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Evaluation of a Prepress Workflow Solution for Sheetfed Offset

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Bachelor of Engineering

Media Technology

Thesis

10.4.2017

Author(s) Title Number of Pages Date	Henrik Viluksela Evaluation of a prepress workflow solution for sheetfed offset 42 pages 10.4.2017
Degree	Bachelor of Engineering
Degree Programme	Media Technology
Specialisation option	Graphic Technology
Instructor(s)	Rami Paakkinen, Development Manager Toni Spännäri, Lecturer

The purpose of this thesis was to evaluate the suitability of a prepress workflow solution for sheetfed offset in commercial printing. The goal was to provide information to support an investment decision between several workflow providers, by investigating the properties of Screen Equios workflow.

The project was carried out by investigating and characterising the production of the company and using the findings as well as specific production requirements to define requirements for the workflows to be developed. Several workflows were prototyped to find out the suitability of Equios in answering the demands of the production environment.

The production of the company was found out to have a large variance in page and sheet sizes and page count, as well as including large number of saddle stitched and unbound products, typical for a commercial printer. This implies high requirements for the workflow in terms of flexibility. Based on the findings, workflows were prototyped separately for bound and unbound products. Job data flow into Equios could be automated, although the lack of imposition automation caused problems in terms of the attainable flexibility of the workflows.

The findings were used in the decision process for the workflow investment, and provide in-depth information about the functionality and automation possibilities of Equios.

Keywords	Prepress, workflow, automation, imposition, offset

Tekijä Otsikko Sivumäärä Aika	Henrik Viluksela Prepress-työnkulun arviointi arkkioffsetpainoa varten 42 sivua 10.4.2017
Tutkinto	Insinööri (AMK)
Koulutusohjelma	Mediatekniikka
Suuntautumisvaihtoehto	Graafinen tekniikka
Ohjaajat	Kehityspäällikkö Rami Paakkinen Lehtori Toni Spännäri

Insinöörityön tarkoituksena oli arvioida prepress-työnkulun soveltuvuutta mainospainatuksessa toimivalle arkkioffsetpainolle. Työn tavoitteena oli tuottaa tietoa uuden työnkulun hankintapäätöstä ja valintaa varten tutkimalla Screen Equios -työnkulun ominaisuuksia.

Projekti toteutettiin perehtymällä painon tuotantoon ja kuvaamalla sen erityispiirteitä. Näin saatua tietoa käytettiin hyödyksi painotalon muiden teknisten vaatimusten ohella tarvittavien työnkulun ominaisuuksien määrittelyyn. Tarkempaa tietoa työnkulun soveltuvuudesta hankittiin luomalla testityönkulkuja määriteltyjen ominaisuuksien testausta varten.

Painon tuotannon havaittiin olevan todella vaihtelevaa sivu- ja arkkikokojen sekä sivumärän suhteen sekä sisältävän pääosin hakasnidottuja tai sitomattomia tuotteita. Kerätyn tiedon perusteella työnkulun joustavuuteen on kiinnitettävä erityistä huomiota. Testityönkulkuja luotiin erikseen sidotuille ja sitomattomille töille työnkulun ominaisuuksien puitteissa. Tiedon kulku Equiokseen toimii automaattisesti komentotiedoston avulla, mutta asemointiautomatiikan puute aiheuttaa ongelmia työnkulkujen joustavuudelle.

Insinöörityötä käytettiin työnkulkuohjelmiston valintaprosessissa tukemaan tehtäviä päätöksiä. Lisäksi työ tarjoaa syvällistä tietoa muualla usein pinnallisesti käsitellyistä offsetpainon prepress-työnkuluista.

Avainsanat	Prepress, työnkulku, automaatio, asemointi, offset

Contents

1 Introduction

Prepress phase of print production is characterised by the programmatic approach to it, in contrast to later stages where most of the processes involve physical products. This enables a simpler approach to developing prepress processes, especially when taking advantage of digitalisation. This might also be the reason why prepress processes have a tradition of being one of the major focus points for automation in print industry. Another point of view on automation in print industry comes from the variance of players in it, from sweatshops with few employees to specialised magazine and newspaper production with extremely high output. The larger companies tend to be the ones focusing the most on automation, and although this might stem from the highly standardised product types such as newspapers and the resources that larger companies are able to allocate on development projects, it might also indicate the somewhat traditional thinking often seen in the industry. However, generally decreasing demand, competition with digital media and the use and maturity of digital workflows and systems impose pressure on adopting more advanced automation and a more comprehensive approach to using digital tools in print industry. This fits well to the more universal trends of data driven businesses, internet of things and the spread of digitalisation in general.

While prepress automation has been successfully implemented in specific processes and tasks, it is still unlikely to find more comprehensive solutions for the automation of complete workflows with required flexibility. This is a result of the amount of variance in the production characteristics of companies and requirements from their processes, which hinders the development of universally functional workflow solutions. Additionally, there are some problematic steps in prepress processes such as the automation of imposition of bound products that often require manual control in production environment. Although these problems can possibly be solved, as examples of companies such as Vistaprint show, they are likely to require large investments into proprietary technology, which is problematic during a time of uncertain future and when few companies produce the required volume and variance to gain the true benefits of comprehensive automation. Regardless of this, modern workflows often provide flexibility, which combined with well-structured data can be used for automation with meaningful results.

In practice the problems related to prepress automation boil down to feasibility of automation projects and the actual implementation using workflow software. Feasibility refers here to the value of the gains that would be obtainable through automation compared to the costs. After the investment decision is made, a suitable workflow needs to be chosen. This thesis focuses on the properties of the workflow that affect the decision, from the perspective of sheetfed offset commercial printing. The purpose of the project is to provide the information necessary to make an investment decision regarding a specific prepress workflow, Screen Equios, by testing its functionality and exploring the requirements set by the company. The focus of the project will be on evaluating the suitability of the workflow in terms of sheetfed offset printing, with special attention given to automation of imposition, as this is a critical phase in offset prepress, with a tendency to cause problems for automation. The investment decision is done by other stakeholders and thus the scope of the project is limited to providing objective information about the capabilities of Equios to support the decision.

2 Operating Environment

The purpose of this chapter is to explore the areas of the print process related to offset prepress to provide the reader a general understanding of the environment in which the bachelor’s project is carried out. Offset printing process is briefly described with a focus on the technical aspects that affect prepress and imposition the most. Prepress processes and concepts are explained with more depth as they relate directly to the properties of prepress workflows. The relation of various prepress processes to print production in general is illustrated in figure 1.

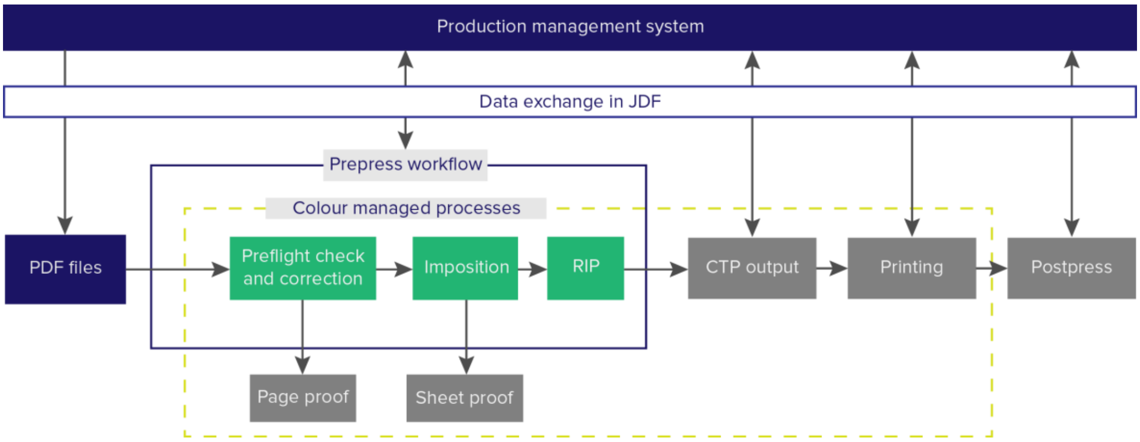


Figure 1. The relation of prepress processes and concepts to print production in general. (Modified from Viluksela 2010, 14; Adobe 1997.)

Even though some of the concepts, such as colour management and preflight, were not explicitly demonstrated in the practical part of the project they are necessary parts of the workflow, and thus included here. Often these can be regarded as fairly well defined and developed processes and as such the evaluation of their practical implementation is beyond the scope of this project. However, they do provide insight into the nature of prepress processes and the type of problems and solutions that define the project environment.

2.1 Offset Printing Process

Offset printing is a printing method that utilises the surface properties of a printing plate to transfer ink to the correct areas of the substrate. Offset printing can be categorised as a mechanical printing method, which means that a printing master (a printing plate in offset) is used for repeatedly transferring the image to a sheet as opposed to digital techniques that form the image individually for each copy. The offset name comes from the use of a special blanket cylinder for transferring the ink from the printing plate to the substrate. Offset printing has traditionally been the most popular printing technique for commercial printing, although advances in digital printing technologies have recently also increased in popularity. However, offset, specifically sheetfed offset, is still the most likely technique to be used for longer print runs. (Kipphan 2001, 206; Viluksela 2010, 46-47, 92.)

The technical basis for offset printing is using oleophilic and hydrophobic regions in the printing plate to control the spreading of oil-based printing ink on the plate and similarly oleophobic and hydrophilic regions for attracting water on the non-printing area. Before ink is transferred the plate is coated with water or a dampening solution with optimal surface properties for suitable degree of emulsification between the solution and the ink. The balance of the solution and ink is critical, as imbalance will lead to quality problems in the spreading of ink. The dampening and inking system of an offset press is illustrated in figure 2. (Kipphan 2001, 206-208; Viluksela 2010, 47, 50.)

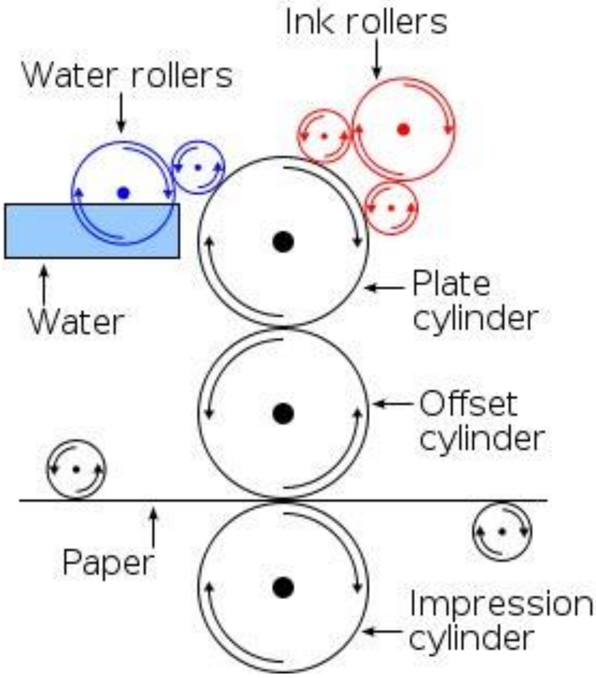


Figure 2. A simplified illustration of a printing unit of an offset press. (Copied from Conquest Graphics.)

Modern printing plates are usually made of aluminium and coated with a photo- or thermosensitive layer. The image is transferred to the plate in a process called computer-to-plate (CTP), which means the use of laser to expose and polymerise the coating layer of the plate enabling the removal of the unexposed regions. An example of a photopolymer CTP process is presented in figure 3. This is just one example of various different processes used for platemaking, although most variations are fairly similar in using polymerisation for imaging. CTP is a fully digital process based on the digital file and processing technologies popularised by the introduction of desktop publishing (DTP), which basically means digital file creation for print. Improvements in CTP technology are enabling faster, more accurate and stable production of printing plates. (Kipphan 2001, 616-619; Viluksela 2010, 51-53.)

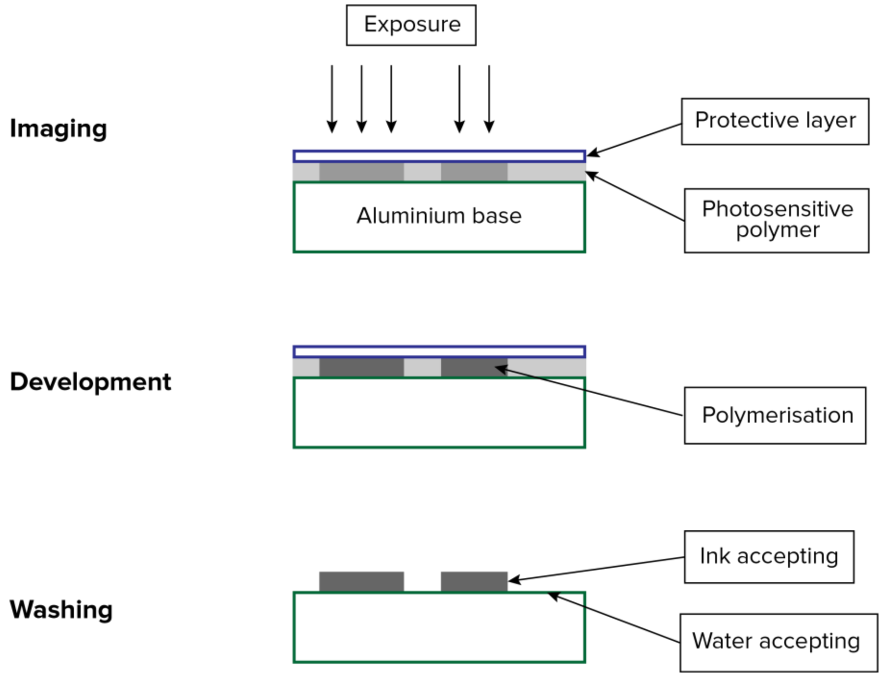


Figure 3. An example of photopolymer CTP plate production. (Modified from Kipphan 2001, 616.)

Sheetfed offset is commonly used in commercial printing due to its flexibility in terms of format, substrate, in-line and off-line finishing options as well as high quality and economical production of mid-range print runs. A typical sheetfed offset press is illustrated in figure 4.

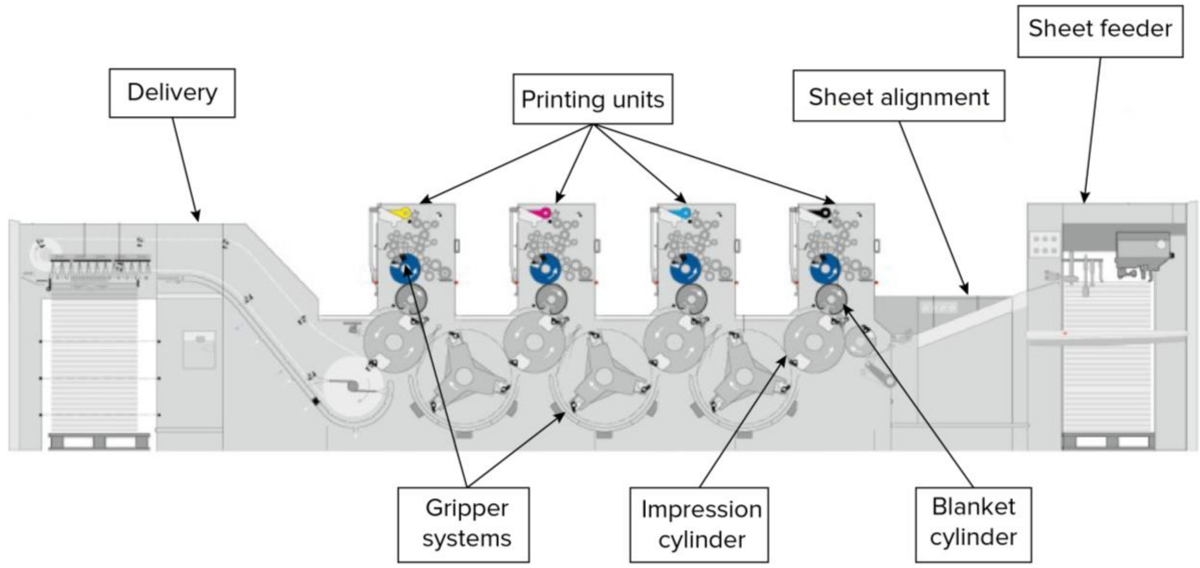


Figure 4. A sheetfed offset press. (Modified from Heidelberg, Speedmaster CS 92; Kipphan 2001, 227.)

Sheet alignment is critical for accurate printing in register, as well as for postpress operations, and alignment often needs to be considered already in the prepress phase of production. Sheet alignment is usually done by using two alignment points in front of the sheet and a single point on the side. When sheets are printed on both sides, they need to be turned either in the press or between two print runs. Two ways are used to do this, called turning and tumbling. The more often used turning is explained in figure 5.

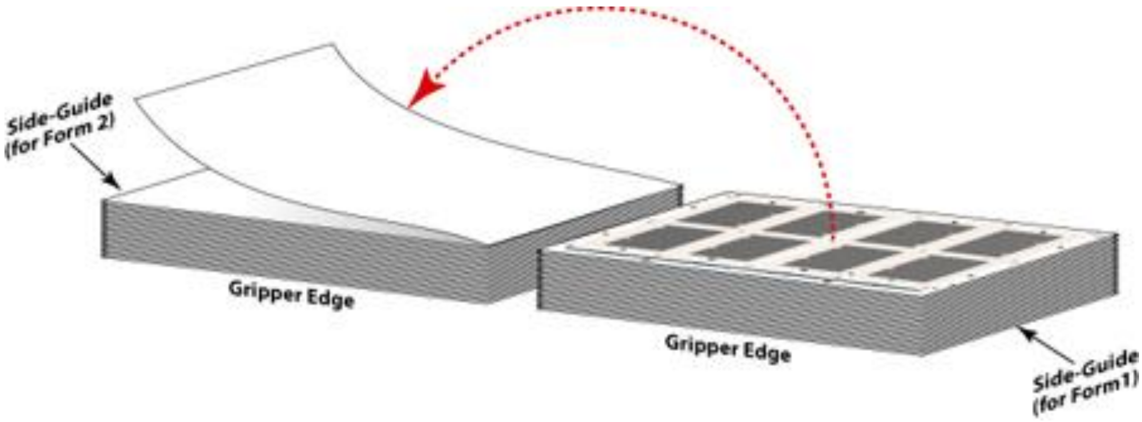


Figure 5. Turning workstyle for printing both sides of the sheet. (Copied from Lawler 2006.)

Turning refers to the sheet being turned perpendicular to machine direction, so that the sides of the sheet change places while the gripper edge stays the same, and tumbling to turning in machine direction, so that the front and rear edges of the sheet change places. When turning, correct alignment can be maintained by using a side alignment point on the different side of the feeder after turning, as this means that the edges used for alignment are the same on both print runs. However, when tumbling, the leading edge of the sheet changes. This might lead to register inaccuracy because of variance in sheet size and is thus rarely used. The perfecting cylinders used in perfecting presses function by tumbling, which necessitates its understanding. (Kipphan 2001, 226, 233-236)

2.2 Prepress Concepts and Processes

As its name suggests, prepress means the parts of the printing process that take place before the actual printing. This includes various steps that either prepare the necessary materials for printing (such as imposition, rasterizing and platemaking), ensure the quality of the print (preflight, color management, proofing) or optimize parts of the upcoming printing process and materials usage. The prepress process is often spread out inside the printing company, and sometimes also between the client, which can streamline the process, but also cause problems in communication and increase the risk of mistakes. Many of the tasks previously handled by the printing house, such as reproduction and layout are now done by a design agency, which allows the printer to optimize the press related parts of prepress. (Leurs 2013; Kipphan 2001, 504.)

Portable Document Format

Portable document format (PDF) is a file format published by Adobe in 1993 and used for transfer and display of complicated files between non-standardised devices. Various programs can be used for creating and reading PDF files, but the major benefit is that a complete description of the document is included in the file, which means that any device capable of reading the file should display it similarly. The spread of PDF has led to it becoming the standard file format used in transferring print materials and the used format for all modern print workflows. Adobe's vision of a modern PDF based prepress workflow is presented in figure 6.

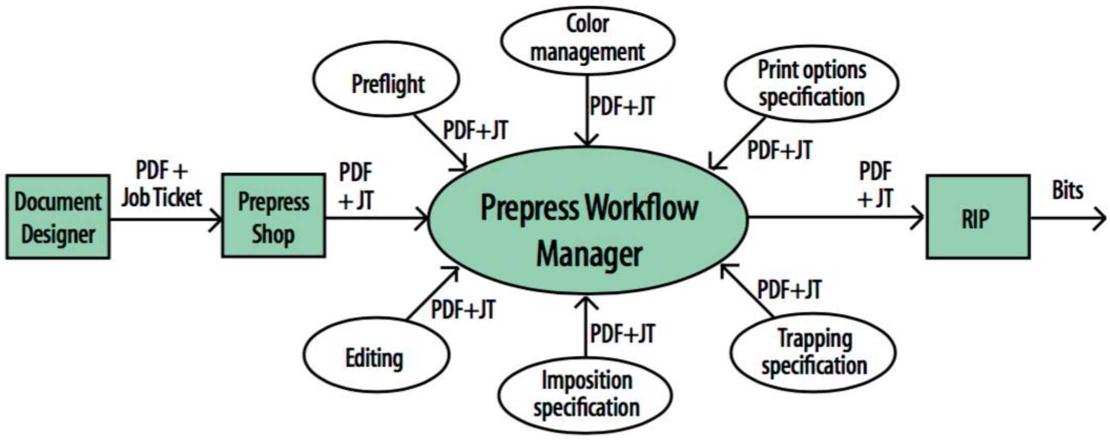


Figure 6. A prepress workflow where all data transfer before the RIP is done in PDF format. (Copied from Adobe 1997.)

Using PDF for most of the workflow is beneficial because of its simplicity in terms of software connectivity and lack of file conversions required, possibility of editing later in the process and the fact that the file can be easily viewed in different parts of the process. As a result, PDF was accepted as an International Organization for Standardization (ISO) standard in 2008, meaning that the future development of the format would be done by ISO. The official standardisation also means that the format is no longer proprietary to

Adobe systems, enabling the development of programs utilising PDF technology. (Adobe 1997; De Abrew 2017; Johansson 2011, 219-220.)

The significance of PDF comes from the standardisation it provides to prepress as a format that should be consistently interpreted by all the participants of the prepress process. However, the increase in the number of PDF properties, such as transparencies, spot colours, comments and non-printable objects like videos that are unsupported by PDF interpreters used in print industry, is causing possible problems in the prepress use of PDF. To combat this, a set of PDF standards, called PDF/X, was created to answer specifically to the needs of print industry. PDF/X files differ from ordinary PDF files by having more rigid rules in terms of what PDF properties can or have to be used in the file. This forces more coherent properties for the file, increasing the likelihood that the PDF interpreter used will be compatible with all the features of the file. There are several different PDF/X versions with different rulesets for use in different environments, PDF/X-4 being the newest with reliable support in print workflows. PDF/X-4 is also the broadest in terms of allowed features, including transparencies, 16-bit images and layers. (Lisi 2010; Leurs 2017)

To further improve the reliability of PDF processing, Adobe has released a PDF based raster image processor (RIP), which is the software used to convert files to bitmap images for printing, called Adobe PDF Print Engine (APPE). Earlier RIPs used to convert PDF files to PostScript format before processing, thus causing problems with files with features that were not compatible with PostScript, such as transparencies or multimedia features. Using a PDF based RIP allows the workflow to utilise PDF format until the end of the process, benefiting the final RIP processing, as more of the output options, such as used colours, resolution and screening, are defined. Using both PDF/X-4 and APPE allows a printer to utilise the possibilities presented by modern PDF features while being confident of the ability to output the results correctly. (Lisi 2010; Adobe, Rendering for creatives.)

Preflight

Preflight is a term used to describe a specific process where a file is checked for mistakes causing printing problems. This should be done in the early part of the printing process, because the earlier any mistakes are found the easier and cheaper they are to correct. Many preflight programs or plug-ins function outside professional printing workflows, so that creative or sales personnel without the technical knowhow of prepress operators could check their files before submitting them to the printing process. Many preflight solutions provide the ability to run automatic checks based on defined profiles, which should make it easy and fast to ensure the quality of the file. (Parker 2016.)

The most basic file properties included in preflight profiles are bleeds, page size, colour management and used profiles, resolution of image elements, and inclusion of fonts and images. Additionally, preflight is often used for checking PDF/X conformity, handling transparencies and managing ink usage. These are properties that may be difficult to notice when creating a file without having an external tool that is used to access the file data itself. Preflight solutions often extend from just reporting the problems to having functionalities to automatically fix them. Examples of this include colour conversions to different profiles or modes, generating bleeds or running specified fixes for missing fonts. Recently attention has also been given to selecting specific areas of the file for preflight checks, to reduce the amount of unnecessary error reports, as these tend to cause slow down automated systems. One of the most common preflight solutions is Enfocus PitStop, which is used as a plug-in in Adobe Acrobat as well as often being featured as a part of other more extensive prepress workflows. (Parker 2016; Selvam 2016; Curcio 2017, Enfocus to release PitStop 2017.)

Colour Management

Colour management refers to the control of colours when reproducing them on different output devices. It is necessary because of different colour reproduction properties and colour modes used in output devices that cause the same numerical colour values to be perceived differently. The goal of colour management is to produce as consistent colour output as possible, regardless of the devices used. In practice, colour management is done by utilising colour profiles that characterise the relation of input and output colour values of a device. Additionally, a standardised profile connection space (PCS) is used between any conversions between profiles, disconnecting the device related profile conversions from each other. The colour values in the PCS are said to be device independent, as they can be correctly converted to any profile without knowing the original creation device. The relation between colour profiles is illustrated in figure 7.

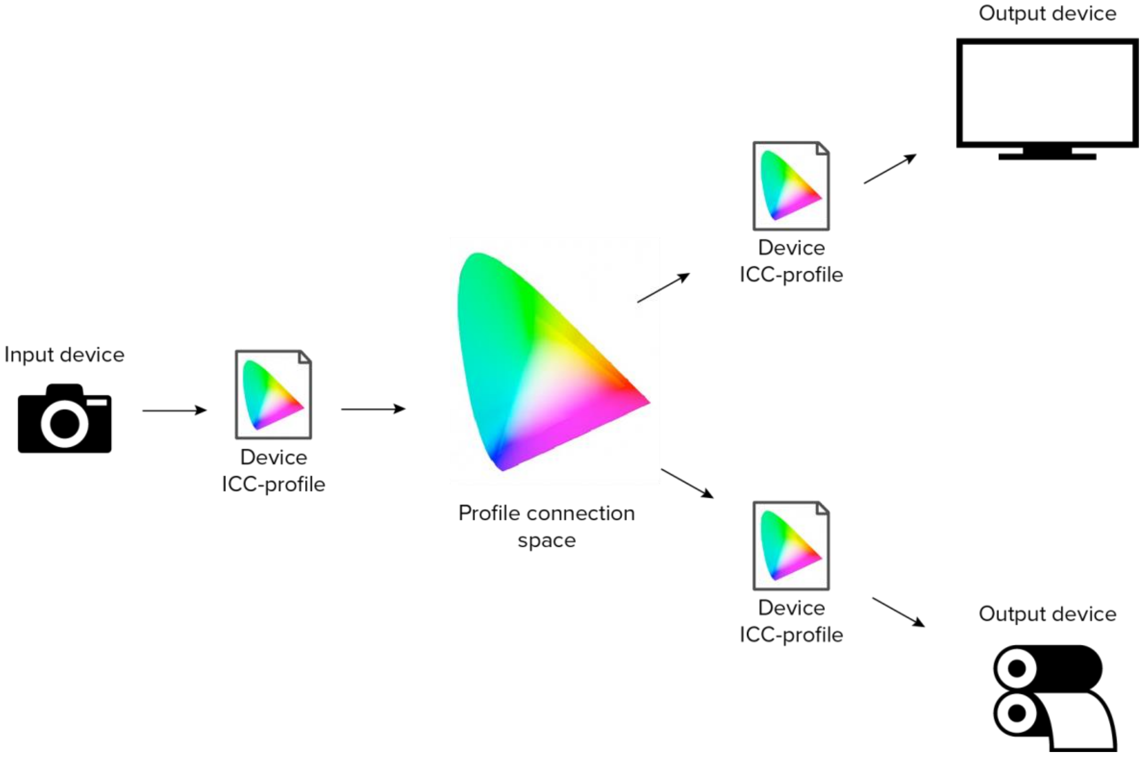


Figure 7. The use of International Color Consortium (ICC) profiles in colour management. (Modified from Cambridge in Colour, Overview of Color Management.)

A device specific profile, containing the information required for correctly representing files created by the device, is assigned to a file when it is created. These are called device dependent profiles, as they are not universal, but usable only with the correct device. After conversion to PCS, output device specific profiles are used to correctly process the colour values from the PCS into output format. (Kipphan 2001, 555-556; International Color Consortium.)

Universal interchangeability of the profiles is necessary for their practical usability, which is why ICC was founded in1993. ICC has defined the structure and contents of colour profiles which are ISO standardised. The ICC colour management model uses CIELAB or CIEXYZ colour spaces as the PCS, which are defined experimentally, as opposed to RGB or CMYK that are defined in terms of output devices. Additionally, ICC has defined an ISO standardised colorimetric observer and illumination for the accurate and unambiguous connection of input and output profiles. (Kipphan 2001, 556; International Color Consortium)

When performing actual colour conversions, the input and output colour spaces rarely match perfectly. To counter this ICC has defined four rendering intents, used in output conversions, that contain specifications for dealing with colour space incompatibilities. These are called relative colorimetric, absolute colorimetric, saturation optimised and perceptual. The most commonly used rendering intents, relative colorimetric and perceptual rendering, are illustrated in figure 8. Absolute colorimetric and saturation optimised rendering are mostly used for specialised cases.

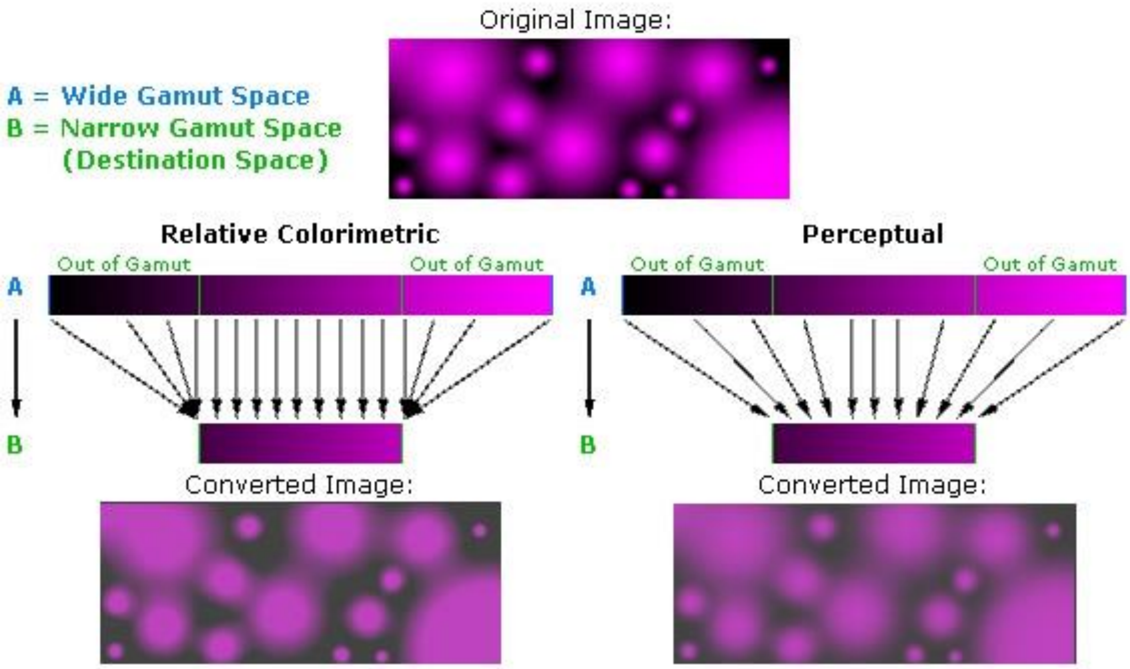


Figure 8. The difference between relative colorimetric rendering and perceptual rendering. (Copied from Cambridge in Colour, Color Space Conversion.)

More theoretically, relative colorimetric rendering adjusts the white point of the PCS to match that of the output media, while colour values exceeding the output colour space are cut. Perceptual rendering adjusts the used PCS colour space to the output capability of the used device. Saturation optimised rendering is used for maintaining the saturation of colours, which may cause problems when converting to larger colour spaces. This is done by increasing the saturation of fully saturated colours, but the exact process is vendor dependent. Absolute colorimetric rendering is used to preserve the colours as close to the originals as possible. Colours exceeding the output colour space are cut out, similarly to relative colorimetric rendering. (Kipphan 2001, 560-561; International Color Consortium; Cambridge in Colour, Color Space Conversion.)

Imposition

Imposition means the positioning of pages on a print sheet in a way that enables the printing, folding and cutting of the sheets to result in the final product. It should also be used to economically optimize the use of materials and time in production. Additionally, marks for finishing and quality control strips are added to the sheet to provide information for the further production phases. The imposition of a single sheet provides the necessary technical requirements for the printing and finishing of the product, and is used to lay out the correct number of pages, possibly on multiple sheets, so that they end up on the correct sides of sheets in the correct order. This will also lead to the number of plates required, and amount of work needed for the printing of the product. (Kipphan 2001, 535-536; Johansson 2011, 246.)

The main variables that affect the imposition are the press format and the size of the product, the number of pages, fibre direction and the required finishing methods. The formats of the printing press and the product, as well as the number of pages lead to the number of products or pages that will fit on a single sheet. This might force the printer to use more than a single run to print all the pages in the product, which increases the production time and costs due to extra plates and makereadies required. The finishing of the product might limit the ways it can be impositioned due to the requirements and properties of the machines used. (Johansson 2011, 246.)

The first stage of imposition is to define the number of pages that are imposed on a single sheet. Kipphan (2001) refers to this as an imposition sheet (imposition scheme is another commonly used term), meaning a document that includes the locations of pages, bleeds, marks, margins and other technical requirements for the sheet. In addition to this, there are several ways in which pages can be assembled on the sheet. Ordinary sheetwise layout, where both sides of the sheet are unique and printed separately, is the most common imposition. However, paper efficiency, printing workload and accuracy can sometimes be improved by using alternative imposition schemes. The simplest scheme, called gang-up, is the one in which multiple products are fitted on a single sheet, named by the number of copies on a sheet (2-up, 4-up etc.) This reduces the time spent on the press, as well as the material required for printing, but can often only be used on very simple products. Work and turn is a variation of a 2-up imposition where both front- and backsides are printed on one side of the sheet and the sheets turned perpendicular to machine direction after the run, as illustrated in figure 9.

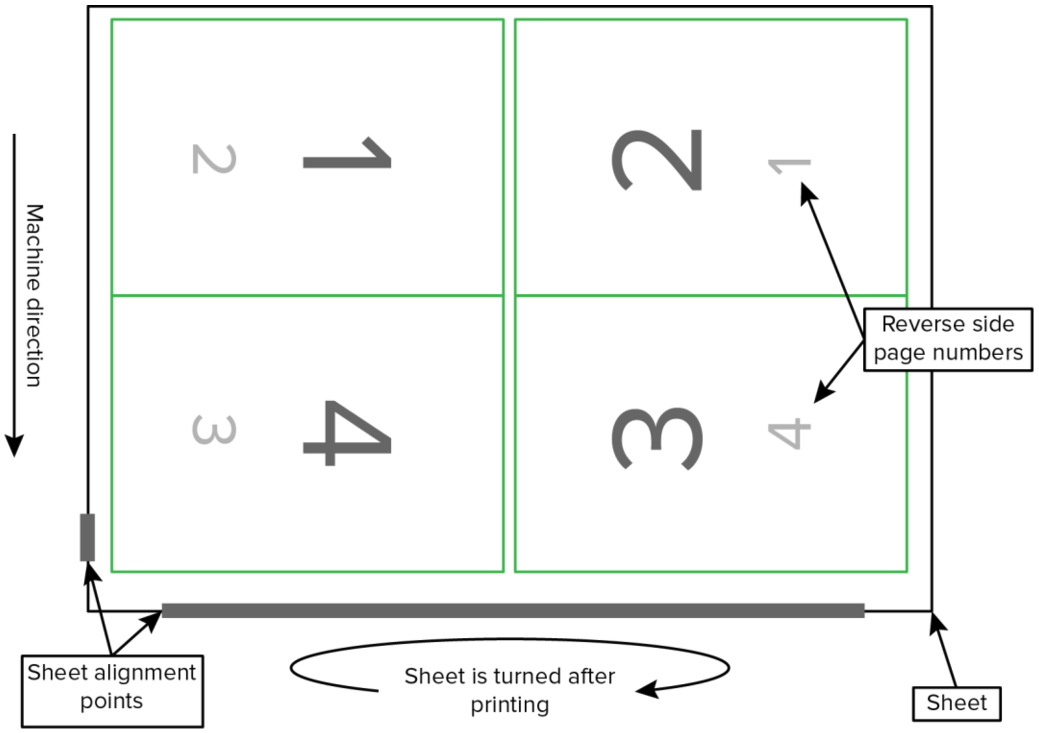


Figure 9. Work and turn imposition for 2 copies of a 4-page product.

This results in two copies of a two-sided product per sheet while using only a single set of plates. This saves the makeready time that would be necessary when using separate plates for both sides. A variation of work and turn workstyle is work and tumble, where turning is done in the machine direction, so that the leading edge of the sheet changes. (Johansson 2011, 247-248; Kipphan 2001, 535.)

Different binding options require the pages to be arranged in different order to accommodate different postpress processes. Glued and sewn products are folded and placed on top of each other, while stitched products are folded and the sheets are placed inside each other. The correct order must be deduced before pages can be imposed on the sheet for CTP output. This is sometimes called pagination, and is usually done programmatically, based on predefined pagination catalogs such as by the International Cooperation for the Integration of Processes in Prepress, Press, and Postpress Organization (CIP4). An example of a pagination scheme is found in figure 10.

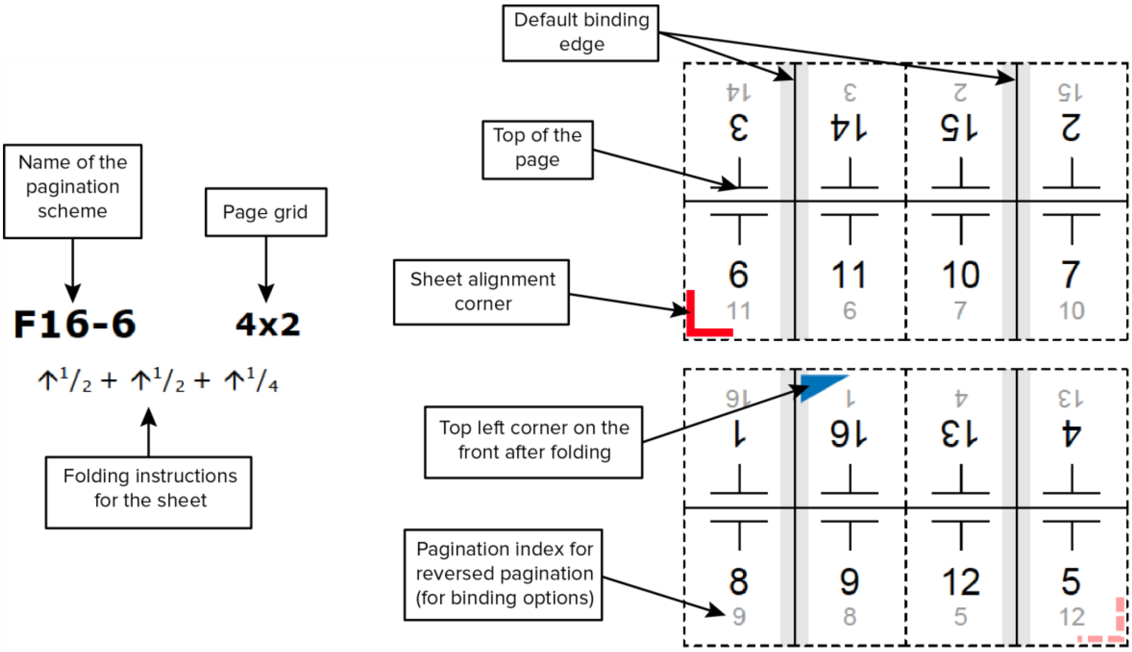


Figure 10. Pagination scheme F16-6, used for a 16-page booklet, from CIP4 pagination catalog. (Modified from Bastien 2009, 22.)

Pagination schemes are used for single signatures that can be used either on their own, or added to other signatures when greater page counts are needed. It is necessary to know the final binding type of the product to use pagination schemes correctly, as they describe only the page order within a signature. (Johansson 2011, 248; Kipphan 2001, 535-536; Bastien 2009.)

Job Definition Format

Job definition format (JDF) is a standard developed by CIP4 used for communicating job data between different phases of print production. JDF is often compared to an electronic job ticket, which is accurate enough, although the universal nature of the format provides system independent communication possibilities beyond ordinary job tickets. JDF aims to cover the whole printing process from the customer to finishing, connecting business systems, production machinery and product information such as files and directions into a JDF file. The role of JDF in the complete print process is illustrated in figure 11.

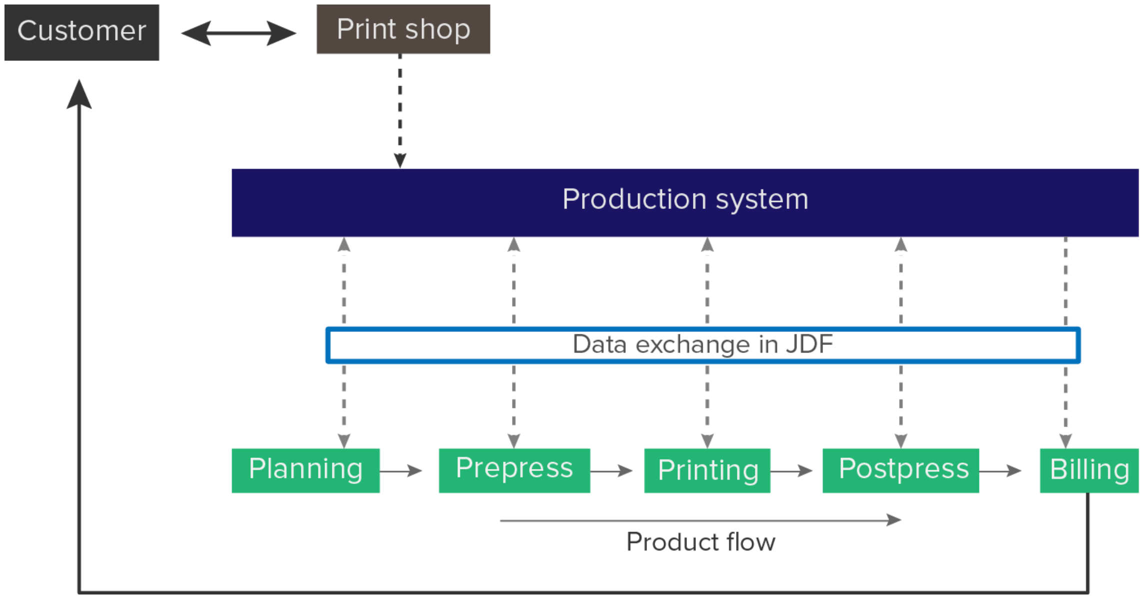


Figure 11. The role of JDF in job data communication. (Modified from Viluksela 2010, 142.)

In practice JDF is an XML based standardised file format that should be understood by business systems and workflow solutions used in the graphic industries as well as production machinery. This allows the different production steps to be registered and updated into the file, which in turn can be followed by production control systems. On the other hand, JDF allows the integration of machinery into production systems and the job instructions contained in them. This enables automatic data flow to the machinery, which can be used for pre-setting and controlling machine parameters, improving makeready times and reliability. Another benefit from JDF based systems integration is the flow of data in both directions, as production information moves automatically from machinery to business systems. This is useful from the sales and management point of view, providing more accurate view of the production and costs. (Viluksela 2010, 161-162; Johansson 2011, 227, 230.)

JDF is an extensible standard, due to the nature of XML, which, while futureproofing the format, also loses some of the rigidity of the standard. This is problematic because the benefit gained from standardisation relies on the universal nature of the system. Vendor specific properties and lack of generalised support are likely to cause problems in the seamless integration of systems and machinery, which naturally does not attract users. (Viluksela 2010, 161-162; Johansson 2011, 230.)

3 Process development and automation

Business process automation (BPA) is currently a hot topic in business in general. Digitalisation and the availability and mobility of data, which enables the automated decision making required for more intelligent automation, is providing businesses possibilities of streamlining their processes and improving their efficiency. This is significant because automation of simple processes is extending to a growing number of tasks as well as companies that may not be as industrially focused as traditional employers of process automation. More specifically BPA refers to the automation of various tasks that form a workflow or a process, but the fact that differentiates it from more traditional automation is the focus on complex and often less technical processes. Examples of these might be document handling, offer responses or more specialised workflows such as marketing automation workflows, as illustrated in figure 12.

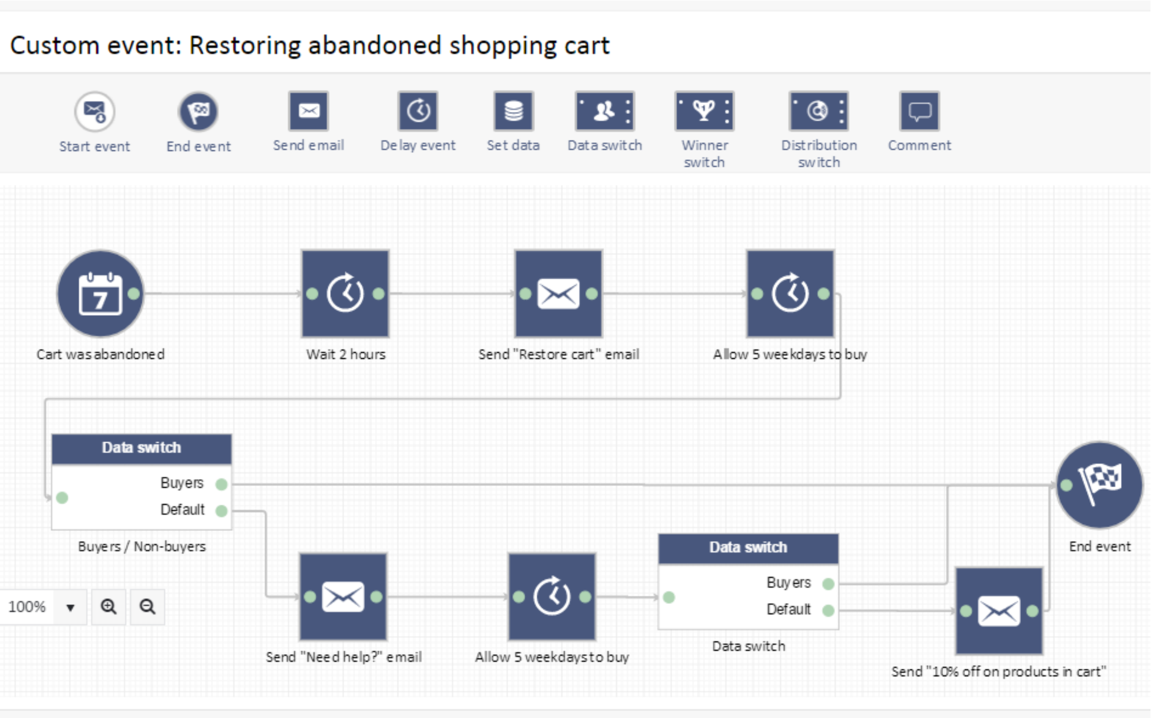


Figure 12. An automated marketing workflow. (Copied from Heba 2015.)

This is a rather clear sign of the increasing effect that digitalisation has on modern businesses, but is also an example of a development that would not be possible without the use of broad data systems that provide the basis for meaningful automation. (Palmer 2017; Rouse 2011; Kolehmainen 2017.)

Another interesting idea that can be brought up from BPA is the interaction of automation projects and traditional process development tools and methodologies used in industrial production. Most articles exploring BPA or automation in general, such as by Shacklett (2015), recommend focusing on the simple processes for automation projects, which is logical because those are the tasks that do not benefit from the perspective of a human employee, but rather from the consistency and speed provided by automation. On the other hand, many process development methodologies also promote the simplification of processes as a way of improving quality and productivity. One such example is lean, which aims at improvements by reducing non-beneficial work among its other goals (Juuso 2016). This also continues outside strict models and methodologies in articles concerned with general business productivity, such as by Markovitz (2014), dealing with simplification and rationalisation of scattered processes, or Bersin (2015), similarly pursuing increased productivity by cutting waste and simplification. The overlap between tools of process development is clear in these examples also demonstrating the synergy that could be achieved by a comprehensive approach to it. This kind of holistic, systematic approach to meeting business goals by process development is called business process management. (Palmer 2014.)

3.1 Automation in Prepress Environment

Automation means the use of technology to control or execute a process without human intervention. This definition is important because it includes the key ideas that provide the functionality of automation: control and lack of human intervention. These are crucial because their presence enables the flexibility and greater autonomy of a system, extending automation from mechanically repeated steps into more intelligent processes. One of the main ideas used in software based automation to improve control and detach a system from human operators is the separation of functions into different layers of abstraction. This means an approach where the logic of a process is hidden from the user (thus it is abstract for the user), and can be controlled by using standardised input parameters. The abstraction of a process is illustrated in figure 13.

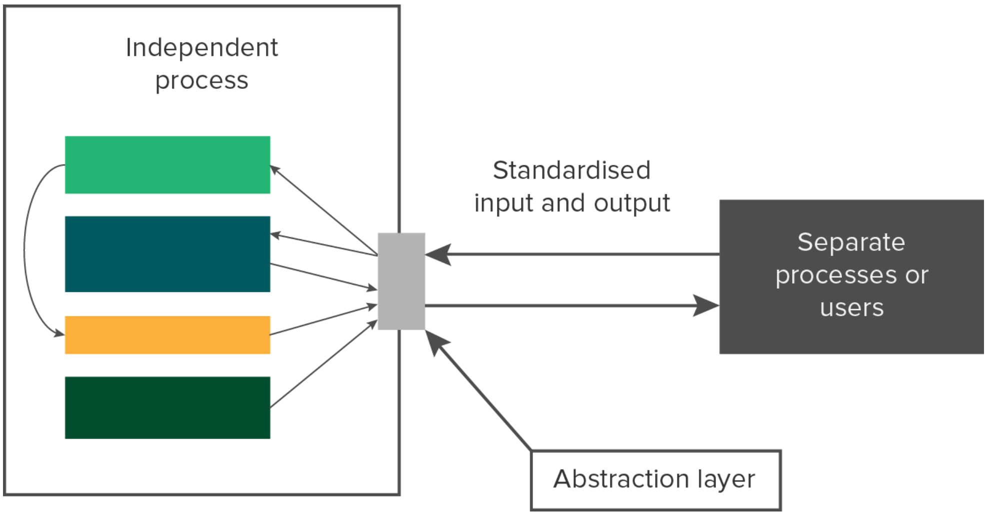


Figure 13. The abstraction of a process.

The most important benefits provided by this kind of abstraction for an automated system are the simplicity of interaction with the system, reusability of the abstracted processes and the ability to modify the underlying processes without affecting interaction with the system. These provide flexibility in terms of control, because any system capable of outputting the standardised input format can be used to control the system, economy and simplicity in terms of the logic build into the system, due to reusability of processes, as well as modularity and ease of development because of separation of functional units and processes. (Brei 2013; Murray 2010; Plexxi 2014.)

Automation is not a new subject in print industry. Especially after the introduction of desktop publishing (DTP) and PDF workflows many parts of the prepress processes have been targeted with automation software and projects aiming to automate preflight, PDF correction and modification and other similar tasks. Another part of the print value chain that has recently been the focus of automation efforts is the customer communication and sales processes in the form of various browser based interfaces for file transfer and job approval as well as more dedicated web-to-print solutions that can be used to automate much of the often-troublesome communication between the customer and the printer, and often provide advanced functionality such as document and brand management tools. (Printing News 2015; Zarwan 2010.)

The collective automation effort is often contained into workflow solutions, a term which refers to software offering different types of functionality to aid streamline production by defining processes and their parameters. In print industry, workflow solutions usually deal with prepress processes, as that is the phase where purely programmatic production automation can be used. The basic functionality of a workflow usually combines tools for file management, preflighting, imposition, colour management, RIP, proofing properties and other smaller processes. In addition, many workflows provide connectivity to management information systems (MIS) and some to brand management, web-to-print or ordering systems, enabling more advanced data flow inside the company and its customers. Figure 14 illustrates some of these additional functions and how they might be related to more production focused workflows. (Curcio 2017, The evolution of workflow tools; Viluksela 2010, 43)

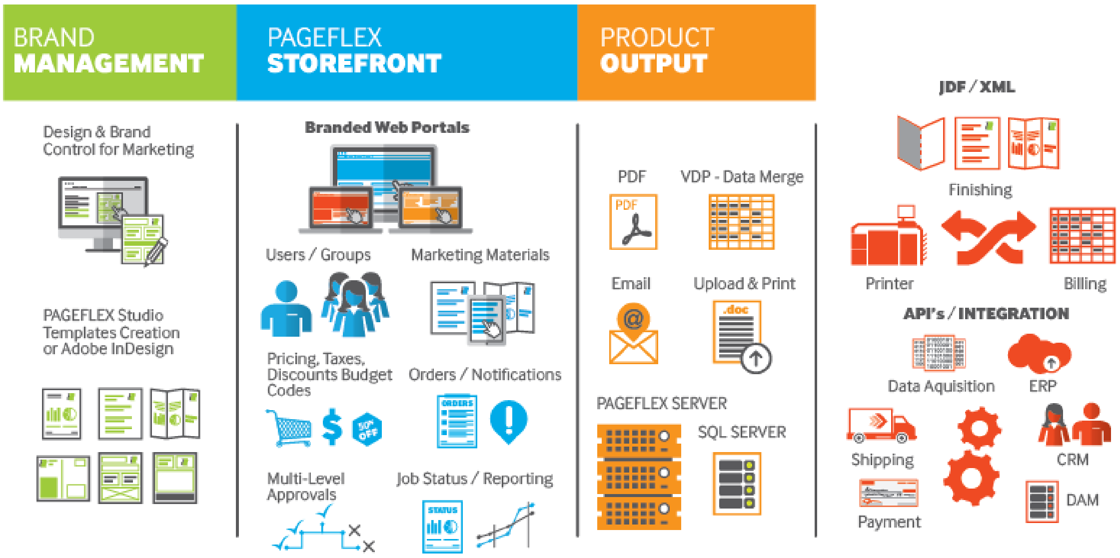


Figure 14. An example of connecting additional functionality to print workflows. (Copied from Pageflex)

In practice, prepress workflows usually function based on user defined workflow templates that contain the processes required. The parameters for these processes may be input manually or be transferred from production systems using JDF based or proprietary data formats. When created, jobs are placed on a list from where they are either manually or automatically approved to a workflow. During the workflow processing the tools defined in the workflow are run, resulting finally in rasterised bitmaps that can be used in a printer or a CTP platesetter. An example of a prepress workflow is given in figure 15, the similarity to figure 12 should be noted. (Viluksela 2010, 43-44.)

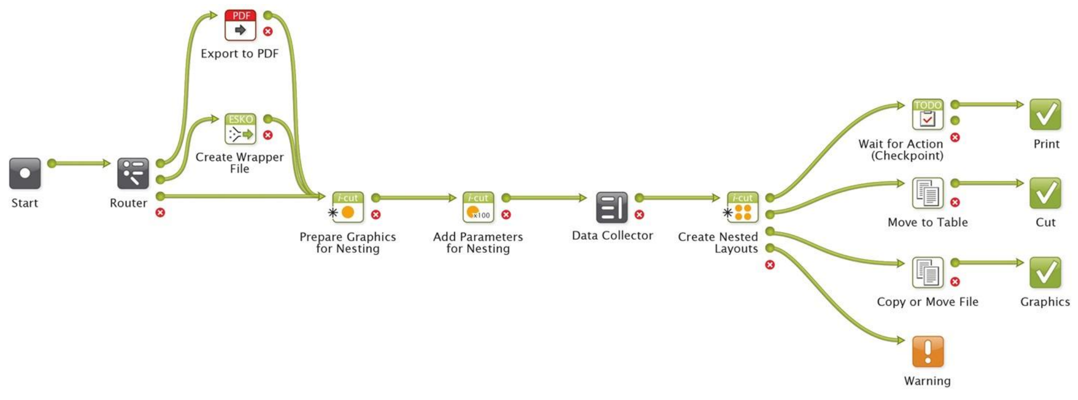


Figure 15. A prepress workflow. (Copied from Esko Graphics.)

Modern prepress workflows aim at removing so called touchpoints from the prepress process, meaning the reduction of workflow steps, decisions or parameters that are required to be done manually. The goal is to free prepress operator's time to be used on tasks that require strong level of expertise, instead of using it on large numbers of simple and repetitive tasks and decision making. Other trends include a holistic approach to the business processes of a company, as the benefits gained from using a single cohesive solution for managing the production workflow usually outweigh the possible gains from the flexibility of smaller individual tools. The flexibility and customisability of complete workflow solutions has also been developed, enabling many workflows to function well also outside their main focus areas and adapt to changing environment and business strategies. In addition to features, also the infrastructure related to business systems has developed, with software as a service (SaaS) solutions increasing the flexibility in terms of hardware and software investments and decreasing external IT costs. However, taking advantage of the developments in prepress workflow also requires efficient and accurate data flow to provide the input to the workflow. (Curcio 2017, The evolution of workflow tools.)

4 Automation of Prepress Workflow for Sheetfed Offset

4.1 Project Planning and Goals

The company providing the bachelor's project is currently in a situation where several mergers have resulted in multiple prepress workflows being used. This is clearly a situation that is not beneficial for the company due to lack of specialisation, standardization and job mobility between different units using different workflows. In addition, the software costs are cumulative and full systems integration benefits are unlikely to be achieved because of lack of specialisation. Thus, the company is aiming to choose one of the several prepress workflows in use and preferably integrate it into the production monitoring and planning systems already in use. The eventual goal is to use the chosen workflow software to create a flexible and partly automated prepress process to improve the predictability (by improving standardization and decreasing errors) and turnaround times of offset prepress. Because of the long-term investment and the labour required for implementing such systems, it is necessary to test and evaluate the suitability of a workflow software to the requirements of the company and its processes before making the final choice of the workflow software.

The set nature of the production environment and current systems provides the bounds and requirements for the workflow, as broader production development would require more resources and possibly affect the ability of the company to maintain normal production. These set requirements lead to a logical testing procedure for the possible workflow software, where a candidate is reflected against the requirements by prototyping their features for suitability to the production environment. This is possibly a labour-intensive procedure, but provides a better view of the capabilities and weaknesses of a software, as well as an initial evaluation of the availability and quality of the support services of the provider.

The whole automation project of the prepress workflows has a much broader scope than the limited extent of a single bachelor project and thus the scope of this bachelor project is focused on testing a single workflow software, documenting its features and options for the implementation of automated workflows and providing information for making conclusions about the suitability of the software for prepress automation in the given environment. The project is to be carried out by analysing the workflows and operating procedures currently used in offset production, collecting basic job data to characterize the production and to deduce the importance of different areas of functionality in the workflow, prototyping and testing the most important features of the software and finally documenting the conclusions and possibilities presented. This kind of progress of the project allows the testing to be based on the characteristics of the current prepress process, but by recognizing the strengths and weaknesses and the hard limits of the environment it also allows development by pushing the boundaries of the existing workflow where beneficial.

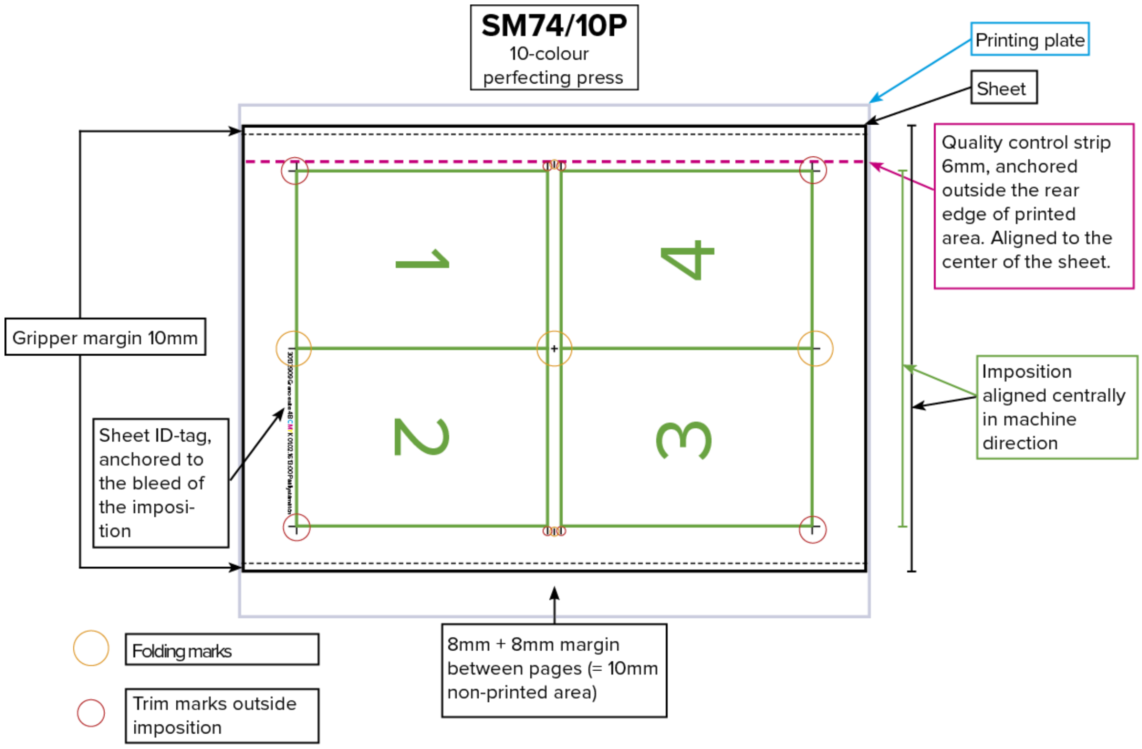
4.2 Current State Analysis

Even with the preference of agile project management in modern systems development, it is necessary to understand the operating environment and the implications it might have on the project. This is especially true when working with systems and processes that might not have been built to accommodate the kind of results that are being pursued, or when the definition of the issue being solved is not perfectly clear. Understanding the starting point and environment helps to see the possibilities of development in a more definite sense and to illustrate the steps required to achieve that goal. Because of this it was decided to investigate the prepress processes taking place currently as well as gather statistical data from completed jobs, to deduce the most important aspects and functions for the workflow. (Korban 2015.)

4.2.1 Requirements of Current Processes

The printing presses and other machinery currently in use, as well as the organisation around offset prepress establish several requirements for the successful use of automated imposition. These requirements vary from technical specifications necessary for correct functioning of machinery to information useful for the print and postpress operators, and they were discussed with the development manager of the plant and the production manager of prepress. The most influential requirements concern the layout of pages on a sheet, and other information required.

The production facility in Vantaa operates with three B2 format offset presses and a smaller B3 press. Out of these, the focus of automation was on the B2 presses, as they form the bulk of the production, especially of the more standardised products. The three presses are a 10-colour perfecting press, a 4-colour press with a coating unit and a 6-colour press with a coating unit. The 4 and 6 coloured presses have similar requirements regarding imposition, but the perfecting press has some differences in its requirements. All the basic requirements of the presses are illustrated in figure 16.



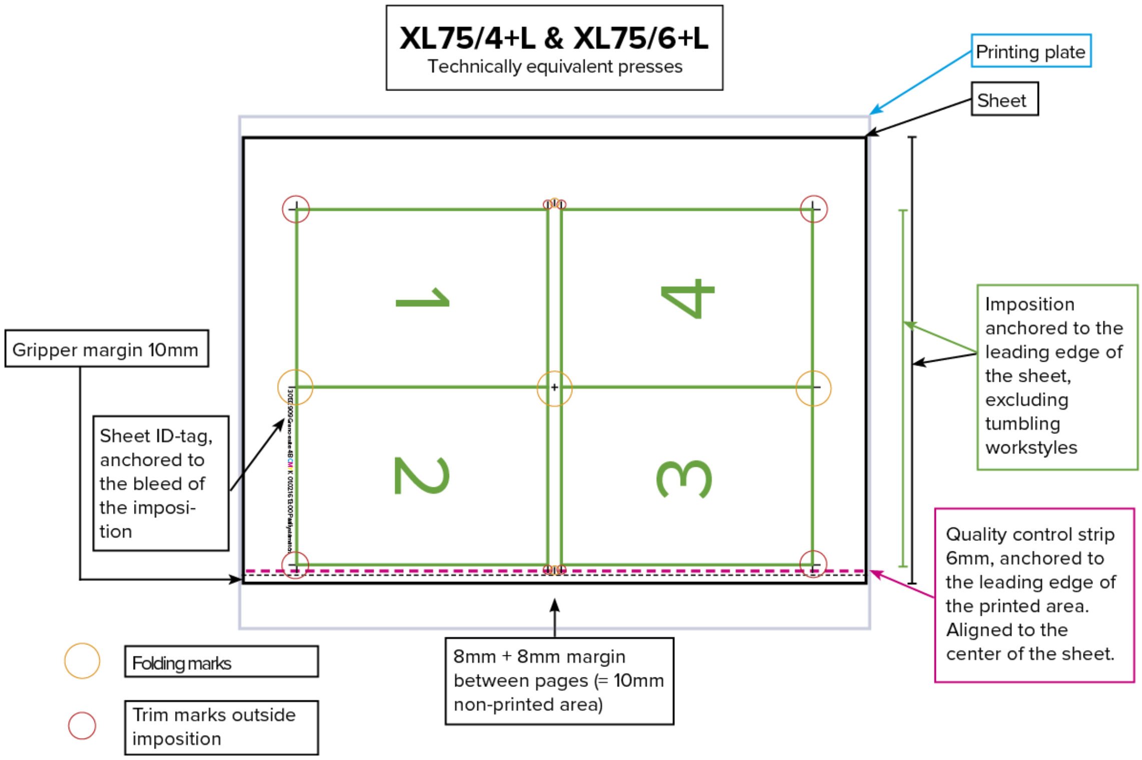


Figure 16. The imposition requirements of printing presses used. (Translated from Rami Paakkinen, development manager, 16.11.2016, personal communication.)

Because of the perfecting method the 10-colour press requires the plates to be imposed in tumbling workstyle, which benefits from anchoring the imposition to the centre of the sheet, resulting in better register accuracy for tumbling. It also requires the quality control strip for automatic colour adjustments to be located to the rear edge of the sheet, unlike the 4 and 6-coloured presses. Another detail that is common to all the B2 presses is the need for a 10mm wide unprinted area in the middle of the sheet to accommodate a sheet guidance roller.

The way these production details affects the automation project is mostly in the details of the imposition workflows to be developed. The way the requirements are achieved depends on the properties of the workflow software used and the possibilities in designing a suitable workflow to make the best complete process within the given limitations.

4.2.2 Analysis of Completed Jobs

In addition to the technical requirements, an investigation for the characterisation of completed jobs was carried out. This was done to aid in both directing the automation efforts to suit the type of jobs produced, as well as to aid in evaluating the extent to which a specified automated workflow could be used in practice. The investigation was carried out by collecting relevant job specific data from the production monitoring system of the company, by choosing four different weeks and collecting data of all completed jobs, excluding jobs where required information was not provided in the job order. Also excluded were self-copying forms and envelopes, as these were not deemed relevant to the investigation due to their specific requirements and low volume. 352 entries were recorded from the Vantaa production site. This data was then analysed to provide an overview of the type of production typical for the plant. The most important findings were related to the amount of variance in page count and size, as these are some of the most influential properties of the products in terms of imposition and the requirements for its automation.

It was found out that the products are highly varied in terms of sizing and page count. 109 different page sizes were recorded for the 352 jobs with concentrations only in the standard A4 and A5 sizes, the other sizes ranging from 0,3% to 3,1% of the total job count. A simplified spread of page sizes is provided in table 1.

Table 1. The percentage of jobs in different page sizes. Because of the large number of rarely used page sizes, the less common sizes are grouped as other.

	PAGE SIZE			
	A4	A5	Other	Grand Total
TOTAL	31,5 %	13,6 %	54,8 %	100,0 %

Page count of products varied from 2 to 232, with a large emphasis on 2 and 4 paged products, which is typical for commercial printing. However, the presence of bound products is also significant and thus needs to be considered when specifying the required automation. Table 2 displays the percentage spread of different page counts.

Table 2. The percentage of different product page counts (6 and 10 paged products imply folding).

PAGE COUNT	TOTAL
2	51,7 %
4	15,3 %
6	3,4 %
8	8,4 %
10	0,3 %
12	5,3 %
16	3,7 %
20	2,5 %
24	2,2 %
OVER 24	7,2 %

In addition to page count, binding type affects the order and orientation of the imposed pages. The data gathered shows a large majority of unbound products and saddle stitched booklets. The practical ordering and sorting of pages is handled by the workflow software, so their effect is mostly on the required workflows and the logic behind choosing the correct one. The amount of different binding types is presented in table 3.

Table 3. The percentage of impositions to accommodate different binding types.

	BINDING TYPE			
	Not bound	Saddle stitched	Perfect bound	Grand Total
TOTAL	73,7 %	23,1 %	3,2 %	100,0 %

A general theme in the production of the company can clearly be seen from the data collected. The production is characterised by the variance of products, although also clearly limited to the technically simpler products with faster turnaround times. This variance is further pronounced by the varied machinery used, and the requirements it establishes for efficient high quality production. The complexity caused by this is illustrated in figure 17, where the data from table 1 is distributed on the used sheet sizes.

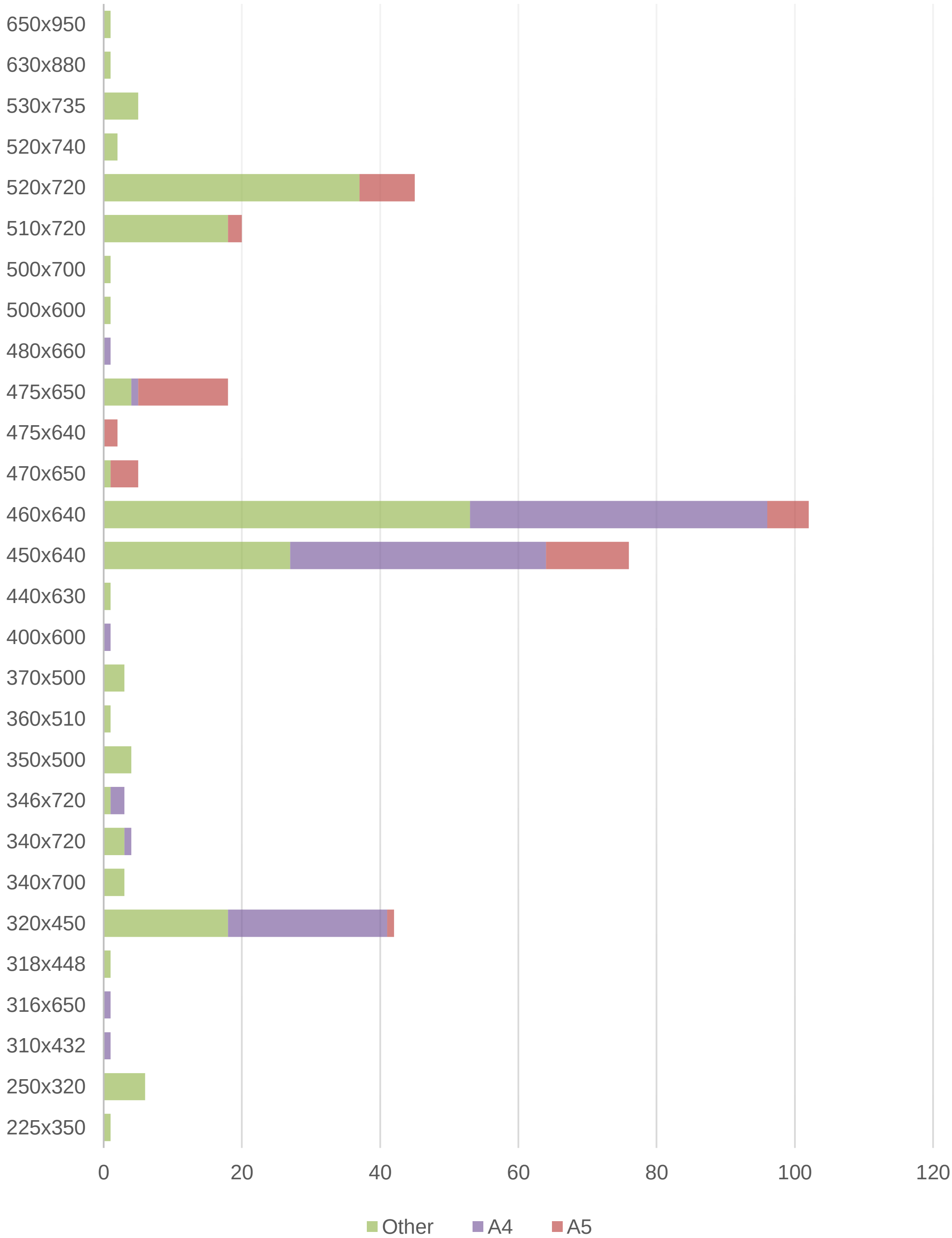


Figure 17.The distribution of common page sizes by sheet size. Measured by number of jobs.

This variance in production is one of the main reasons for the complication of implementing automated imposition workflows in commercial printing. This is also one of the main reasons why flexible and intelligent automation could benefit the printer by providing consistency, reliability and speed for prepress workflows, but the requirement is a well implemented integration to production systems to provide the necessary data for efficient automation.

4.3 Specification of the Workflow Processes

Having studied the requirements for automation of imposition, the used workflow, Screen Equios, was taken under inspection. As discussed earlier, a prototype demonstrating the properties of Equios and the principles for its operation was defined as the goal of the project. To achieve this goal, the workflow was divided into several parts, namely file input to Equios, the imposition processes and their automation, and the produced output from Equios for later stages of prepress and printing. In addition to this, some parts of file input and imposition processes had to be treated separately to improve the flexibility of the workflows.

The basic functionality of Equios is typical for an offset workflow. The main view is comprised of a list that can show jobs or templates and their processing stage as well as other simple info. Jobs are created either based on pre-defined job templates that include workflow information for the further processing of the job or manually so that a new workflow is defined. An imposition template can be included in a job template, or a new one can be defined manually. The imposition editor is a basic one and functions by placing a number of pages on a sheet and defining their order when imposing bound products. This is easily done by utilising Equios-defined or JDF-based folding catalogs. The main window of the imposition editor used for creating imposition templates is presented in figure 18.

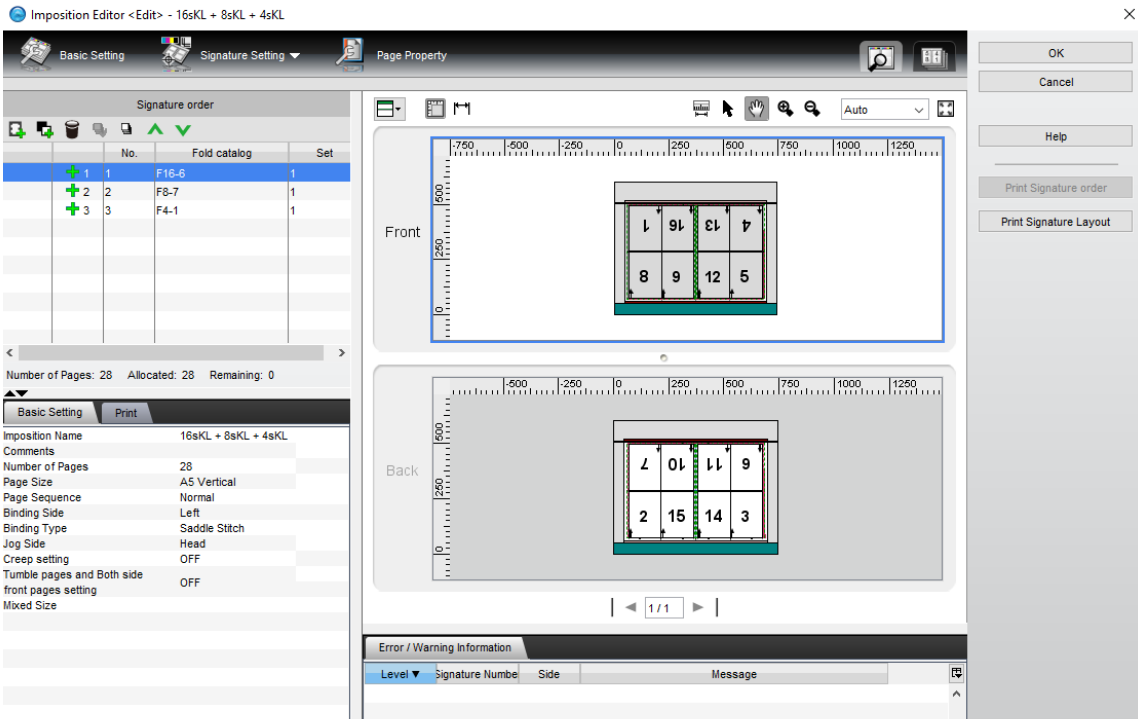


Figure 18.The imposition editor used for creating imposition templates.

Several impositions can be used in a single imposition template, as can be from the table below signature order in figure 18. This is useful for example when printing a 24-page A5 booklet on a B2 press. In this case 16 pages fit on a single sheet and the remaining 8 pages can be printed 2-up, saving paper and printing time.

After the PDF file is registered into the used imposition scheme, an imposition proof may be output, if necessary. When approved, the imposition is processed by the RIP resulting in 1-bit TIFF files that are used for platemaking. Figure 19 shows an example of an Equios job template.

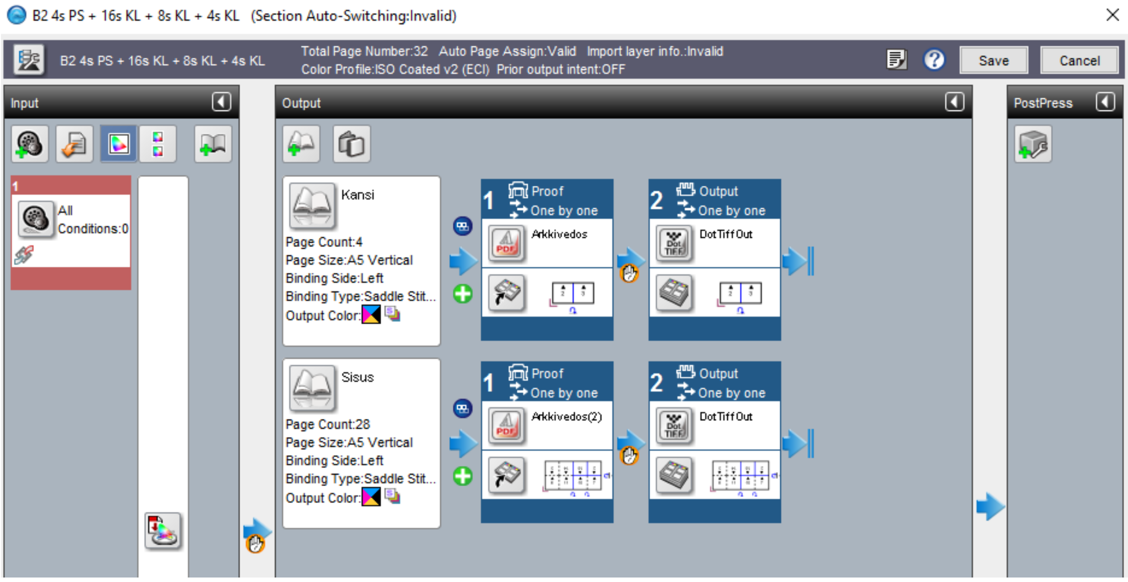


Figure 19. An Equios job template containing separate workflows for cover and body sections.

The workflow presented in figure 19 begins from the input process shown on the left, which contains settings related to the properties of the PDF file to be processed. The file is then manually registered into the correct section or sections and into the imposition template specified for the section. After this, an approval begins the imposition proof process according to the settings specified in an Outline PDF (a lightweight PDF format used in Equios for proofing) ticket, which is set for the proof process (number 1 of the output processes). The way the output process functions is also based on a set ticket, called DotTiff in Equios, which controls output to 1-bit TIFF files for each printing plate. Another option would be to output directly to a CTP platesetter, but 1-bit TIFF files are more suitable for vendor agnostic use. After processing with a RIP, information about the job is usually generated into a PPF file. Equios only provides identification information for the job and the plate and data for pre-setting inking on the press. This is rather limited compared to many other prepress workflows for offset printing. The processes performed in the workflow are examined in greater detail in the next chapters.

4.3.1 File Input and Registration

Beyond manual file input methods Equios has a feature called Simple Job Creation Interface, which can be used for importing job info, PDF files and setting several parameters for the imposition and output workflows. The interface functions by using a tab-separated values (TSV) file containing the information for processing. This is beneficial because it is relatively simple to add a functionality that outputs files of this type from production systems, which enables the automation of data flow between systems. From the imposition point of view, the ability to control parameters of imposition vastly improves the flexibility of the workflows compared to traditional hot folder automation. Naturally, the important point here is that the input parameters do not need to be manually entered into the imposition workflow but originate from job properties in the production system.

For demonstrational use, a .csv file created in Microsoft Excel was used. The command file consists of two parts, setting creation and file registration. Setting creation is used to define the parameters of the job, the used workflows and sections of the job, and file registration to specify the PDF to be imposed and how it is placed into the imposition. The parameters are generally input in key-value pairs. However, section definitions are input in a more array-like form. An example of the command file is given in figure 20.

<CreateSetting>									
JobName	A4 28s								
JobTpl	B2 4s YA + 8s KL + 4s KL								
Customer									
OrderCode									
DueDate									
Comment									
BindingType	SaddleStitch								
Amount	5000								
%%Section	Name	WorkStyle	BindingType	PageSize	PageNum	FoldingCatalog	FolioStartNo	OutputWFTpl	OutputMediaSize
%Section	Cover			210.0 297.0	4			Silk	
%Section	Body			210.0 297.0	24		2	Offset	
<RegisterFile>									
JobName	%CreateSetting%								
IsDeleteInputFile	FALSE								
%%InputFile	FilePath	StartJobPageNo	EndJobPageNo	ReFileName					
%InputFile	\\filepath\demo\file.pdf	1	28						

Figure 20. An example of the .csv command file used to control Equios by utilising Simple Job Creation Interface.

The most important command file parameters for understanding the principles of the process are JobTpl, Section, OutputWFTpl, OutputMediaSize and the differences between PageNum and Start- and EndJobPageNo. JobTpl is used to select the used workflow template from the ones saved in Equios, which contains the information for the processing steps and required approvals, imposition, work style and sections of the job. This is where most of the basic information regarding the processing of the job is located. The section array is used to control the parameters of different sections of the job (such as cover or body) and can also be used to decide when not to use a certain section. It also allows the use of OutputWFTpl to choose between output workflow templates mainly to choose different plate profiles for different substrate types, and OutputMediaSize to adjust the sheet size. Finally, the PageNum property of section is used to specify the page allocation into the job templates sections, while Start- and EndJobPageNo control the pages of the input file that are to registered into the workflow template.

The input process for the job data is quite simple, and it is based on utilising the pre-set workflow templates. After the command file is moved to a hot folder located in //host name/HFLink/sei, a new job is created based on the job template and the job identification data from the command file. An input process is specified in the workflow template, which can be used to issue input process tickets, define colour conversion settings and control further processing through input conditions. An input process ticket is the main instruction set used to control the processing of the input file. This includes controls such as rules for processing spot colours, overprinting and preflight using PitStop profiles. Colour conversion settings can be defined for different input colours, as well as being controlled by input conditions. Input conditions test the input files against different PDF-based properties, such as page count, page size (by utilising PDF TrimBox definition), output intent or inclusion of transparencies or spot colours. This can be used to control the later processing of the file, and was used in the demonstrational implementation for controlling the workflows of unbound jobs by classifying them for different imposition schemes based on page size. (Screen 2016, 67-72, 330-338)

When using input conditions to direct jobs to certain sections the logic of the system changes: the use of section parameters in the command file will cause the section definition and the input condition to conflict resulting in an error. This can be worked around by removing the section array from the command file. However, this also results in not being able to access the parameters nested under the section controls, most importantly output workflow template and output media size. Despite this, the intelligence that input condition testing brings to the system, regarding the imposition of variably sized pages, was deemed beneficial enough to be used in the workflow of unbound products.

The last part of the input process is the registration of the file into the specific imposition scheme that is used. This basically means using the page numbers, defined for the PDF and the section in the command file, for placing the pages of the PDF into the imposition scheme set for the section in the workflow template. The number of pages is used to control the type of signatures set in the template, as well as the order the pages are placed into the scheme (this results from the binding type of the job, as well as the folding scheme of the imposition. The complete workflow when utilising automated job data input is illustrated in figure 21.

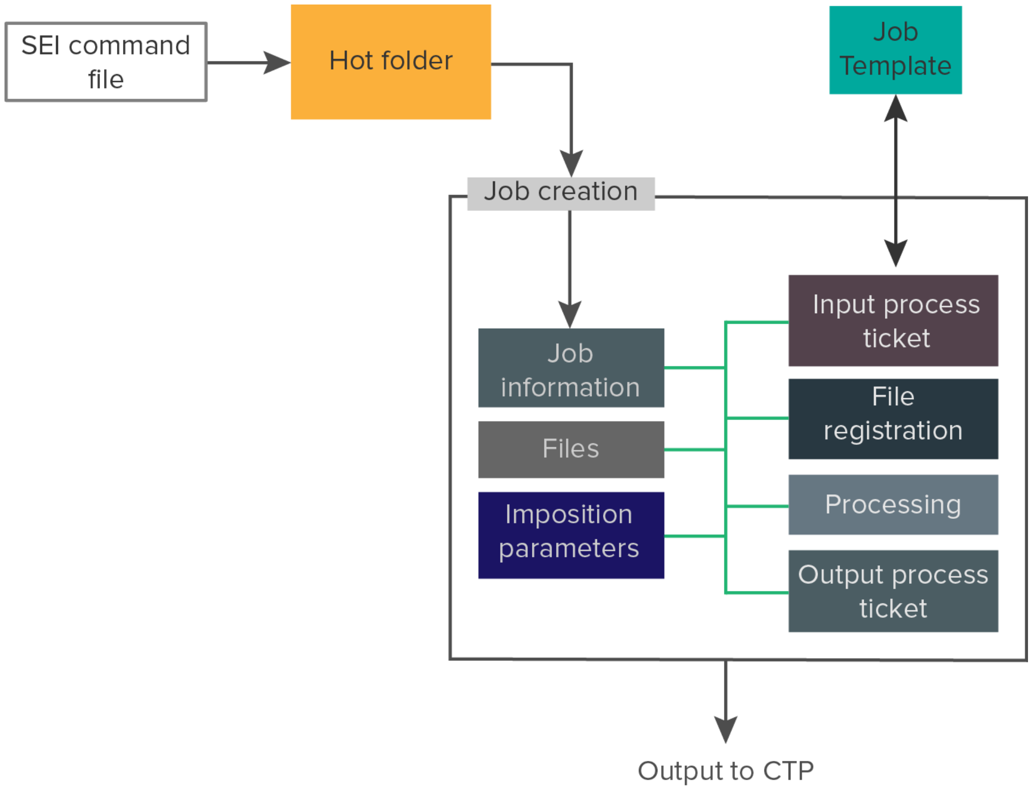


Figure 21. Prepress workflow based on automated job data input.

The role of automated job creation and file registration is crucial for the functionality of automated imposition, as this currently tends to be the most manual and labour intensive phase of the imposition workflow. This is the result of the use of pre-defined imposition schemes used often for the imposition of standard jobs. It is also likely to be the most demanding task to automate, as the choice of workflow or imposition scheme means extending the process automation from linear, repeated steps into more intelligent, data based automation which is capable of simple decision making.

4.3.2 Automation of Imposition

In addition to intelligent job data input and registration the flexibility of the workflow will benefit largely from streamlined and efficient imposition process. Even though static job templates and imposition schemes are common in modern prepress workflows, they are likely to cause bloating in the prepress systems, which further increases the risk of errors in manual systems and complexity of automated systems, posing bigger requirements to the input phase of the process as well as making them harder to manage or develop efficiently. This is similar to any overly complex system or process.

Equios does not provide flexible imposition automation suitable for bound products, so a more basic approach was used by creating separate job templates for impositions of different page counts and work styles. This means that instead of the template adapting to the job properties specified, the used job template should be specified in the production monitoring system. As an example, a workflow used for the sheetwise-turn printing of a 20-page A5 booklet, with the cover printed on a different paper, would be a 16-page sheetwise-turn workflow with a separate workflow for the cover (4 pages) which would be printed 4-up. This workflow could be used for any products that fit 16 pages on the used sheet, regardless of the page count or the inclusion of a separate cover (as this can be deleted in the command file). However, the workstyle of the workflow cannot be changed, so for example a product imposed for the 4-colour press in sheetwise-turn workstyle could not be used with the perfecting 10-colour press, as the perfector functions in tumble workstyle.

In addition to the basic workflows used for bound products, Equios' Section Auto-switching workflow type was used to create more flexible imposition process to be used for unbound products. Auto-switching enables the sorting of jobs into different sections of the job template according to input conditions. To utilise this, the page size break points for different number of pages on a sheet were calculated, and the results used as the input conditions to choose the most economical imposition. The benefit of this compared to a normal workflow is that the selection of imposition scheme is done in Equios, simplifying the process for the user. An example of an auto-switching job template is shown in figure 22.

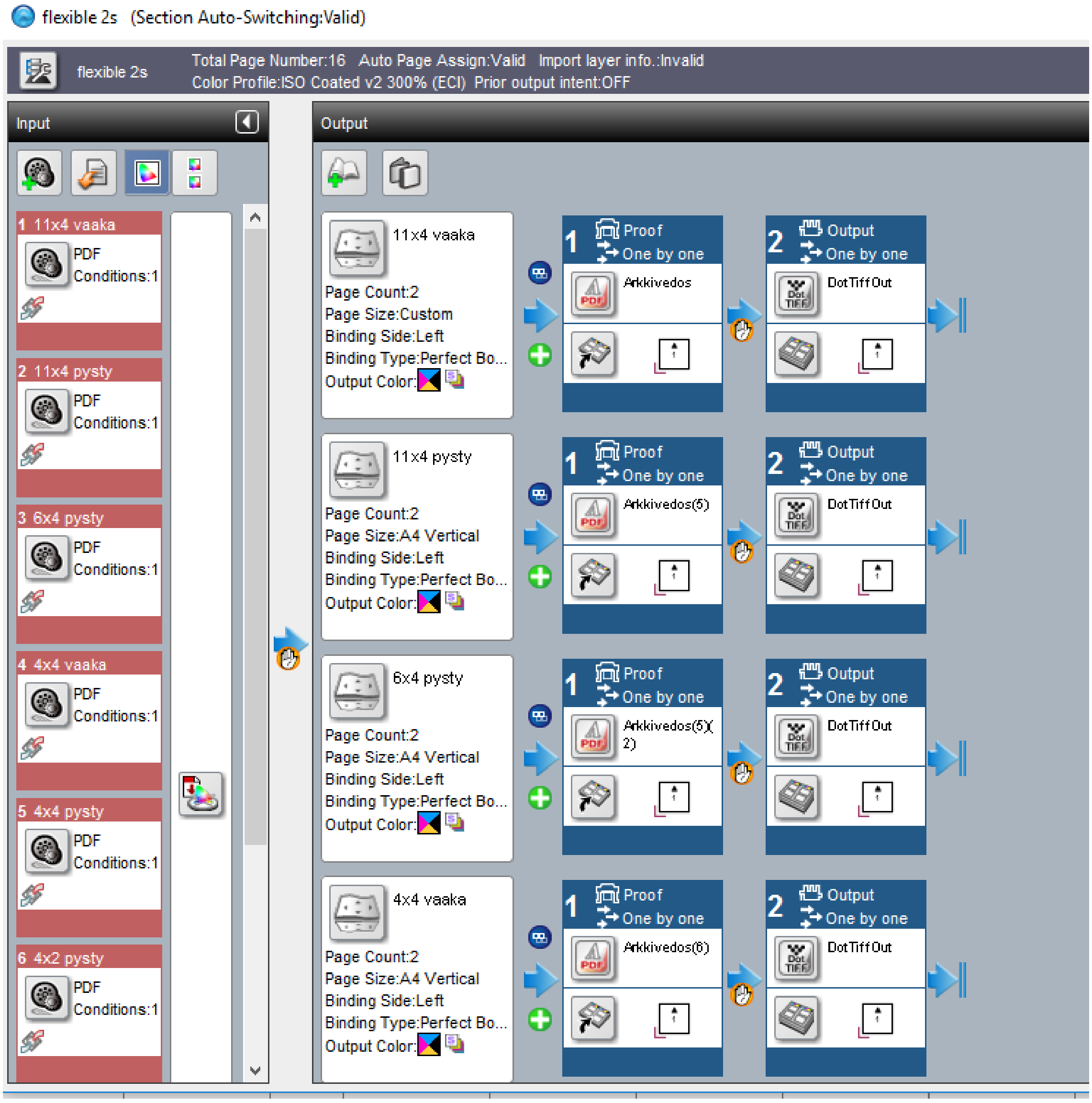


Figure 22. An example of an auto-switching job template, where sections are chosen based on the page size of the input PDF file.

As figure 22 illustrates, even a demonstrational workflow starts to become alarmingly complex, when compared to the underlying logic (determining the number of times a page fits on a sheet).

The state of automatic imposition in Equios is elementary in terms of the flexibility of the process. This is challenging when building workflows that should provide high output of flexible products. The lack of flexibility can be worked around in several ways, but the result is unlikely to be as successful as a solution that would be planned and built into the workflow software.

4.4 Results

Several workflows were built to demonstrate and answer the different needs of the company. These were two workflows for the automated imposition of unbound products and four workflows for the prepress production of bound products. Equios lacks imposition automation and functions only based on predefined imposition templates. Although the templates will allow page size changes, the scheme used is not flexible. This was surprising considering that Equios also includes a mode called Autogang which calculates the number of pages or jobs that can be fit on a sheet. However, Autogang cannot be operated by using the Simple Job Creation Interface, which is crucial for the integration of the workflow to the business systems of the company. This problem can be theoretically worked around for unbound products due to their simplicity, but the related complexity and the inconsistency of workflow types and their operation resulting from this are major drawbacks. The process differences between bound and unbound products are illustrated in figure 23.

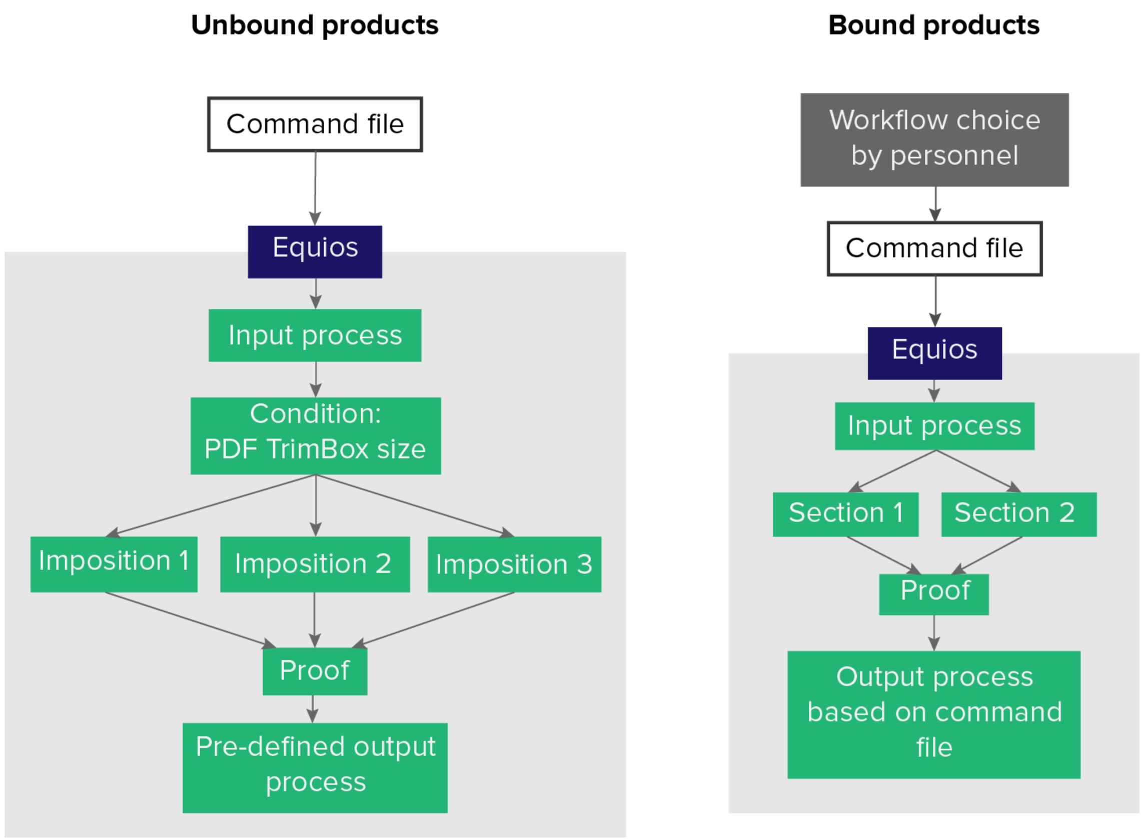


Figure 23. The differences in the principle of bound and unbound workflows.

The data transfer model using the command file is functional, although a JDF based solution would be preferred. This also demonstrates the problems in a loose standardisation, where different interpretations of the standard result in non-conforming areas of implementation. Data transfer in Equios works, although problems in consistency between its utility for different tasks, and strange structural choices in the nesting of parameters obstruct some of its functionality.

The prototyped system was tested concisely to evaluate the benefits gained from automation by comparing the manual imposition durations of 5 jobs to the processing time of the same jobs on Equios. The results are presented in table 4.

Table 4. Comparison of the duration of automated and manual imposition.

	Unbound			*Bound*	
Manual	7 min	6 min	11 min	8 min	12 min
Automated	38 s	3 min 28 s	36 s	55 s	2 min 8 s
% of manual	9,0%	57,8%	5,5%	11,5%	17,8%

As can be seen from the table, the time savings are significant. On average the automation only took approximately 29% of the time that would be manually required. It is also necessary to keep in mind that this is inactive time, as the processing is done by the software, meaning that the time currently spent on manual imposition of basic jobs could be spent on more complex problems that require manual control. This test assumes that the job is suitable for automation, instructions are correctly formatted and necessary data input before the job is transferred into the prepress phase. In practice this data would flow from the production monitoring system via the command file into Equios. Another benefit of automation is that in this kind of system the job could be assigned to the prepress workflow by other employees than dedicated prepress operators, given that the necessary information regarding the production workflow would be provided. This could be as simple as pressing a button in the production monitoring system, and thus simplify the production process by removing unnecessary steps and further save the prepress operator’s time when basic jobs could be routed directly to CTP output.

The results of the prototyping clearly demonstrate the benefits that can be achieved from automation, although the feasibility of automation projects and their suitability for the company still need to be evaluated separately, as this is independent from singular tests and prototypes. Also, the feasibility of automation largely depends on the tools used for it, as different vendors provide highly varied workflows which are likely to be specialised to the certain type of companies the providers cater for.

5 Conclusions

The goal of the thesis was to provide information to support an investment decision for the prepress workflow for sheetfed offset. This was done by researching the basic properties and characteristics of prepress and its automation through workflows, examining the requirements set by the production environment and prototyping the required workflow properties of Screen Equios. The findings regarding the properties of Equios were presented to the company and the information gathered was used to support the investment process. This type of product testing is necessary especially when dealing with large investments or technologies that form an important part of the strategy of the company, as mistakes in these cases can be expensive and laborious to correct. Finding objective information to support decisions is problematic when the products are not very commonly in use and the users are likely to be specialised into their own niches. Even though there are internationally lots of information sources for print industry, few of them can provide the depth of knowledge which is necessary when evaluating products.

Although the impact of prepress automation seems significant, it is also necessary to consider the problems that prepress production already faces. Especially file issues and problematic instructions pose threats on the success of automation projects. For example, of the five jobs presented in table 4, three had file issues resulting in 5 to 8 minutes of extra time spent per job on correcting the files. On the other hand, efficient workflow automation might provide tools for identifying these problems earlier or in some cases even utilising automated preflight to correct issues. Nevertheless, file quality is one of the crucial elements for gaining the benefits of automation.

The role of automation is also likely to extend into the strategic thinking of a company, providing opportunities that have earlier seemed unattainable. This should be kept in mind when developing automated systems, as the flexibility of a solution might prove to be important for the further development of production in achieving new goals. Another subject that may have a high impact on new possibilities is the development of new MIS or other production monitoring systems, as well as brand management and web-to-print systems; these could function well together, expanding profitable print production to smaller individual units by reducing the costs occurring from manual labour. As the base layer for much of the later stages of print production process, the significance of prepress is clear. By investing in a meaningful data transfer between the systems the efficiency and flexibility of prepress can be ensured.

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