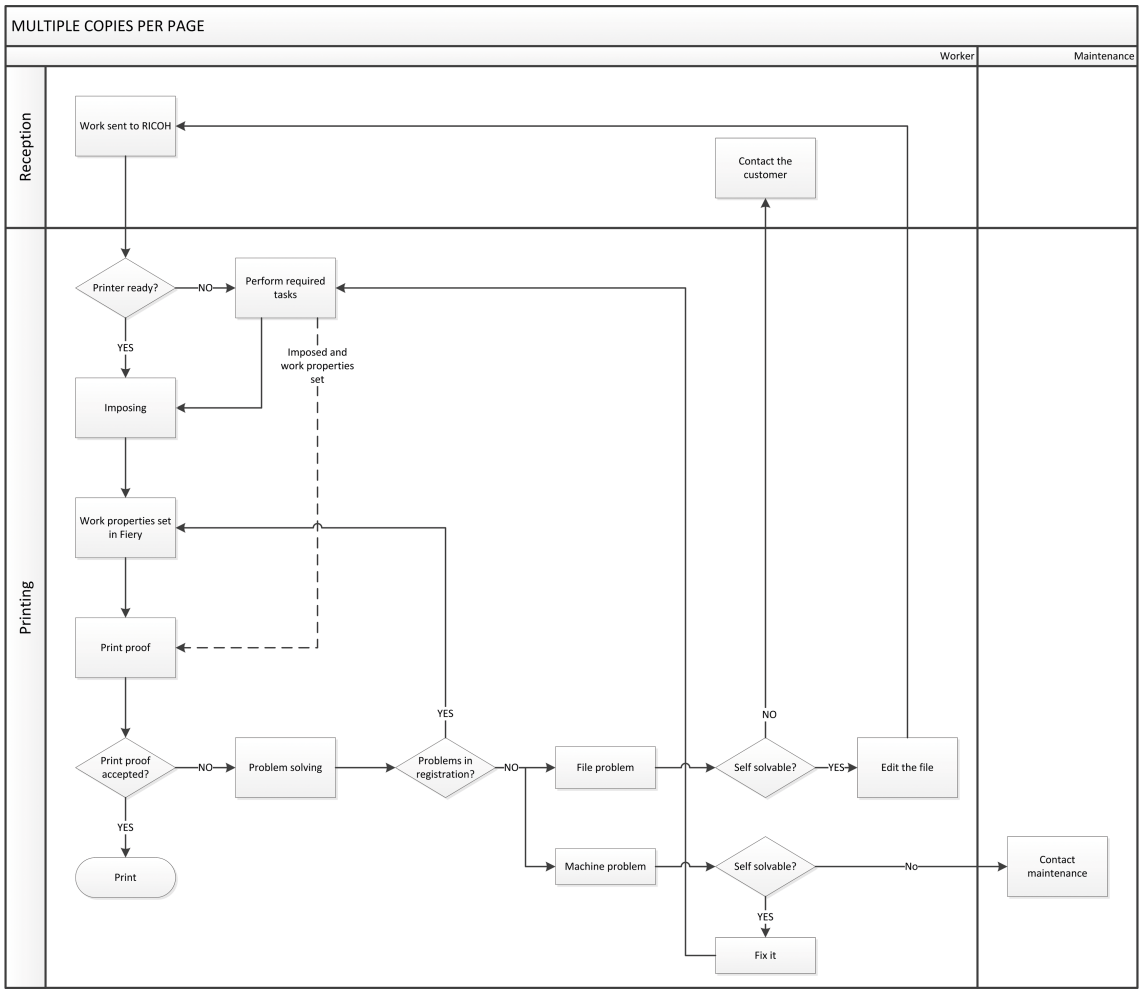
Workflow path is marked with red line.



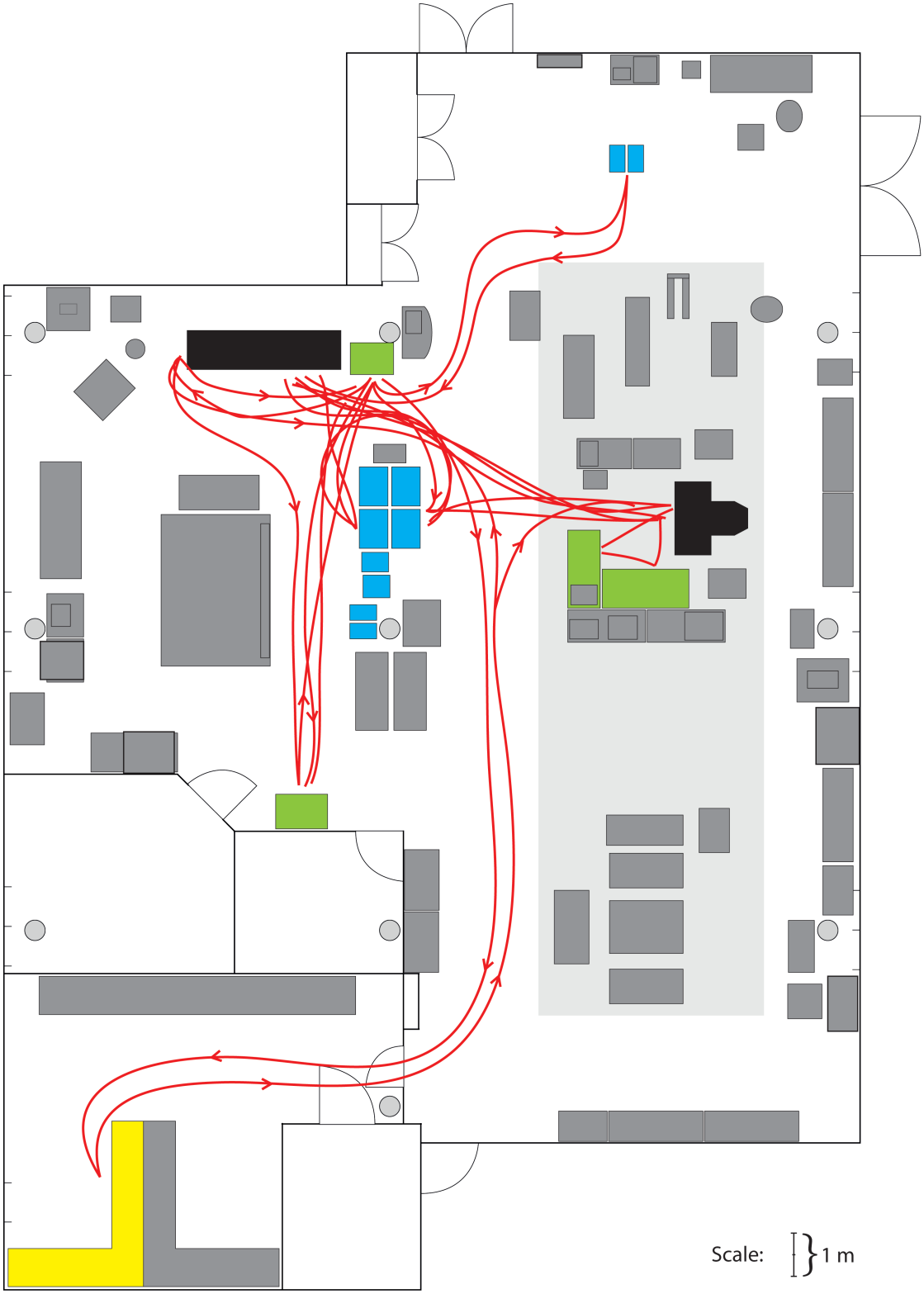
Lean Basic Workflow



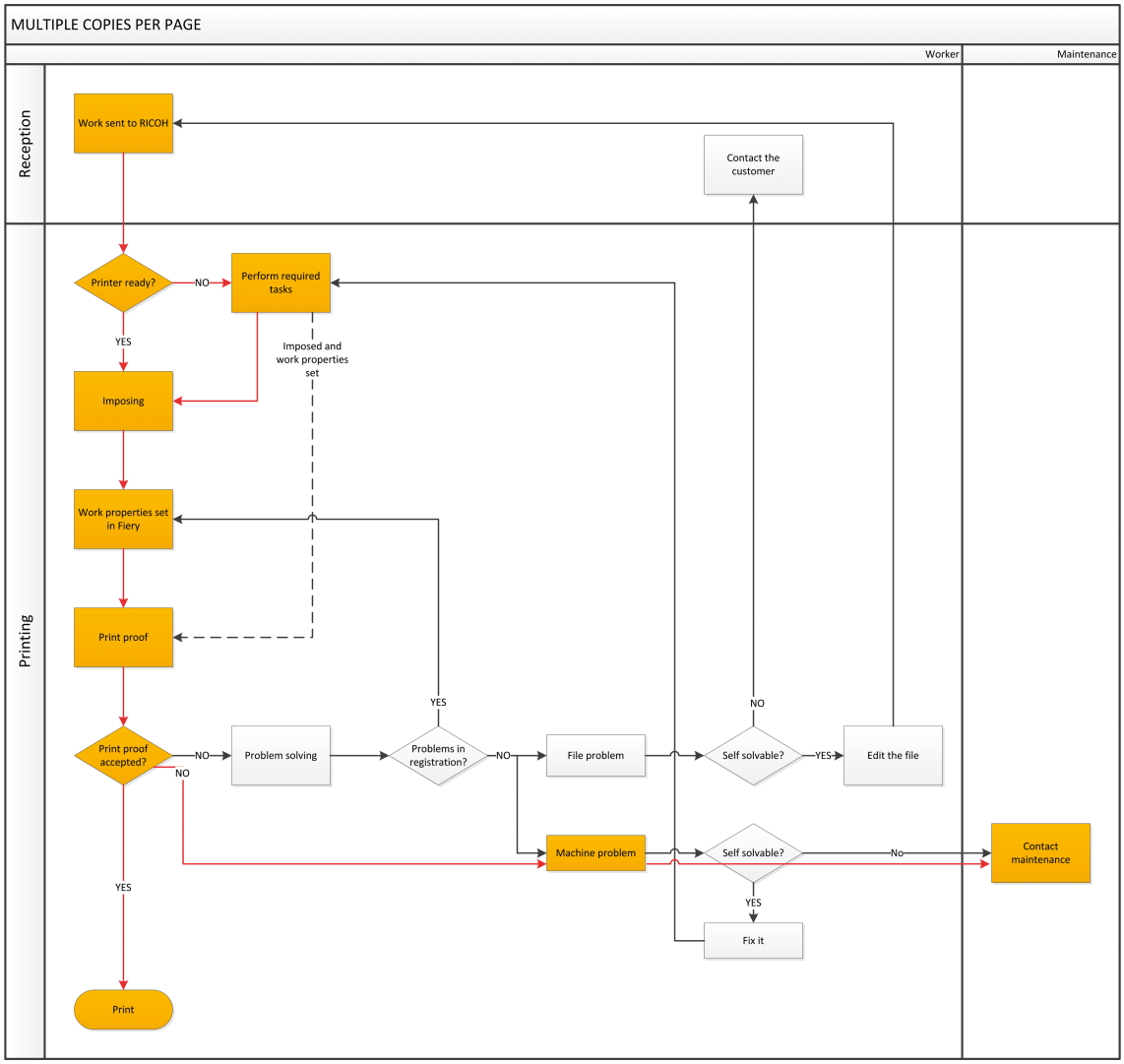
Multiple Copies per Page Workflow



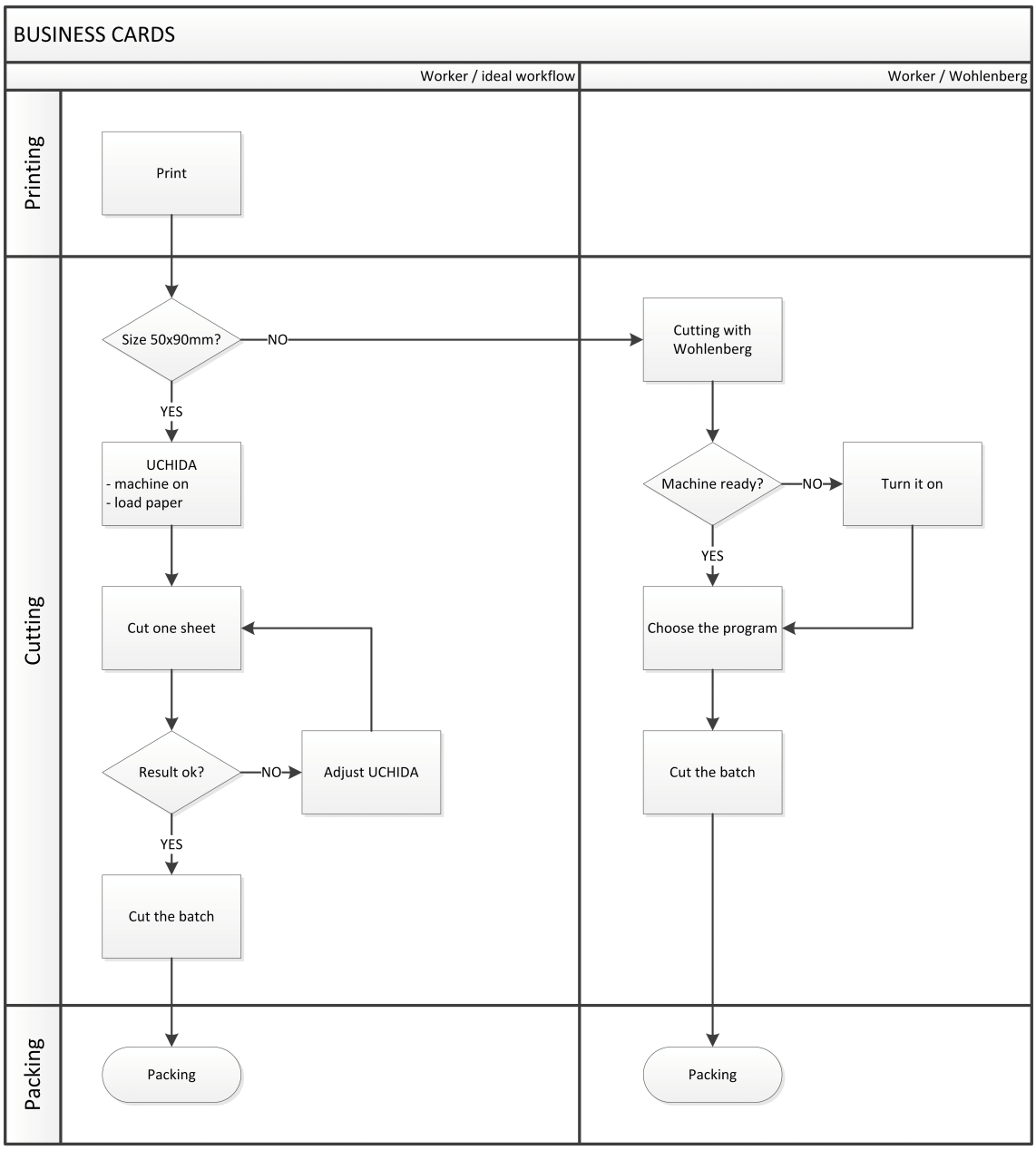
Path of Multiple Copies per Page Workflow



Lean Workflow of Multiple Copies per Page

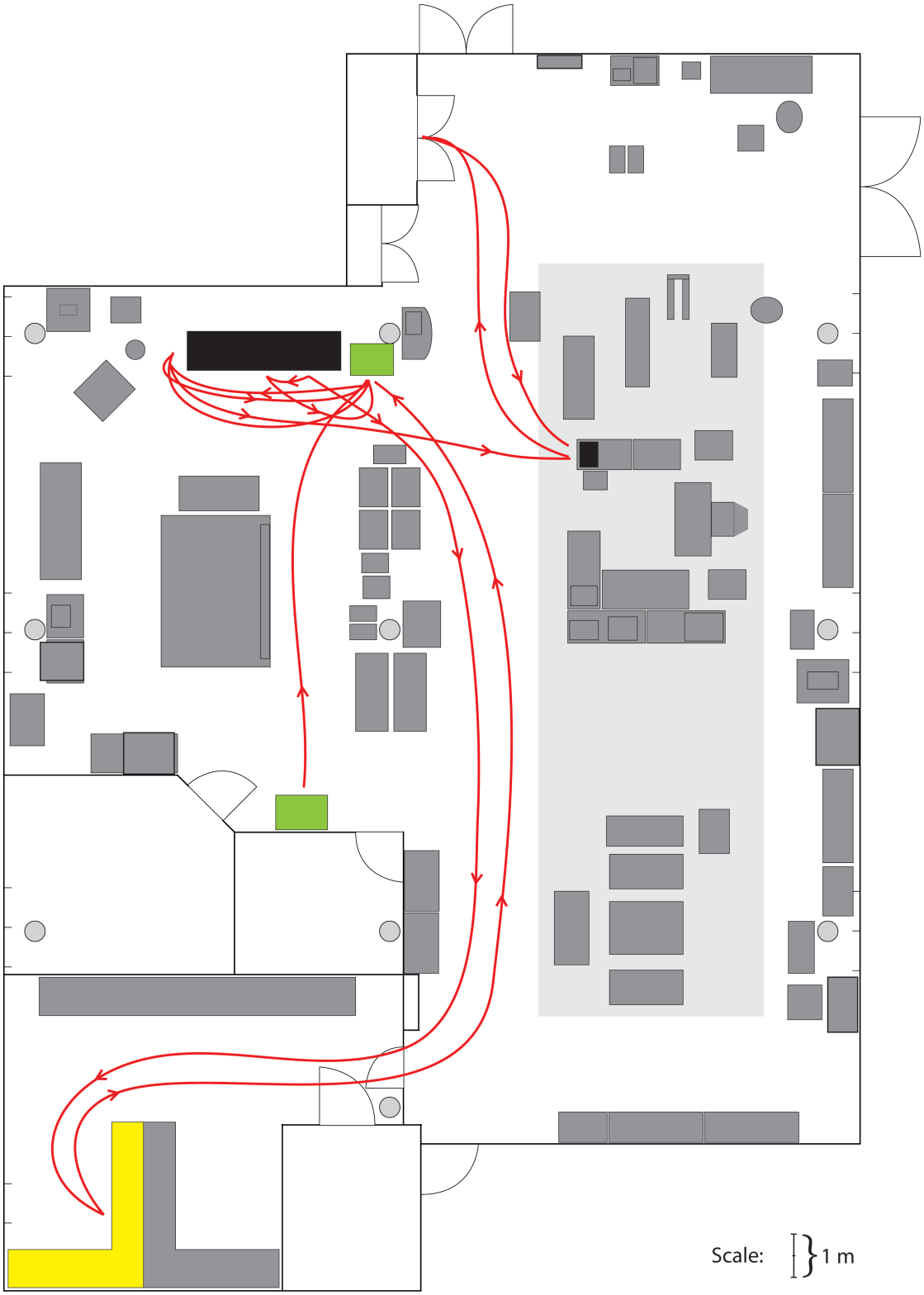


Business Card Workflow



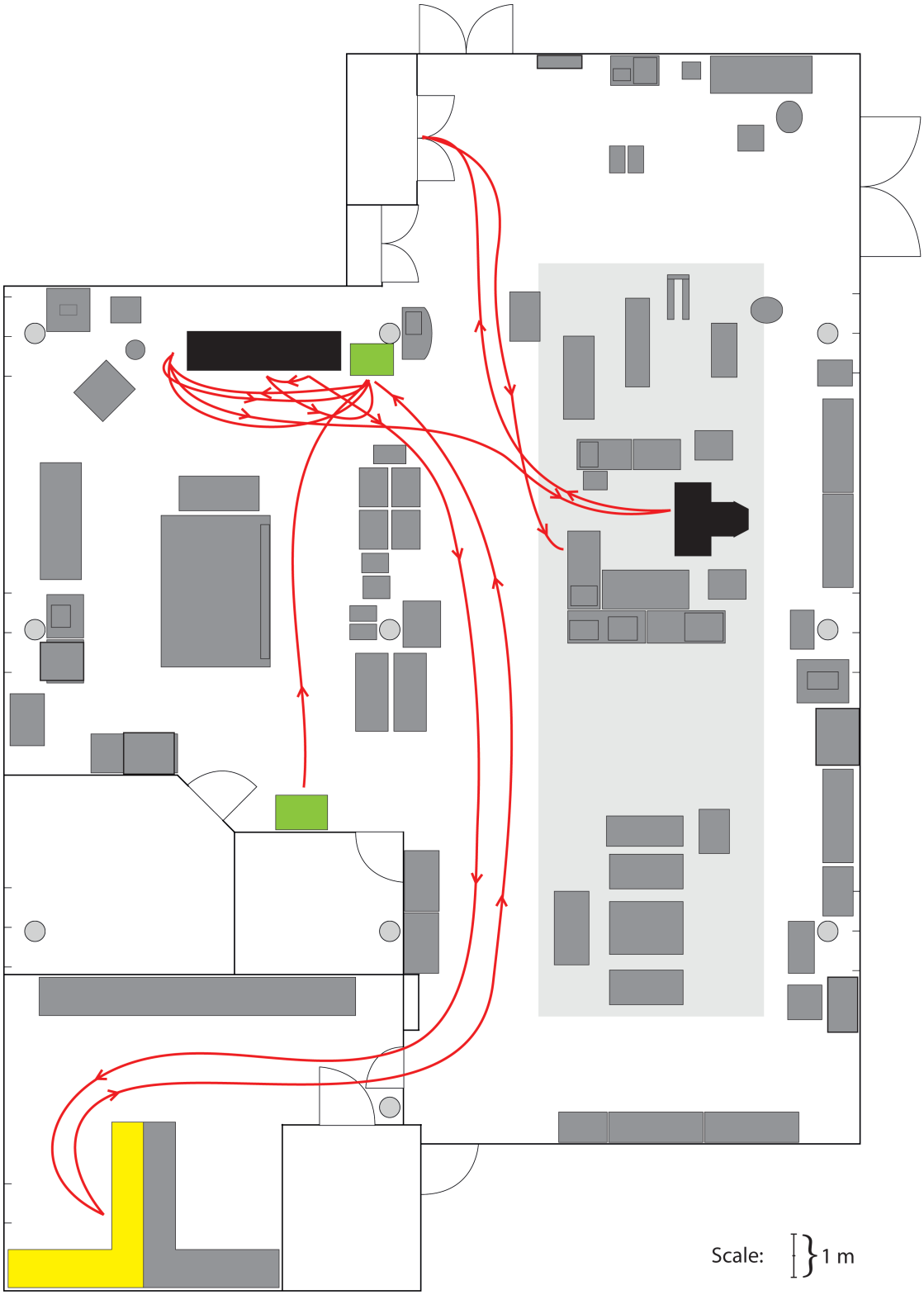
Path of Business Card Workflow

Ideal workflow.

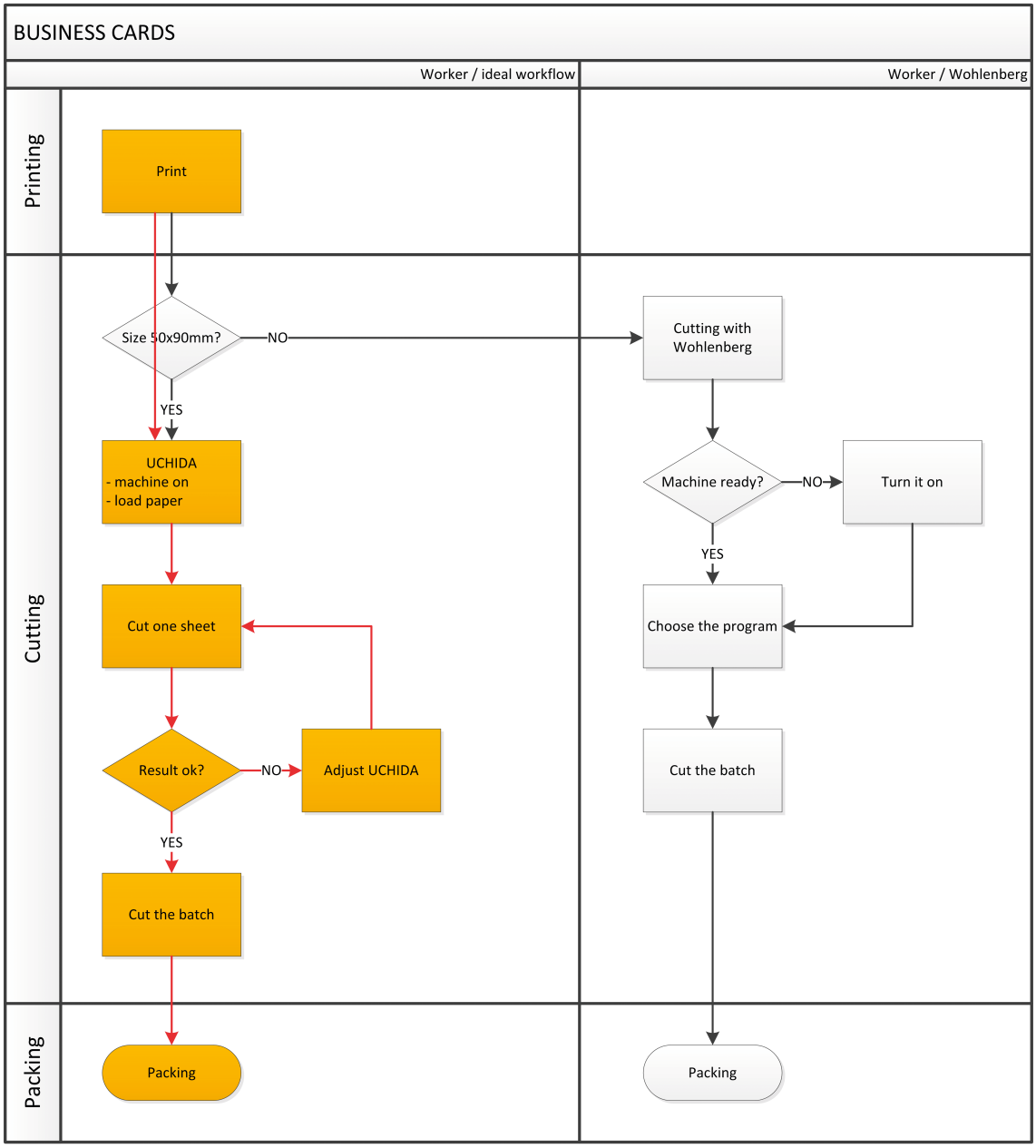


Path of Business Card Workflow

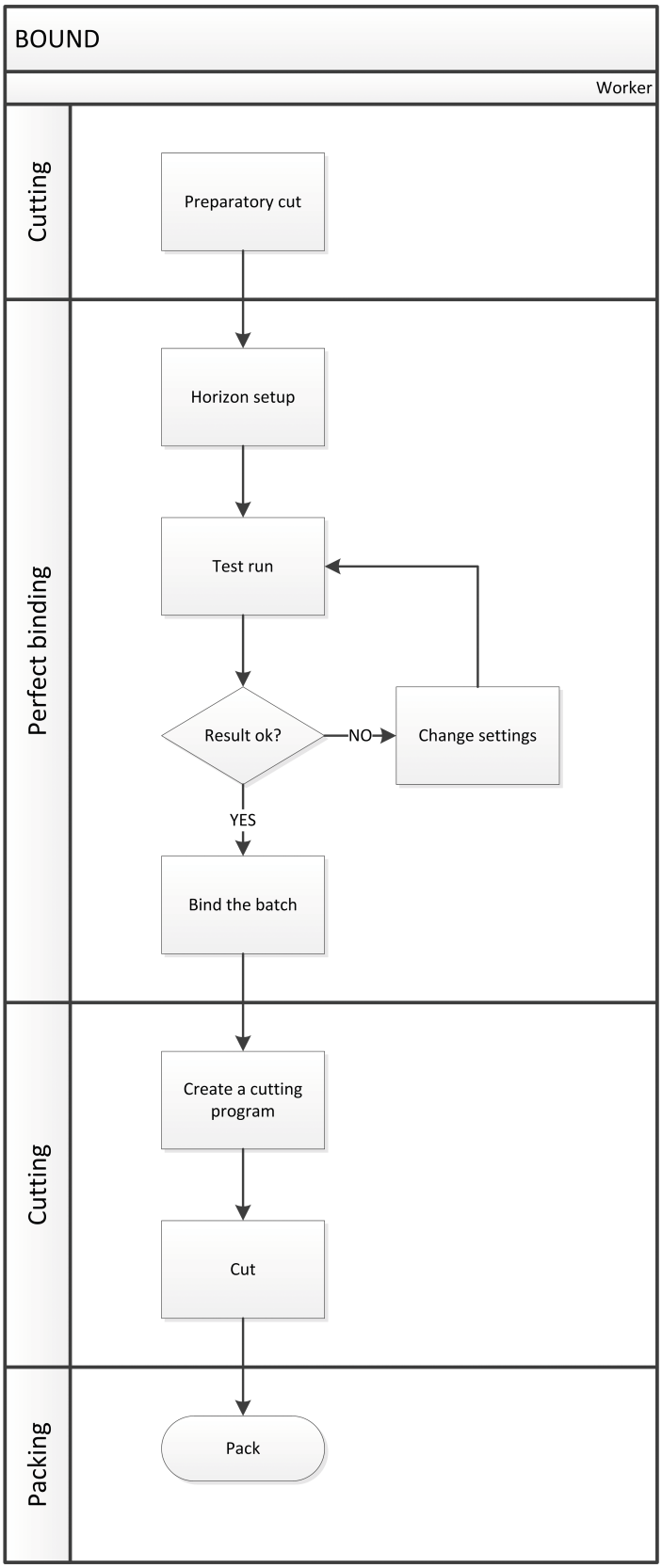
Wohlenberg workflow.



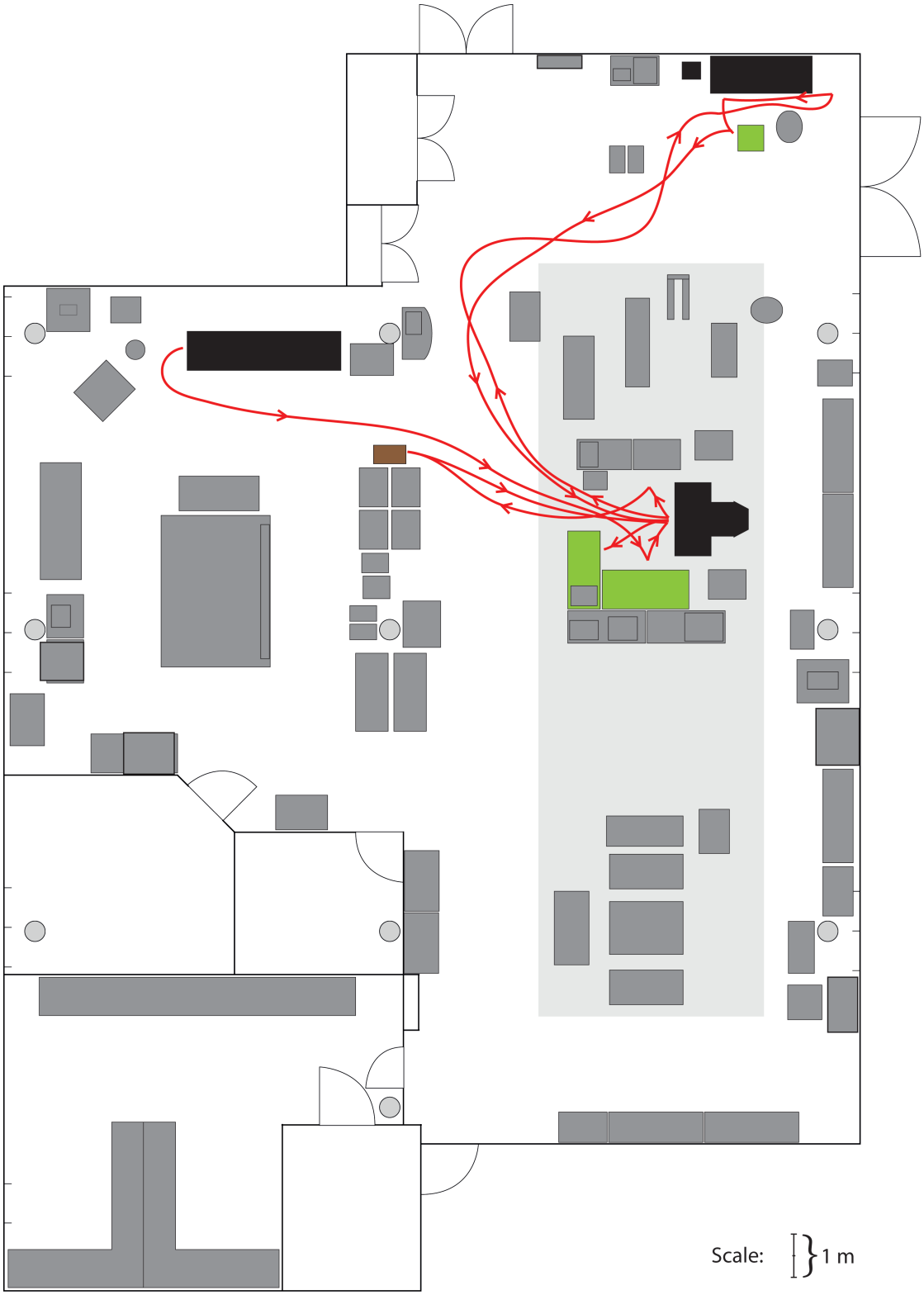
Lean Business Card Workflow



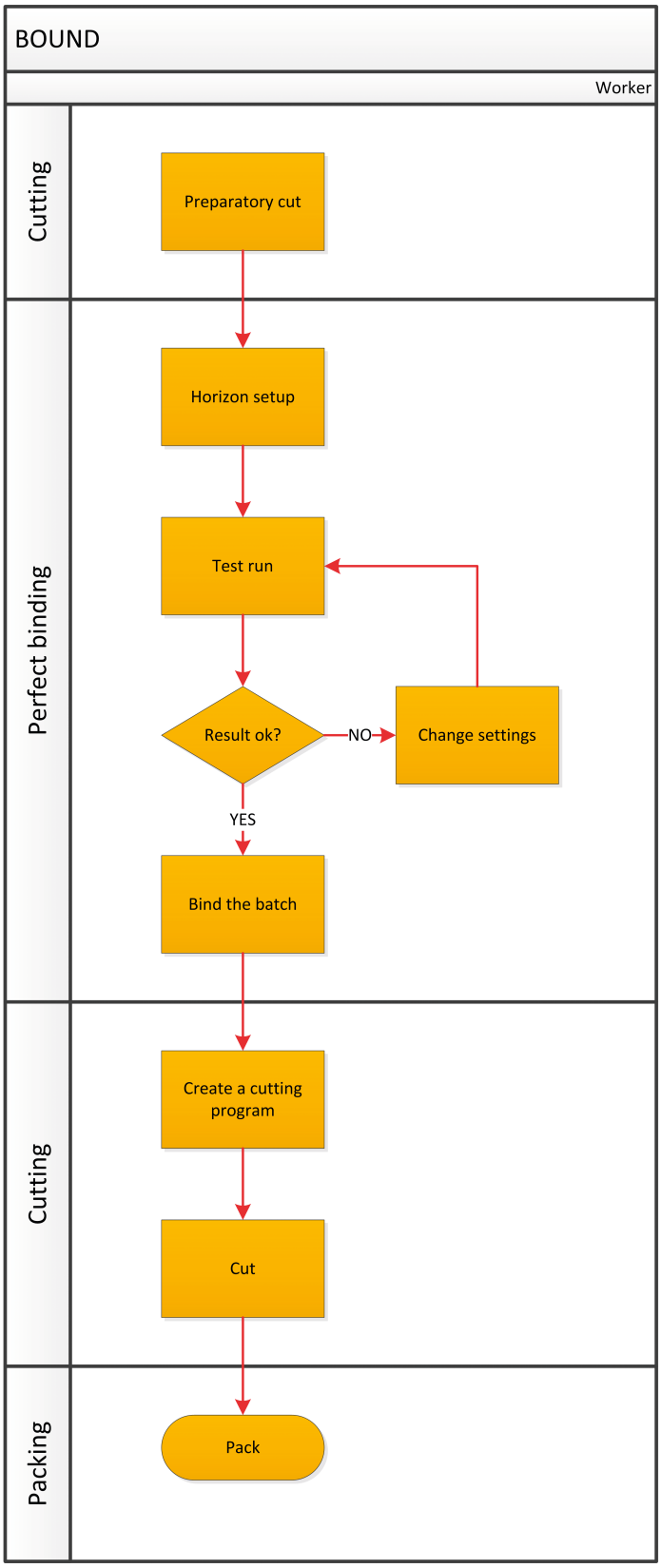
Bound Products Workflow



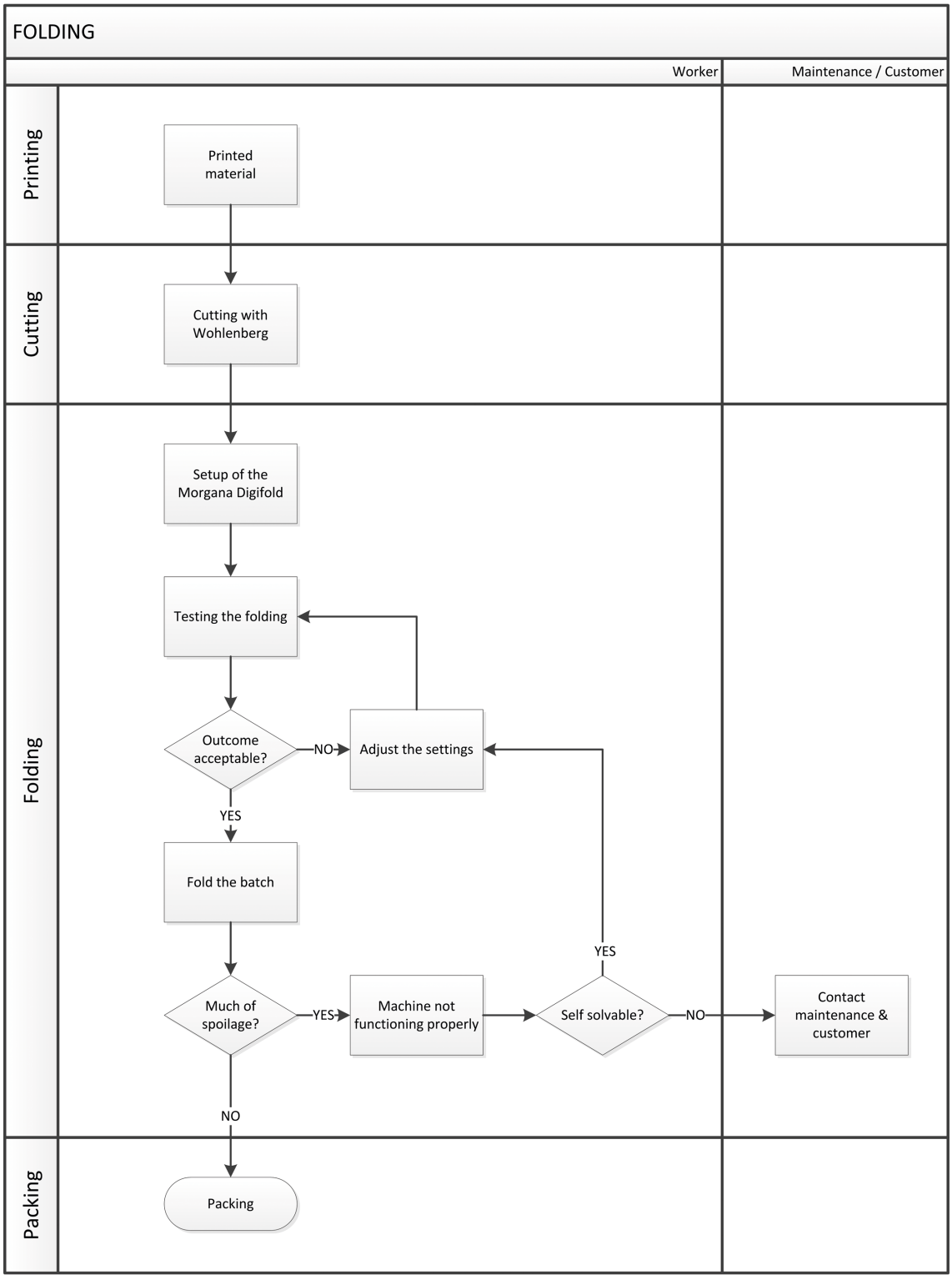
Path of Bound Products Workflow



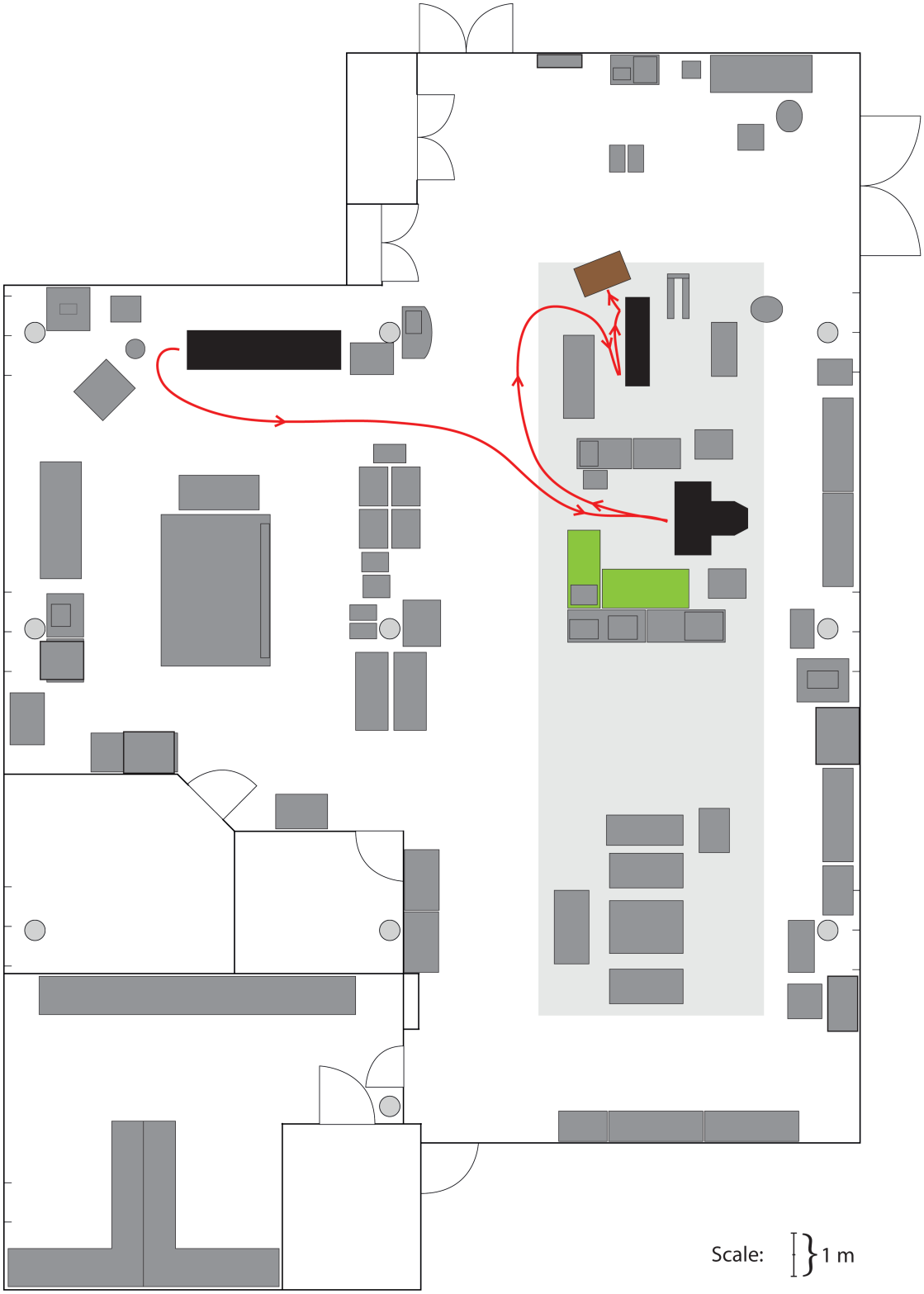
Lean Bound Products Workflow



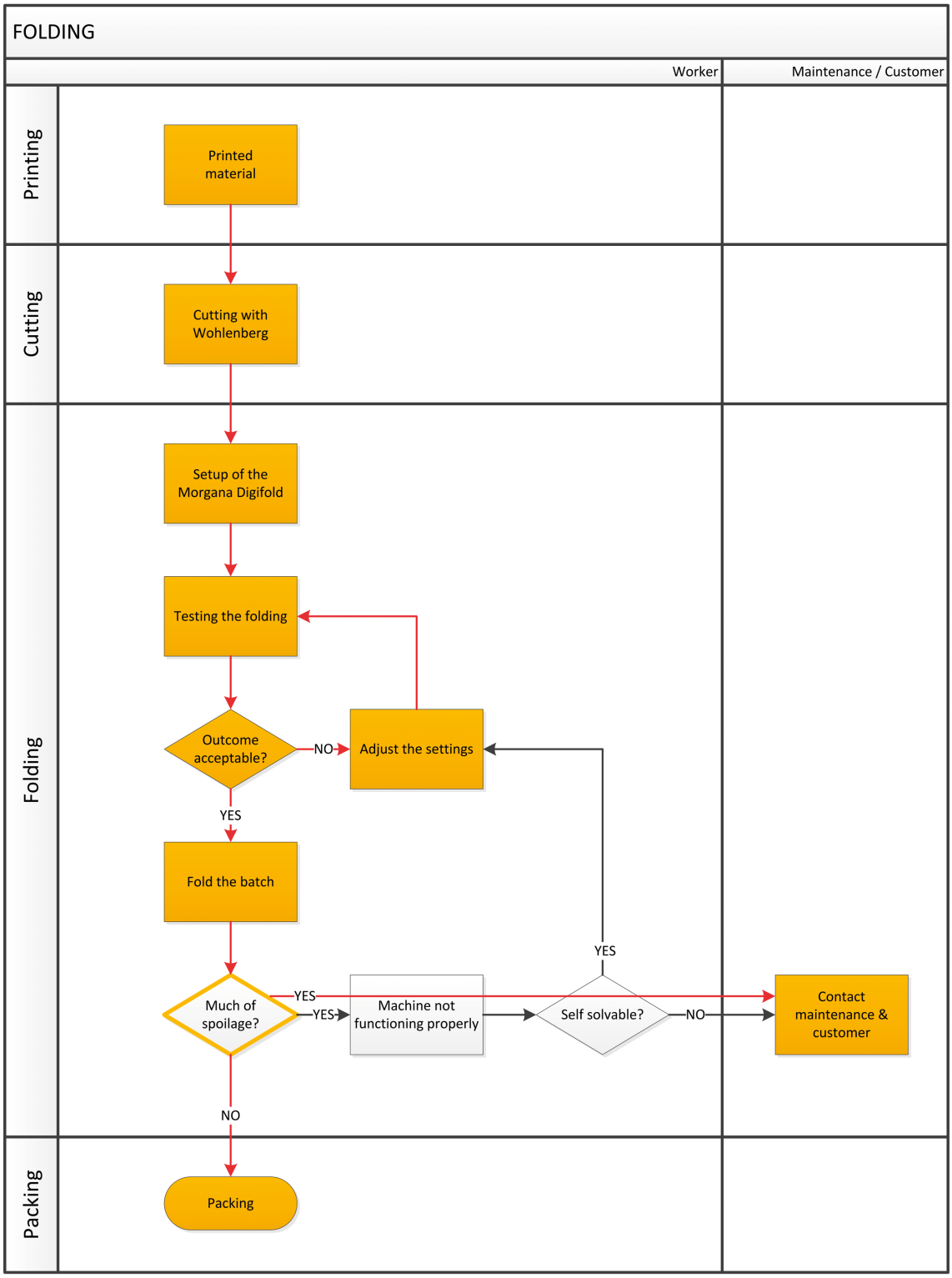
Folding Workflow



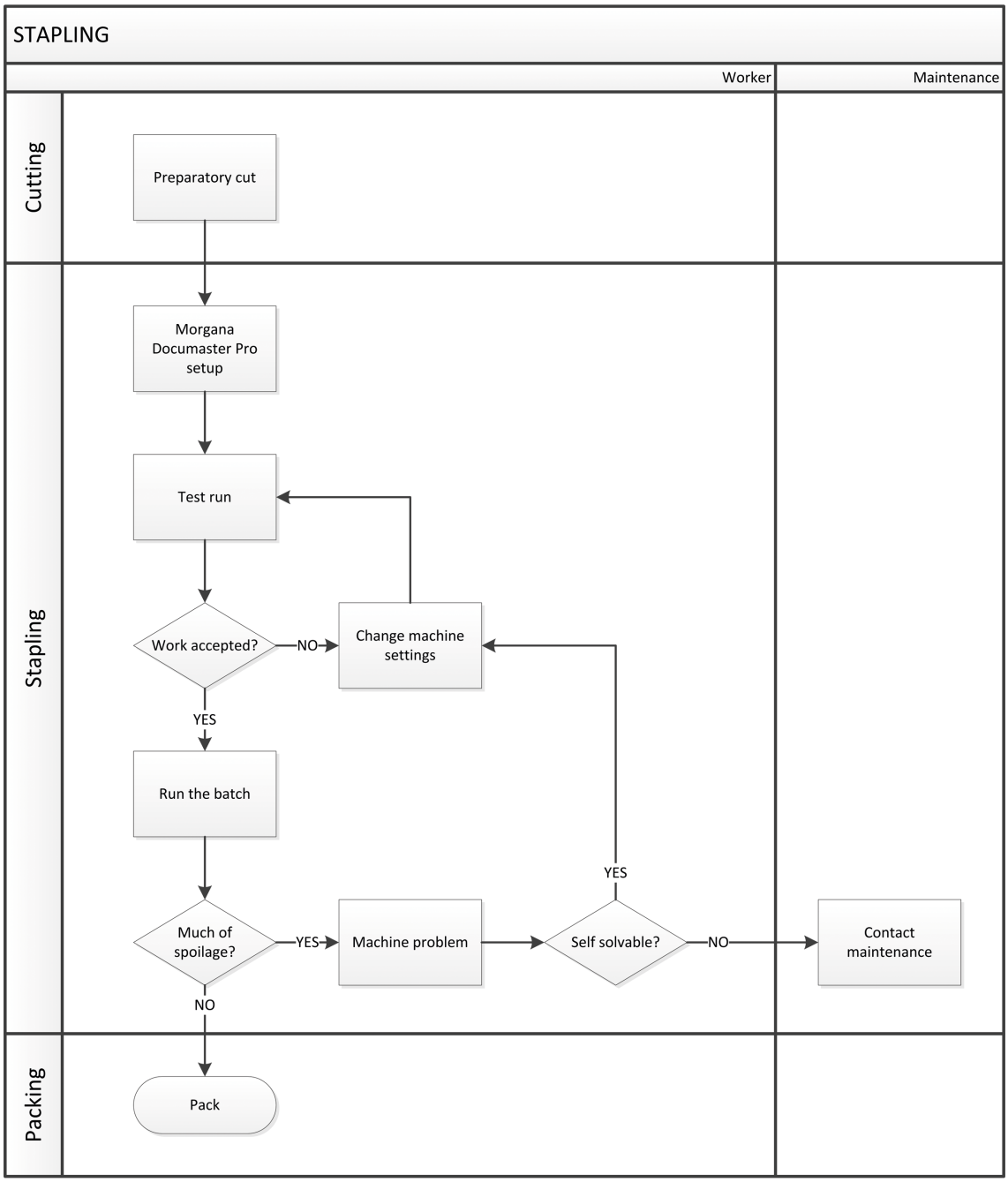
Path of Folding Workflow



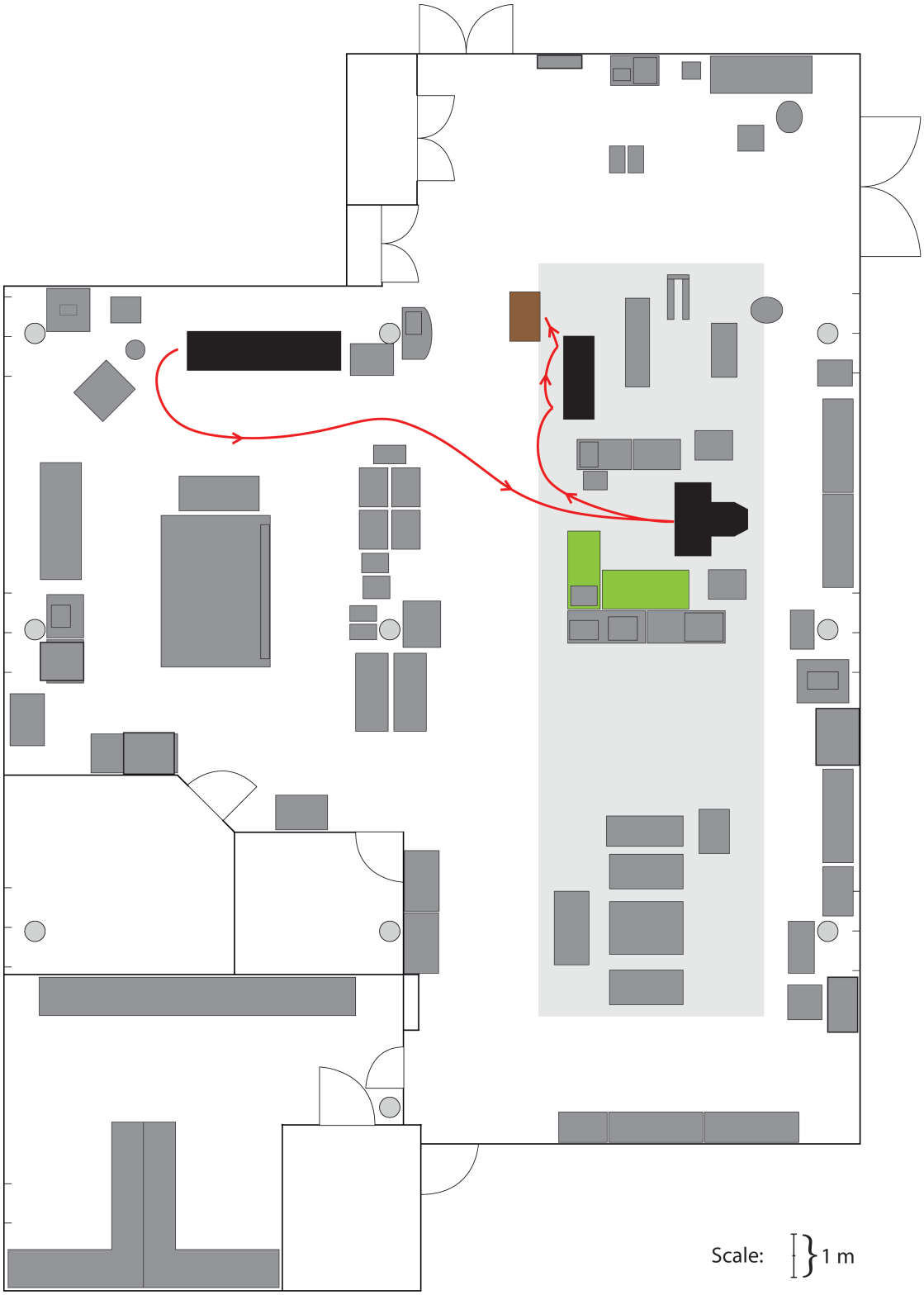
Lean Folding Workflow



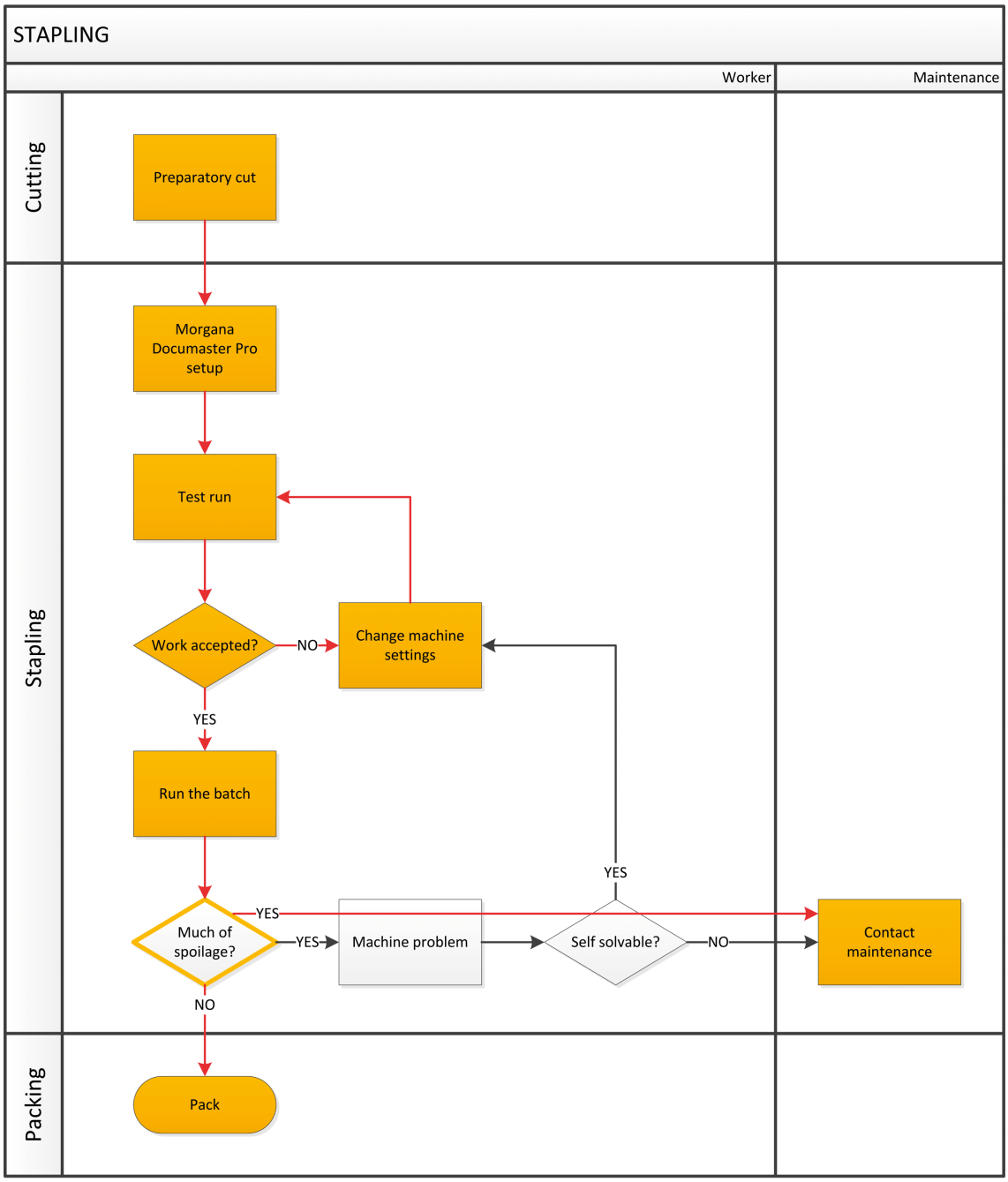
Stapling Workflow



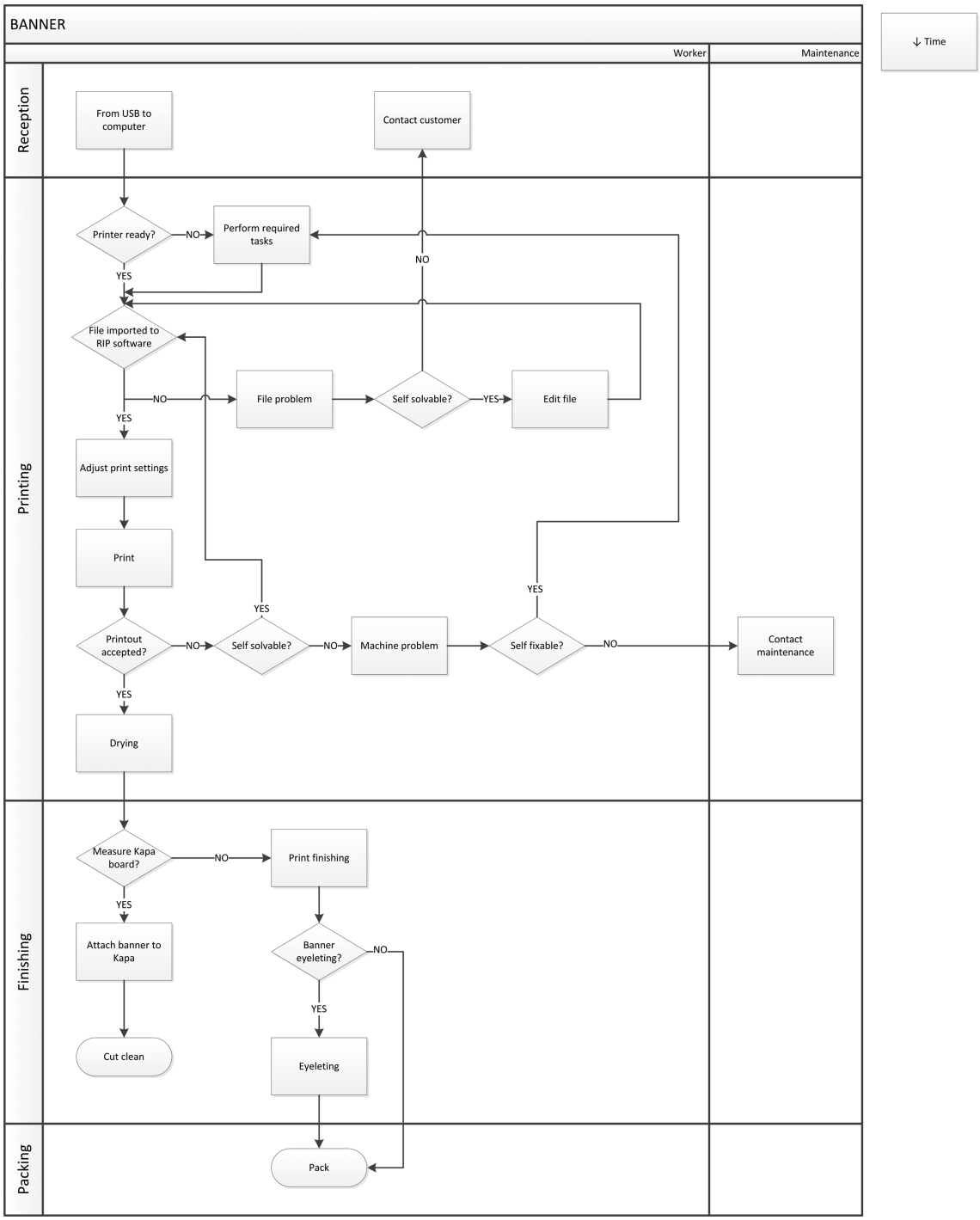
Path of Stapling Workflow



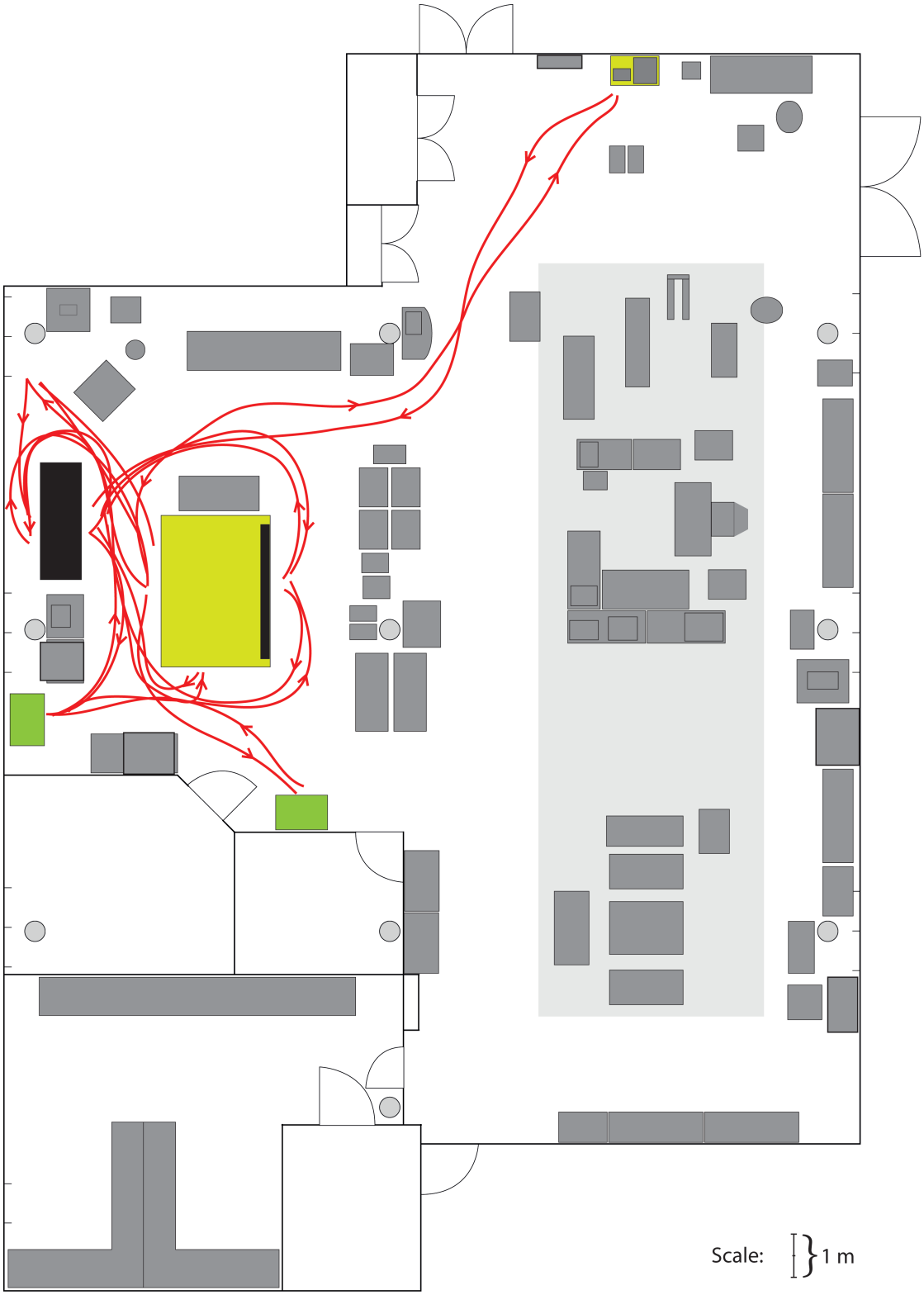
Lean Stapling Workflow



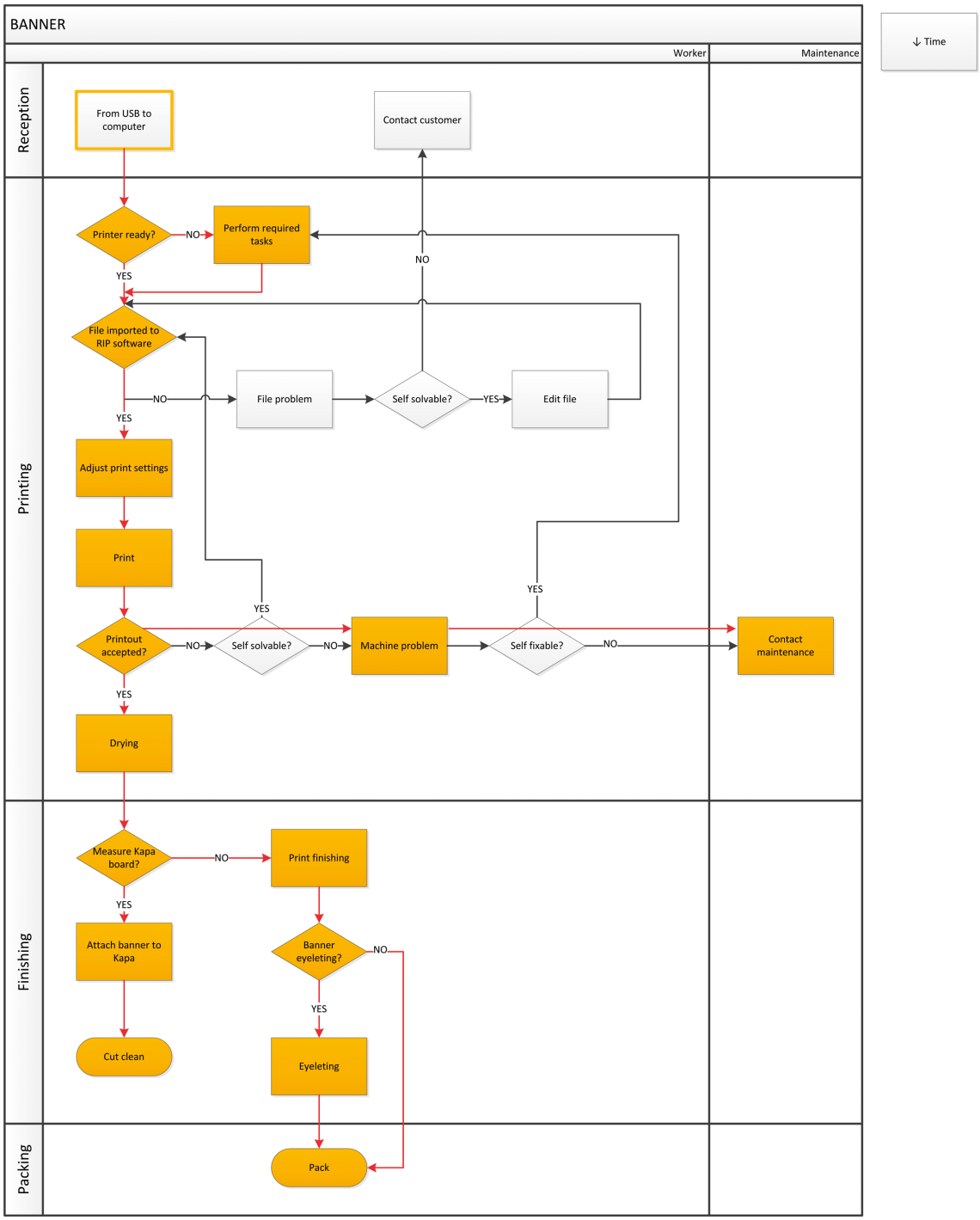
Banner Workflow



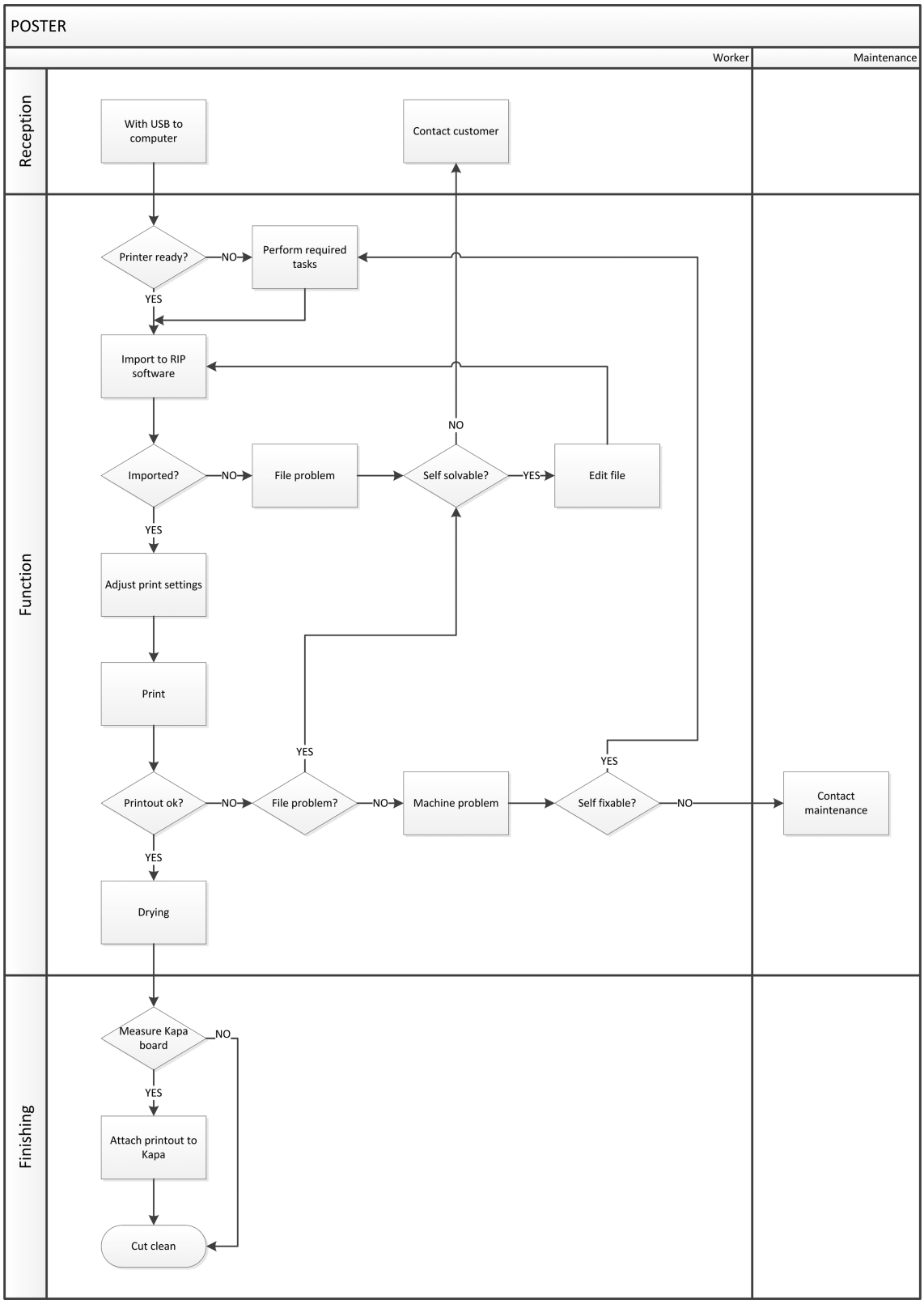
Path of Banner Workflow



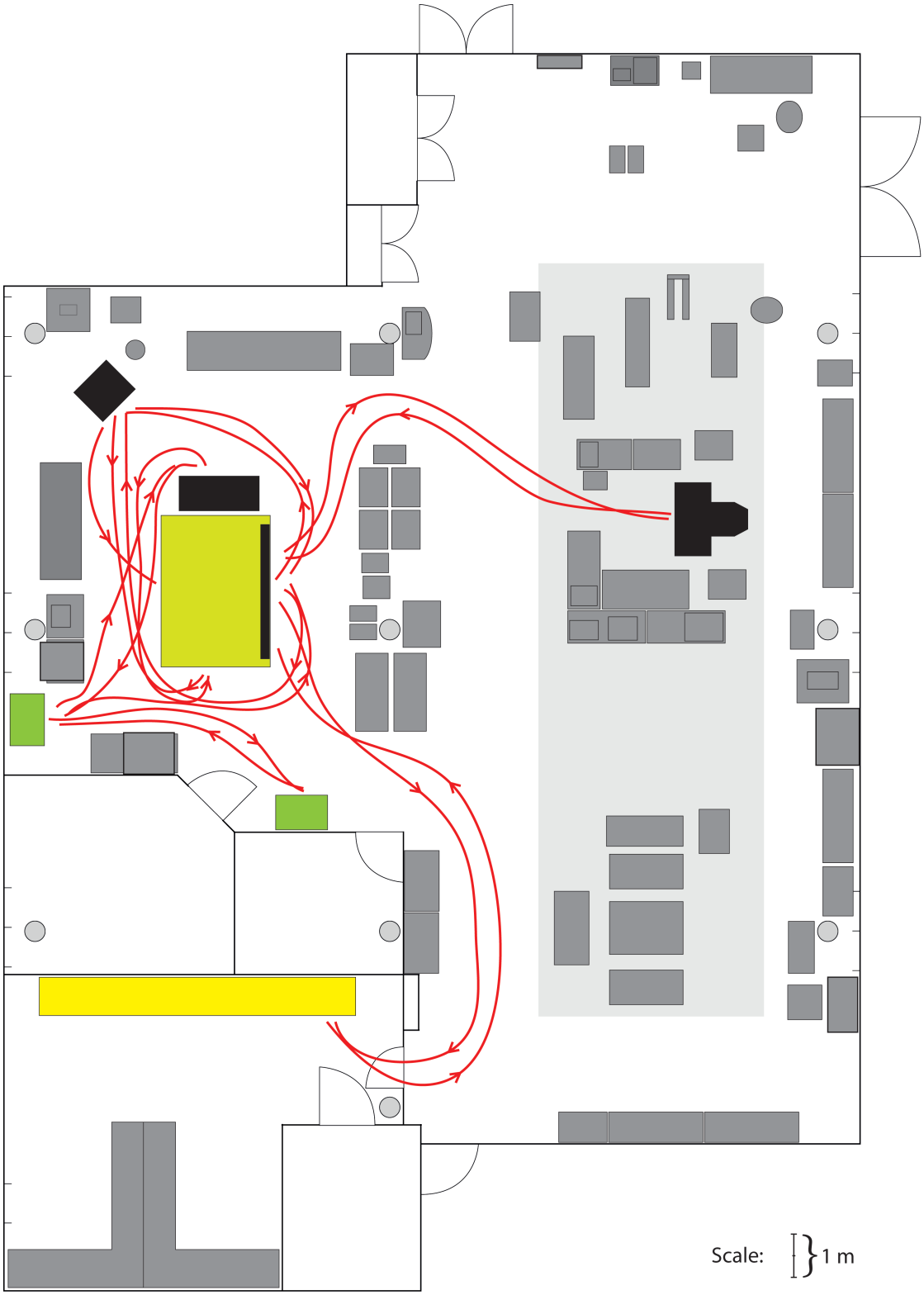
Lean Banner Workflow



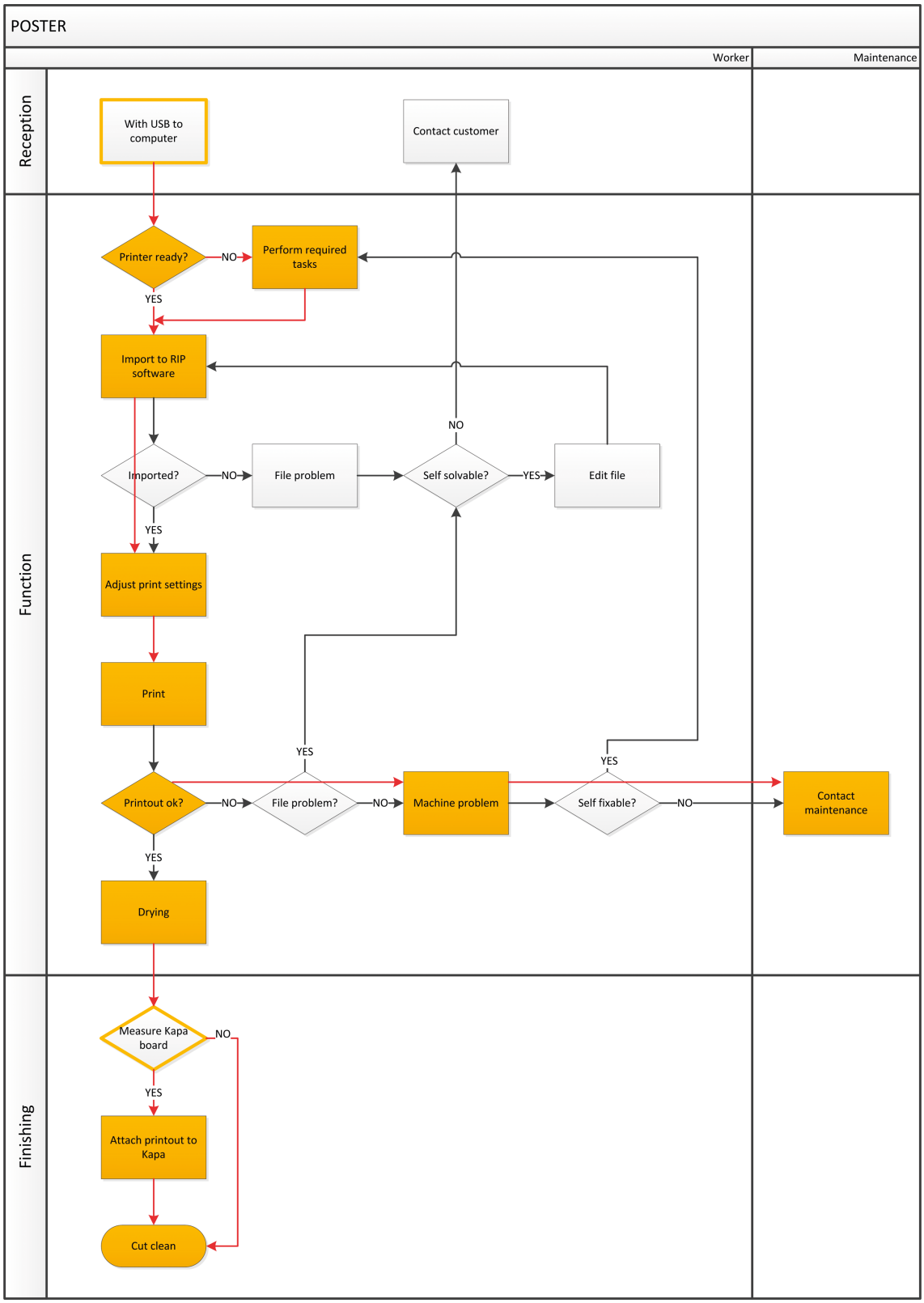
Poster Workflow



Path of Poster Workflow



Lean Poster Workflow



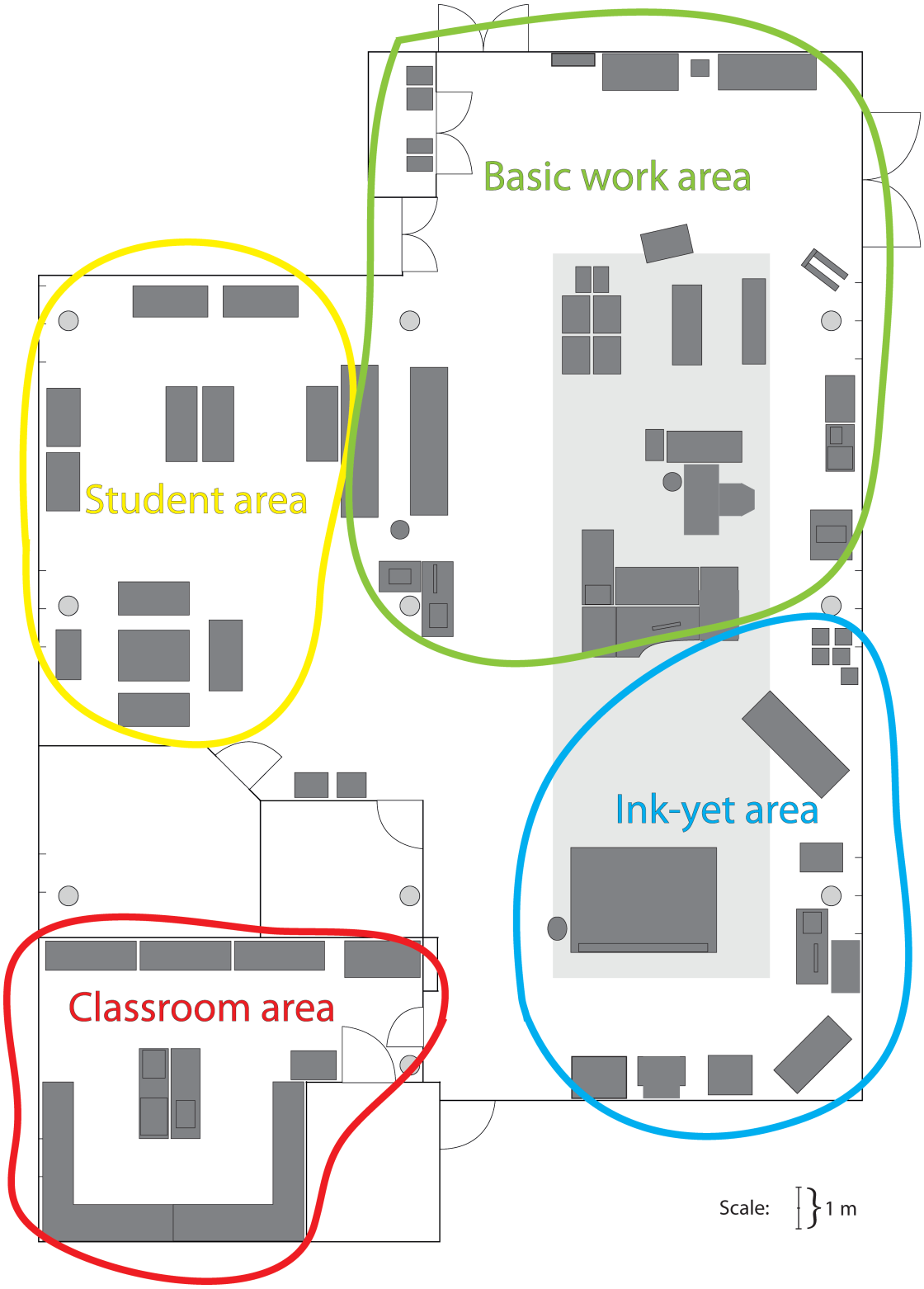
Digipaino's Lean Floor Plan

Digipaino's Lean Floor Plan

Machine list

Number	**Machine**
1.	Horizon perfect binder BQ-270
2.	Morgana Documaster Pro (greasing, folding, stapling)
3.	Morgana Digifold (folding machine)
4.	RICOH Pro C751 (electrophotography)
5.	Wohlenberg MCS-2TV guillotine
6.	RENZ WBS 360 and closing bar (wire binding equipment)
7.	EIRI small light table
8.	Computer for RICOH Pro C751
9.	UCHIDA BC-10 business card cutter
10.	Hand guillotine
11.	Reception computer
12.	GRAPHTEC cutting pro FC 4510-60 (flatbed cutter)
13.	Clamshell heat press
14.	Material for EPSON Stylus Pro GS 6000
15.	EPSON Stylus Pro GS 6000 (ink-jet)
16.	Paper shredder
17.	RICOH Aficio MP C2051 (copy machine)
18.	EVOLUTION 310cm-124 wide format cutter
19.	Summa D60R (cutter)
20.	Gretag macbeth calibrator
21.	Computer for Epson machines' software
22.	EPSON Stylus Pro 9900 (ink-jet)
23.	EPSON SureColor T3000 (ink-jet)
24.	EPSON Stylus Pro 4900 (ink-jet)
25.	Linea DH-360 (lamination machine) and Fastbind (hard cover binding machine)

Division of Lean Work Areas



Lean Workflows