Sodurga.com Feasibility Study Report

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Executive Summary

1. On-line Bureau for processing CAD (Computer-Aided Design) drawings for Laser Cutting

There is a business opportunity in offering an online service which would tidy up drawings submitted by people who want to have things cut on a 2D laser cutting machine. A large part of the work done by 2D laser cutting firms is the tidying up of drawings, dimensioning of drawings and clarification of drawings. If all this work could be done by an online service before the drawings were seen by the laser cutting firm, the work of interaction between the laser cutting firm and the customer could be significantly reduced.

2. Possibilities for creating an online Open Source CAD package

Large amounts of money are spent by universities on student licences for proprietary CAD packages. This can be seen as a drag on innovation because, should these students then decide to try to start their own businesses, they have to buy their own licenses for the same CAD packages.

At the same time, businesses that are trying to take advantage of the possibilities that the web offers for submission of drawings online are currently faced with the problem of how to get their potential customers, who may have no experience of any CAD packages, to submit their drawing ideas. Several of them have come up with the solution of commissioning their own reduced-function CAD packages which they have integrated into their web-sites. This is unsustainable as a strategy in the long-term.

3. Other business benefits from an online market in 2D laser cutting jobs

There are several business benefits that might come from directing 2D laser cutting jobs that might be done by several suppliers through one single aggregating web-site, both for customers and suppliers. A supplier might be able to take jobs at a discount in order to make sure that he has filled a sheet of a particular material with cutting jobs, so that no material is either wasted or required to be held in storage. A customer might, through such a site be able to navigate to suppliers that specialise in certain processes, or certain materials – for example if a customer requires a job in armoured plate, the main criterion for being able to satisfy the job is that

Aim of the study

The aim of this study was to take a big of idea of providing an online market for the manufacture of anything – "An Ebay for making stuff" and explore the feasibility of this idea within the single focussed market of 2D laser cutting. The study also aimed to develop relationships and possible partnerships and collaborations with people in the field of computer numerical control and 2D laser cutting.

Details of the study

The study consisted mainly of a series of site visits and interviews. We visited a wide variety of people who have some part to play in the current supply chain of cutting of 2D shapes using lasers and also other computer numerical controlled (CNC) processes such as waterjet and flame cutting. We talked also talked to a other people who are involved in many diverse aspects of the 2D laser cutting supply chain. We talked to four companies that currently undertake 2D laser cutting jobs that varied in size from 2 – 200 employees. We also talked to administrators and researchers in universities that have their own in-house rapid prototyping bureau, one of whom is currently studying for a PhD on the subject of computer-aided design software and rapid prototyping.

We also talked to potential customers for the kind of on line service that we propose, from professional users such as architects who use laser cutting to create architectural models through to potential retail consumers: mums in a school who want to make novel Christmas decorations. We talked to micro-businesses about the difficulty of getting design ideas manufactured, both here and abroad. We also talked to people who design, manufacture and maintain laser cutting machines.

This report summarises the main findings from the first-pass processing of these interviews, which has been possible with current levels of time and resources. As part of this process of exploration, we also identified many other people connected with the process of 2D cutting using lasers, water jet and flame cutting that we did not have time to talk to as part of this piece of research.

Findings

Problems with proprietary CAD packages an Open Source opportunity

Input to the process of 2D laser cutting are drawings in the form of files produced by computer aided design – abbreviated to CAD – software packages. From discussions with laser cutting businesses and staff who operate laser cutting machines in university workshops we identified several major problems with the current CAD software that is available. Firstly, most CAD software is proprietary and expensive to license. Even for educational use, licenses aren't cheap – for one of the cheaper CAD packages - Rhino, licenses are £140 per seat or around £1800 for thirty-seat lab licence. This problem of licensing costs is compounded when students who have learnt how to use a proprietary CAD package decided to start a business on their own. They must then pay a commercial licence to use the software that they learnt with at a point when they have no money and no longer qualify for an educational discount. The temptation to use illegal software is strong – as one person we talked to put it: *'"Guerrilla" engineers tend to have cracks (Illegal downloads and passwords) for all of the big packages. You train how to use the software at uni, then you leave to start up on your own. What do you do? Fork out £20,000 for software?'*

This hints at another problem with CAD software packages. Because the software is closed and the users do not have access to the software code, there is no way of knowing for sure how a complicated surface is being represented by the package. One particularly frustrating aspect of this is that the best ways of representing complex shapes is often found in open source software which has been developed by academics and is shared freely, yet there is no easy way of integrating this work into commercial packages.

Drawings done in one package are not fully interchangeable with drawings done in another package. For example, several of the laser cutting companies that we talked to cited the problem of a CAD package appearing to have created a curved line in a drawing file. However, depending on which package is used, and how drawings have been swapped between drawing packages, this curve could end up being represented as a very large number of short lines. If this is not spotted before the file is sent to the laser cutting machine it could result in a job taking far longer than anticipated – thus costing far more in terms of machine time which is a scarce resource. In extreme and unfortunate cases, for example where the material being cut is plastic, such a mistake could result in a fire.

For this reason, many of the laser cutting companies that we talked to had gone to the expense of having licensed copies of all the leading CAD software packages. This is a clumsy, but necessary measure to ensure that they can handle files in every possible submitted format and make sure that they are financially and literally safe to send to their machines.
It seems clear that there is an opportunity to create an easy-to-use open source CAD software package. Rather than starting from scratch, it may even be possible to start with existing software packages such as Blender and incorporate the latest mathematical research on the

representation of complex surfaces. Given the enormous amount of money spent by design schools and engineering schools on licensing, any development funded by the schools would probably pay for itself in a very short space of time.

The main work of laser cutting – the job of processing drawings

The difficulty in obtaining licences for CAD packages, combined with the difficulty in actually using the packages even if access to the packages can be obtained, perhaps explains why many of the job requests submitted to laser cutting companies are not in a recognised CAD format.

We've just got autoCAD. Which reads DXF's and drawings. But oh, the number of people that send thing in now as PDF's - as Tiffs - just scanned in for their little scanner and it'll come through and it's only half dimensioned. And then you have to ring them up - "Well can't yer scale it - well, yeah I can but it's not going to be that accurate [laughs]

This same company received up to half of it's job requests in no computer file format of any kind, but as faxes. As a result of this wide variety of request formats, a substantial amount of the work in processing a 2D laser-cutting job is the processing of the request into a format that can be accepted by the laser cutting machines. One company that we talked to estimated that it dealt with about 2000 requests for work every month, of which between six hundred to eight hundred resulted in jobs that would be produced. Processing these jobs and making sure that for each job a DXF CAD file was created that would be acceptable to the laser cutting machine required the services of 6 full-time trained draughtsmen.

Creating a file is a skilled job which requires considerable knowledge of the capabilities of laser cutting machines and of CAD software. Most fundamentally, the draughtsman has to make sure that the drawing is the right size:

We've cut the DXF files that people have sent and insisted they were right and they go "Me bits ten times smaller than I thought it would be". Right, well we've cut to your DXF and when you look. Lots of things. They've actually drawn it in inches and labelled it in mills. They drawn 10inches long and labelled it 100mm. Or they've drawn it in centimetres when they actually wanted it in millimetres and it's ended up 10 times bigger.

Other things have to be considered are making sure that parts of the drawing that are supposed to be joined up are actually joined up and, as mentioned before that curved parts of the drawing are actually represented as curves and not as a very large number of lines. Even after all this processing, the drawing still requires more process, which requires intimate knowledge of the capabilities of individual laser cutting machines and the way they move. For example – a sharp ninety degree angle, as might be shown on a drawing of a square will cause the laser cutting head to stop and then start again.

P: If you have a rectangle for example. A lot of people do square cornered rectangles. Now for that, the machine would have to slow down, come almost to a stop and then set off again. If you put a small radius on the corner - [waves hand] same speed all the way round.

Interviewer: So if somebody sends you something that's square - do you go into the file and put a radius on it.

P: We tend to put a small radius

Similarly there are many other details connected with the width of the line that does the cutting, the size of hole that can be cut relative to the material and where the cutting starts that have to be decided at the drawing stage.

P: Because when you lead into a material, you've basically two options. You lead in, run round the job and then you come back to come out again, you can either come out just before you went in, in that case you end up with what we call a tit. Or, you come in just after you

went in, in which case you'll get a scar. Now some people don't like scars, some people don't like tits.

The possibility of processing these jobs on line

The main finding from this piece of field work is that that a large part of the work done by laser cutting companies is the processing of "drawings". These drawings are not all submitted ready for direct submitting to the laser cutting machines, but are rather submitted in a wide variety of formats, a substantial number of them are submitted as faxes, some of them are even submitted as back of the envelope sketches.

From our point of view this is an opportunity because this is exactly the kind of work that can be undertaken on line. We can imagine an on line bureau where skilled draughtsmen would accept drawings in almost any state, back-of-the-envelope sketches, faxes, drawings created in graphics packages and also drawings created from CAD packages. The draughtsmen would, for a fee turn these drawings into CAD files that could be fed directly to laser cutting machines. This is a skilled job, requiring knowledge not only of CAD packages, but also of the specific requirements of creating CAD files for use with laser cutting, flame cutting and water jet cutting machines.

It would seem that such an on line bureau might be a threat to the jobs of the people who currently undertake this work at large laser-cutting companies such as some of those that we interviewed, however this need not be the case, rather such companies could offer the services of their skilled draughtsmen – at a premium - to other companies.

Such an on line bureau would be an interesting first step towards an "Ebay for making things" which is our ultimate goal.

Next Steps

Our intention now is to develop a prototype site which would allow almost anyone to submit a "drawing" – this would include files in the wide range of formats that we have seen that existing laser-cutting companies take, including faxes, pencil sketches, scanned tiff files and pdf files as well as files generated directly from CAD packages. This site would then allow people skilled in taking these files to offer to re-draw these files so that they are suitable for laser cutting. It is not clear how this process of offering would work. Our first thoughts were that it might be some kind of reverse auction, but several of the people that we interviewed were resistant to the idea of reverse auctions and a system of agreeing a price and paying for work would probably require further investigation. A large number of the transactions on the world's most famous auction site – Ebay, are not really auctions at all, but transactions for a fixed price and some other sites that work in this space – such as Elance.com do not enforce a strict reverse auction, but rather allow the user to accept bids and decide between them as they see fit, based not only on price, but history and reputation.

As with these sites, our laser-cutting drawing bureau (for which we obviously need a better title) would allow people who submit their drawings based on criteria other than price, such as reputation.

It may be that some draughtsmen would specialise in difficult jobs – jobs that start with a pencil sketch or just a rough description. These draughtsmen would be prepared to engage in a dialogue with the customer to get the drawing to a stage where it was suitable for submission for laser cutting.

One crucial aspect of such a system is that would need to allow the laser cutting company to give some kind of idea of its capacity, for example the capabilities of its machines and the kinds of materials that it can stock.

Such a system bypasses the current problems that are experienced with proprietary software – those who want to create drawings are either not trained in the use of expensive to license CAD software, or, even if they are, may not have access to it. Rather, people who are skilled in taking imperfect drawings in almost any format and who understand the requirements and tolerances of laser cutting machines can – for a fee – use their CAD expertise to tidy up drawings to the required standard. As mentioned above, several companies have tried to offer a web portal to their laser cutting capacities. Many of these have tried to solve "the drawing problem" by installing a proprietary drawing package as part of the site. Others have simply allowed potential customers to upload their files accompanied by a series of strictures on the web site attempting ensure that the drawings are in a form that is suitable for submission to the laser cutting machines. Our suggestion of an on line drawing bureau solves the problem by exposing it on line to the expertise of draughtsmen, rather than trying to solve it with either yet another piece of custom proprietary software or a series of complicated technical instructions.

A drawing bureau would offer considerable benefits to clients. However, it is possible that such a service could offer a large benefit to companies that offer laser cutting services.

Opportunity for specialisation

We expected to find that large laser cutting companies would be the least accommodating to unusual requests and that smaller companies would be more tolerant of them. We in fact found completely the opposite. One of the larger companies that we talked to were prepared to talk to anyone about a job, and in fact in several cases had undertaken unusual one-off jobs with no drawing at all.

In contrast the smaller and medium-sized laser cutting companies, especially the one and two-person micro businesses are much more reluctant to take on idiosyncratic jobs. One of the laser cutting companies that we talked to, a two-person company saw dealing with such idiosyncratic requests as waste of time and possibly a very expensive distraction.

P: I mean we had a guy in the other day who just turned in out of the blue. "You cut steel don't you?"
"Yeah"
"I'll tell you what I'm after, I want four blokes and a rope pulling a lorry. 'cos we're having a lorry pull and I want to make an award." So one of our guys drafted him something up.
Inteviewer: You did it!
P: Yeah! I mean why not - you know. We'll not turn much away.

In comparison, one of the smaller laser cutting company that we talked to had a firm limit of £250 on the size of a job. A lot of this reluctance to take on idiosyncratic jobs is the understanding – often gained from bitter experience - of the expense and risk involved in developing the drawing of an unusual idea to the point where it can be submitted to a laser cutting machine. By creating an on line drawing bureau, the process of finalising the drawing – and the risk associated with it - is separated from the process of cutting the material in a specific material, in this way, draughtsmen may be able to specialise, not only in creating drawings which are idiosyncratic, or in a specialised field, but also in pricing such jobs and making money out of them. This then leaves the laser cutting companies to specialise only on the manufacturing, the cutting and the handling.

Opportunity to take jobs, possibly at a discount to fill up a sheet

One problem common to many laser cutting companies is that they often do not have enough jobs which are to be cut from one material to fill up a whole sheet. At the moment, there are only two ways to solve this problem. One is to cut the jobs that need to be done now from a full sheet, and then, either waste the rest of the sheet or store an unusual-shape piece of sheet in the hope that at some point in the future other jobs can be cut out of it. The alternative is to wait until there are enough jobs to fill the sheet.

Because four to five days is the maximum time that most customers are prepared to wait for a cutting job, waiting until the sheet is full is not really an option. An on-line drawing bureau, which listed jobs which had been brought to the stage where the drawings were ready for submission to the laser cutting machine, could be searched by material. In this way, when laser cutting companies had space to fill on a sheet of material, they could search the on-line drawing bureau for jobs that were to be cut in that material and offer to take these jobs at a discount.

Conclusions

We have identified a possible business opportunity in the field of 2D laser cutting which fits with our high-level idea of "An Ebay for making stuff". This opportunity is a surprise. It is not quite where we expected it to be and could only really have come out of the kind of detailed exploratory research which we have undertaken.

We now intend to create a prototype on-line drawing bureau that would allow anyone to submit a drawing, or even a text description of something that they want of have made and allow draughtsmen to agree, in some method yet to be decided to undertake to tidy that initial specification up to the point where is could be submitted directly to a computer numerically controlled cutting machine. We have agreement in principle from several laser cutting manufactures to try out the prototype.

Appendix 1: Alignment with proposed deliverables

Deliverable 1 - Identifying and interviewing CNC machining companies
Deliverable 2 - Identifying and interviewing potential commissioners

The bulk of this reports details the finding from the extensive interviews we conducted and our findings

Deliverable 3 - production of an early demonstrator platform which allows contact between CNC companies and commissioner

In parallel to our interviewing efforts we did develop an early prototype online bureau (see Figure 1) and did show an early version of it to one of the laser-cutting companies that we interviewed. It was thought when we put together this prototype that the main requirement for online software in this area would be to:

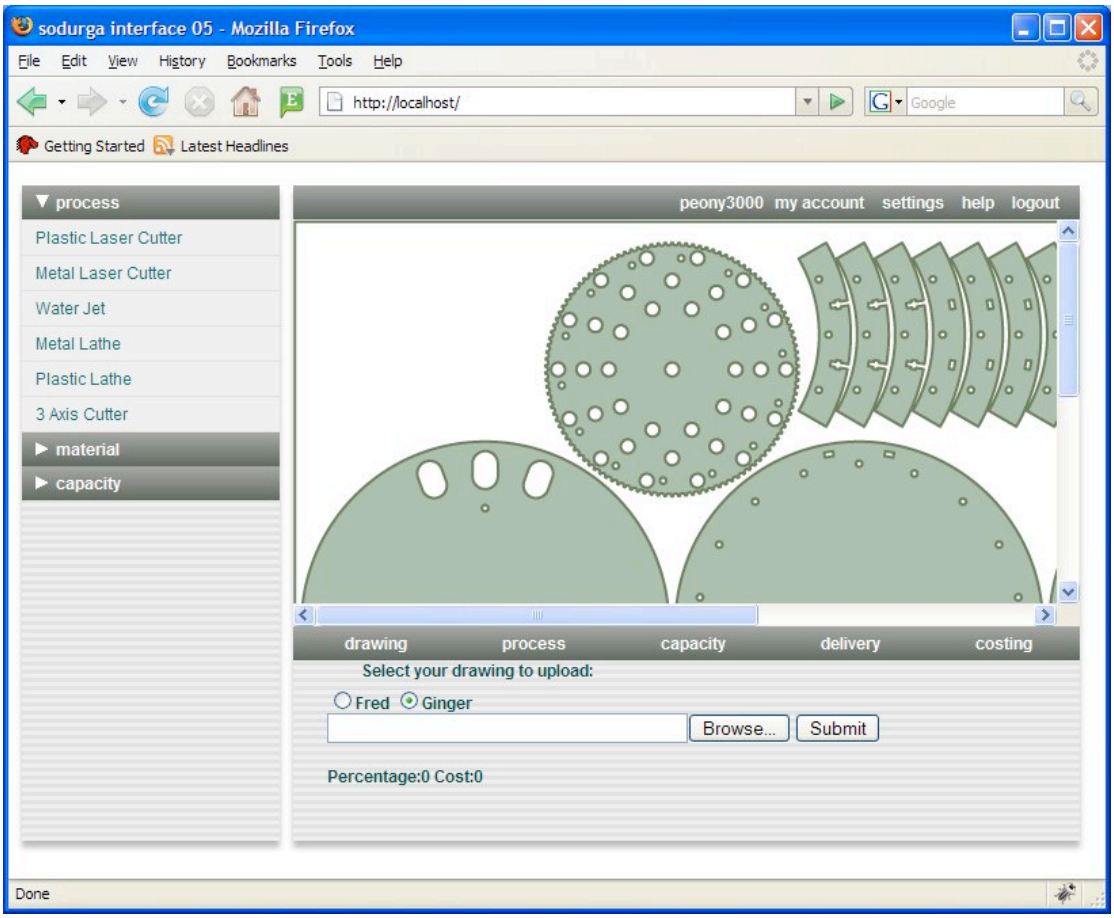
- Allow graphics files in a wide variety of formats to be uploaded to the site and converted into the DXF format – a format widely accepted by 2D laser cutting machines.
- Calculate from the resulting drawing a rough price for the the job, based on the complexity of the drawing.

However, this software did not become the focal point of this research because it became clear through the process of first conducting and then reviewing the interviews that we would need to completely re-think the focus of our software before we could deploy it. The software that we need would be required to:

- Allow users to post graphics file online
- Allow professional draughtsmen to somehow agree a price for the tidying up of drawings with users.
- Allow users and draughtsmen to converse in order to resolve queries regarding drawings.
- Represent some primitive form of workflow for the drawing so that the stages of price being agree, and drawing completed can be represented.

It was however not possible to implement this software as part of this research, firstly because resources had been used to create the first prototype and secondly because the real requirements for this software did not emerge until the very end of the interviewing process.

It maybe that substantial parts of the original prototype, including the interface design and file upload mechanism can be re-used as part of a future prototype.



Run of several proof of concept designs through the platform with selected commissioners and suppliers

This section did not take place as envisaged because, as described above, we did not reach the end of the interview process with a prototype that we felt was suitable for deployment. Instead we studied the process of possible commissioning in two groups that do not currently commission pieces from 2D laser cutting companies, but might do if the kind of online drawing bureau that we outlined in the main body of the report did exist.

After speaking to various laser service suppliers we realised that our preconception about automated accessibility was possibly not the only solution and we should possibly re-evaluate the commissioning process and allow a solution to organically develop.

Design process with inexeperienced users: "Steiner Mums"
Through existing contacts we recruited and gave the Edinburgh Rudolph Steiner Christmas Fair Committee £100 and our contact at Charles Day Steel, Sheffield. We instructed them to make anything they wanted and not to contact us again until they had finished. We selected this group as they are committed to 'hand' making all their Christmas stall goods so they are experienced commissioners with little experience of a formal design process.

Their first action was to hold a design meeting where ideas and hand drawn sketches were generated of snowflake Christmas tree decorations. The elected "Convener" then contacted Charles Day Steel and managed to obtain a quote based on a conversational description of the design over the telephone, but when Charles Day Steel realised that the item was potentially

to come into contact with young children they declined to produce the item as they believed the item might be sharp.

The Christmas Fair Committee then decided to make the snowflake in wood and proceeded to hunt out another supplier. They Googled for "wood laser cutting" and found a company called "Heritage Inlay" on the first results page. Again they managed to obtain a quote based on a conversational description of the design over the telephone. The material, 3mm MDF was suggested by the supplier.

One of the Christmas Fair Committee was a graphic designer who was skilled in the use of the "Adobe Illustrator" application and she generated a vector drawing from the original hand drawn design sketches. When "Heritage Inlay" received this file via email they immediately suggested that the item would be better at 65% the original size in order to achieve the required number of pieces and agreed to supply a sample. When "Heritage Inlay" cut the first sample they discovered that some details were too delicate and burnt out during cutting. Unprompted, "Heritage Inlay" emailed images of this problem along with a new altered design that eradicated this problem.

The Christmas Fair Committee was so delighted with this image that they pledged an additional £100 to double the quantity of snowflakes to be produced. They were very happy with final result when delivered the only comment being a questioning of the choice of material as some people were initially unsure as to MDF's Health and Safety record but a Committee member managed to Google for a UK school's favourable "Health and Safety Assessment".

Design process with inexeperienced users: “Steiner Mums”
Following our interview of the workshop manager on the Architecture course at Edinburgh University we contacted several local Architects and finally managed to interview one. During the interview with Andrew Stoane, a professional Architect and Architecture Lecturer at Edinburgh University, it quickly became apparent that he considered hand model making as part of the creative process. This meant that he wouldn't consider creating a CAD drawing of a building until the client had first signed off the model for production. Detail drawing would then be made and then the building would be built.

He also informed me that he taught this as the design method to his students. This was contrary to previous observations and interviews at Edinburgh University where the laser cutting machines were heavily used and embedded into the creative process.

We tried to interview a new Architectural Practice that might use laser cutting machines as part of their design process but extensive investigation failed to gain a contact. We concluded that rather than poor research being to blame maybe new Architectural Practices also hand made models. A brief interview with RMJM (a large international architechture practice) in Edinburgh revealed heavy use of computer modelling and external model makers who have their own dedicated CNC laser cutting and 3 Axis milling machinery.

We have concluded from these interviews and the commissioning experiment that the accessibility of laser cutting machinery is largely conceptual. The ignorance of the variety of practical problems would seem to be an advantage.