A Nuffield Farming Scholarships Trust Report

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Maximising the efficiency of the UK Sugar Beet supply chain

Paul Fishpool

July 2016

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A Nuffield (UK) Farming Scholarships Trust Report

"Leading positive change in agriculture. Inspiring passion and potential in people."

Date of report: July 2016

Title	**Maximising the efficiency of the UK Sugar Beet supply chain**
Scholar	Paul Fishpool
Sponsor	Richard Lawes Foundation
Objectives of Study Tour	• Understand the principles of an efficient sugar beet and cane supply cane from field to factory or mill. • Benchmark the UK Industry against other sugar beet and cane producing countries. • Understand new and innovative techniques in the sugar beet and cane supply chains. • Develop and introduce new ideas into the UK sugar beet supply chain. • Determine how to operate the most efficient supply chain, from field to processing site in the UK sugar beet industry
Countries Visited	USA, Australia, South Africa, Zambia, Malawi, Slovakia and Spain
Messages	The UK sugar beet supply chain is hugely complex, involving many stakeholders but must introduce change in order to compete post-2017. Total visibility of the whole supply chain is critical to improving its efficiency A better-planned and co-ordinated approach also needs to be adopted to improve machinery utilisation and efficiency Flexibility, planning and communication are key to improving beet scheduling in the UK Harvesters and cleaner loaders are massively underutilised and different working practices need to be adopted Haulage is key to the whole supply chain. By adoption of new working methods and techniques, efficiency can be increased.

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, or of any other sponsoring body.

CONTACT DETAILS

Paul Fishpool
3 Scotland End,
Chippenham,
Ely, Cambridgeshire. CB7 5PN

Mobile 07850 369883

Home 01638 725954

Email Paulfishpool@btinternet.com

Twitter @PFishpool

Nuffield Farming Scholars are available to speak to NFU Branches, Agricultural Discussion Groups and similar organisations

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Southill Farmhouse, Staple Fitzpaine, Taunton TA3 5SH
Tel : 01460 234012
email : director@nuffieldscholar.org
www.nuffieldscholar.org

Chapter 1: Introduction

Although I am not from a farming background, I have grown up surrounded by family friends who are, or have been, involved in the agricultural industry. At first I would watch the tractors and combines working in the fields at any opportunity and then, once old enough, I was allowed to perform my first field operation on my own: rolling grassland with a Ford 4000! Since my childhood I knew I wanted to be involved in the agricultural industry and without a family farm to fall back on I became interested in being involved either in farm management or in the allied industries associated with agriculture.

I studied Agriculture with Crop Management at Harper Adams Agricultural College and graduated in 1997 with a 2:1. During my time there, I also had various part time roles to support my income. One involved soil sampling for a company called British Sugar Plc and, having spent time working for this business, I then knew where my true interests were – SUGAR BEET. Having started working with British Sugar Plc in March, 1998, as a graduate nearly 20 years ago, I have held various roles located at many different factory locations, not only in the UK but also spending time in China. In my current role of Crop Production and Logistics Manager, I manage all aspects of the British Sugar Self Grow operation which involves growing nearly 4000 ha of sugar beet across many counties. I also manage the 300 ha farm owned by British Sugar and manage the Industry Harvesting and Haulage Scheme, which involves organising the harvesting and delivery of 1.5 million tonnes to our processing sites.

Figure 1: The author, Paul Fishpool

I live in Cambridgeshire with my partner Emily who has given me great inspiration in completing my study. Away from work I enjoy playing sport including cricket, shooting, cycling and spending time with my family.

The roles I have undertaken during my career have given me a wealth of knowledge and experience of the growing and processing of sugar beet in the UK. I am so lucky that I am now fulfilling the role I once dreamt of whilst growing up. My study project is driven by my passion for rapid improvement, for I understand the need to promote change in these uncertain times in the sugar industry due to the demise of the European sugar quotas and BREXIT.

I would like to thank the Richard Lawes Foundation for their generous sponsorship and support for my Nuffield Farming Scholarship.

Chapter 2: Background to my study subject

Sugar is primarily used as a sweetener in food and drink. Sugar is produced from two key agricultural sources. Sugar **cane** represents the larger proportion (80% according to the European Commission). This is a perennial grass and is grown in countries in the southern hemisphere. Sugar **beet** is grown in a smaller proportion (20% according the European commission) and is grown mainly in the northern hemisphere.

The largest sugar producers in the world are Brazil, India, and the European Union (EU). While Brazil and India produce sugar cane, sugar beet is mostly grown in the EU where the climate and soil conditions support high yielding sugar beet crops. The largest producers in Europe are France, Germany, Poland and the United Kingdom (*Figure 1*). In terms of sugar beet production these countries are some of the most efficient in the world due to good yield and long processing period (sugar beet processing periods are referred to as "campaigns").

However, EU sugar production is governed by a sugar quota, which primarily sets a minimum sugar beet price and oversees trade agreements. In the **EU** this production quota is 13.5 million tonnes of sugar (*CEFS statistics, 2015*). The **UK** currently has a quota of 1.056 million tonnes of sugar (8% of total EU quota) and 3500 growers, producing nearly 7 million tonnes of sugar beet (*British Sugar, 2016*). In the UK, there is one processor: British Sugar, which operates four factories primarily located in the East of England.

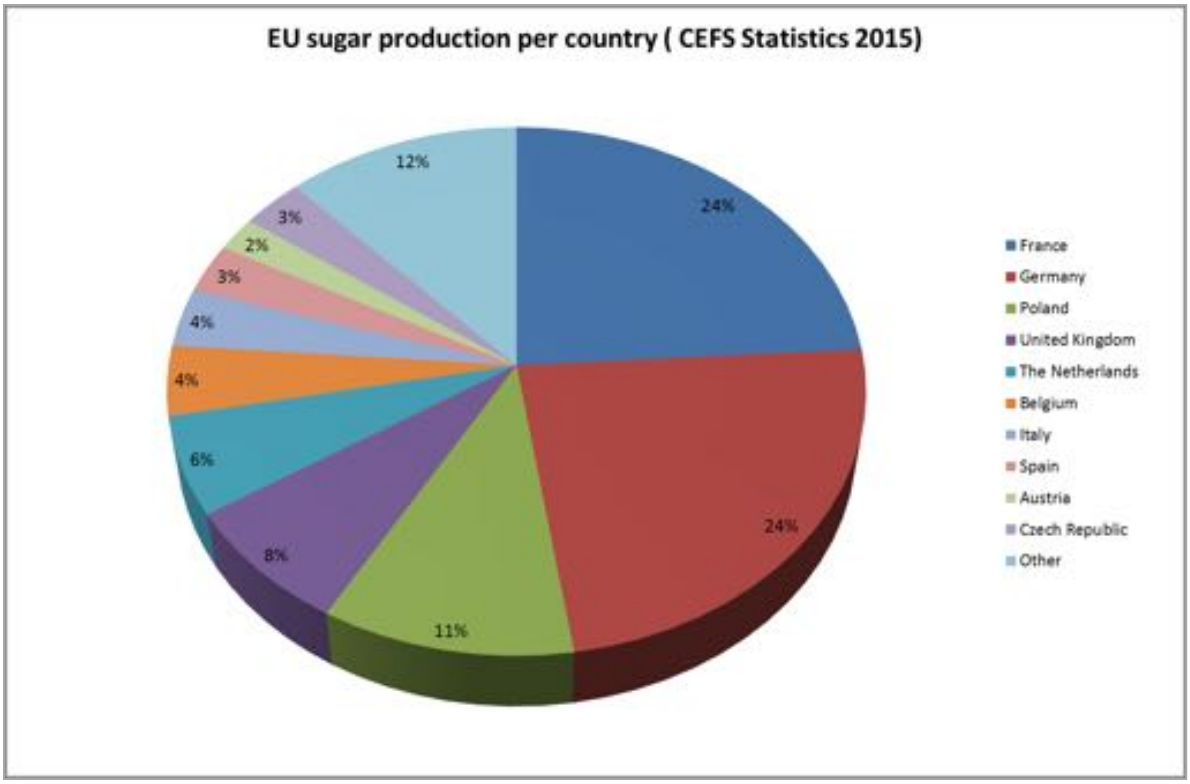


Figure 2: EU sugar production per country.
Source http://www.comitesucre.org/site/wp-content/uploads/2016/03/SUGAR-STATISTICS-2015.pdf

As a result of the reform of the Common Agricultural Policy (CAP), sugar production in the EU is organised into the 'Common Market Organisation of the sugar sector' - also known as the Sugar CMO. The Sugar CMO was reformed in 2006 to substantially reduce quota sugar production - by 6 million tonnes (-30%) according to CEFS Sugar Statistics 2015. This reform also saw the removal of the interventional mechanism that set the minimum sugar price, alongside a 36% cut in the reference sugar price (from €631.9/tonne in 2006/2007 to €404.4/tonne in 2009/2010) (*CEFS Sugar Statistics 2015).* This encouraged less competitive growers and sugar processors to leave the industry, assisted by a restructuring funded by the sugar industry.

This resulted in five factories closing in the UK since 2001: Ipswich and Bardney factories closed in 2001, Kidderminster closed in 2002, and Allscott and York closed in 2007. As in the UK, the EU also saw substantial industry restructuring with the increased need to improve efficiency. CEFS sugar statistics 2015 suggests: '*Virtually every country and region of the EU has been affected. This restructuring process has been radical. In the period 2000-2005, taking the EU as a whole, 68 factories were closed, an average of 11 per year. Between 2006 and 2008 a further 83 factories were closed (almost 28 per year!), resulting in an overall reduction of 60% of European processing capacity between 2000 and 2008.*'

In 2013 it was agreed that **sugar quotas would be abolished by the 30th September 2017, after which sugar quotas for domestic production would end.** The end of quotas will abolish minimum protected beet prices and will open up sugar trade to the world market.

… the world sugar market price reached a seven year low last September.

This had created additional competition in the market to ensure EU processors had sufficient market share for their sugar products, which has resulted in a massive downward pressure on EU sugar prices recently. This is coupled with large global sugar stocks causing the world sugar market price to reach a seven year low last September.

Due to this rapidly adjusting market ahead of the regime reform in 2017, the UK must become more efficient to remain part of, or even competitive in, the EU market. The uncertainty over the latest BREXIT deal further adds to this uncertainty.

Due to my knowledge and experience, I believe one of the key areas of sugar beet production we must ensure becomes more efficient is the beet supply chain, from field to flume, as this represents significant cost in the production of sugar.

Chapter 3: My study tour: which countries and why?

From the outset it was always my intention to visit those sugar processors, growers, and industry experts who seemed to be the most efficient and who fully understood how to run an efficient supply chain from field to processing site. So with that objective in mind I set out to benchmark the UK industry against some of the best sugar beet and cane growers in the world.

> *I set out to benchmark the UK industry against some of the best sugar beet and cane growers in the world*

I began my research by travelling in February to Idaho in the USA to visit The Amalgamated Sugar Company, which processes around 6.5 million tonnes of sugar beet. They currently have two systems of delivering beet, dependent on the time of campaign. The campaign typically starts in mid-September and, dependent on crop size, finishes in mid-March. At the beginning of the campaign beet is delivered directly to the factory and a Just in Time (JIT) system is operated. **(*Just in time is a manufacturing-industry term meaning that supplies are obtained on the basis of what is needed, when it is needed, and in the amount needed*).** The factories have no flat pads as seen in the UK and have little room for storage, so good co-ordination is critical. Sugar beet is loaded from the field into the trucks with either a Ropa Maus or Holmer self-propelled loaders. From about the 6th October beet is delivered to the piling stations by the growers (at the growers' cost) to begin building the long term storage piles. Some beet is also stored in buildings to maximise the campaign length. Most beet is harvested by 6- or 12-row trailed harvesters, although self-propelled harvesters have now started to be introduced. Harvest typically finishes around the end of November at the latest due to the risk of frost and not being able to harvest the beet from the field. From this period onwards beet is delivered straight from the piling station to the factory. This is organised by the agricultural team and they employ haulage contractors directly to transport the sugar beet. The agriculture team also controls feedstock quality to optimise operational performance by monitoring piles for quality.

In July 2015 I then visited Australia to investigate the cane industries which are based mainly in Queensland and New South Wales. The main aim here was to investigate how they organise and manage getting the cane from the field to the mill. Sugar cane is more susceptible to sugar loss when harvested/cut, so supply chain management is critical to ensure minimal sugar loss. The Australian industry is very efficient in managing this process which operates 24 hours a day, seven days a week. In nearly all the cane mills I visited, the agricultural team manages the inbound logistics at each site, via supply chain management software designed by a company called Agtrix. I was keen to visit Agtrix as this Australian company leads the way for sugar logistic management systems in both Australia and Africa, creating sophisticated technological solutions to the agricultural sector worldwide. According to their literature they service more than 85% of Australia's sugar industry (*Agtrix.com, 2016*). They are experts in improving supply chain efficiency by creating spatially enabled IT based management systems. Their aim is to improve harvest management by improving total visibility for various agricultural activities (*Agtrix.com 2016*).

During my visit I also met many cane growers who are pushing yields to the maximum, including Joe Muscat who was awarded a 2013 Nuffield Farming Scholarship to research best practice in production, manufacturing and marketing of fibre crops. I also visited farms growing avocados, mangos and macadamias, and also SunRice the world's fifth largest rice food exporter.

I then travelled onward to Africa where I visited Illovo in South Africa, Zambia and Malawi, where again the objective is to get the cane from the field to the mill 'Just In Time'(JIT). Again the agricultural teams use supply chain management software to manage this process 24/7 with the aim to have the cane processed with 48 hours of cutting.

In October, 2016, I again visited the USA, but this time Michigan, Minnesota and North Dakota – the largest sugar beet areas in the country. Again they manage a similar inbound supply chain model as that seen in Idaho. This comprises JIT harvest and delivery at the beginning of the campaign to minimise sugar loss; delivery to piling stations, which are then delivered to the processing factory; and then at some sites they deliver beet from long term storage in buildings.

During December, 2015, February and June, 2016, I have also visited other European countries processing sugar beet, including Slovakia and Spain, to investigate different software solutions.

My report details some of the major findings from some of my travels. This is not an exhaustive study, but is aimed at outlining some of the more successful processes used to help maximise the efficiency of the sugar beet supply chain.

Chapter 4: An efficient supply chain – what do we mean?

Efficiency signifies a level of performance within a process that uses the lowest amount of inputs to create the greatest amount of outputs. Efficiency relates to the use of all inputs in producing any given output, including personal time and energy. Efficiency is a measurable concept that can be assessed by determining the ratio of useful output to total input. It minimises the waste of resources such as physical materials, energy and time, while successfully achieving the desired output. *(Investopedia, 2016*)

In this case, a supply chain can be defined as a system of activities, resources and other elements in which the sugar beet crop is harvested from the field and delivered to the sugar factory ready for processing. Therefore, an efficient sugar beet supply chain is one that makes best use of its resources available, including labour, harvesters, cleaner loaders and haulage vehicles; and minimises the loss of sugar yield of the sugar beet crop that will be delivered to the processing sites.

Within the UK sugar beet supply chain, many stakeholders have different ideas and agendas. These stakeholders include growers, harvesting and haulage contractors, and sometimes one individual can wear all three hats! These stakeholders can prevent progress towards an efficient supply chain. William Martin (2014), NFU Sugar Board Chairman, shares these views, "I*t's a frustration to the NFU Sugar board that the industry is not moving more rapidly to embrace some of the savings and changes this could generate*". Martin continues: haulage is "*something farmers feel very strongly about and sugar beet growers are no exception; that both British Sugar and the NFU were at fault for the reluctance of many growers to adopt the transport scheme. I think British Sugar has been reluctant to look beyond a simple cost-saving measure and look more widely at how we can improve efficiencies – but I think there are some growers who have been reluctant to contemplate doing anything any differently to how their fathers did it*."

These comments resonate with my day-to-day experiences and are a key motivation for undertaking my Nuffield Farming Scholarship.

The sugar beet supply chain contains many stakeholders, is complex and, due to these multiple factors, progress towards efficiency can be slow and difficult at times.

Chapter 5: The sugar beet supply chain – what does this include?

In the UK there are there are four key parts to the sugar beet supply chain: harvesting, cleaning and loading, storage, and delivery to the factory via haulage vehicles.

5.1: Harvesting

Currently about 370 harvesters are used to harvest the UK sugar beet crop. These are predominantly machines owned by contractors, although a small proportion is still owned by growers who, as well as harvesting their own crop, they may also harvest their neighbours' to help justify the investment. In the UK, the majority of machines are now 6-row self-propelled, although there are some 9-row machines and some smaller 3- or 4-row machines.

Figure 3: A 6-row sugar beet harvester

Harvesting normally commences about a week before the processing campaign begins and most harvesting contractors aim to harvest for as long as possible during the campaign to ensure they maximise the income from their capital. There might be around £0.5 million invested in the harvester. The length of season can be very dependent on weather conditions, soil type and the size of the UK crop in terms of hectares and yield, and can vary between 112 - 182 days. Depending on weather conditions experienced during the season the conditions for efficient harvesting normally deteriorate throughout the season due to damper soil conditions, rainfall and the risk of frost. These conditions can all lead to more difficult harvesting conditions, which slow the process down resulting in less hectares been lifted per day and higher harvester losses.

Sugar beet continue to increase yield throughout the autumn and the maximum sugar yield is normally achieved by the end of November; however during a mild winter sugar beet left in the ground, particularly near the coast, can continue to increase yield.

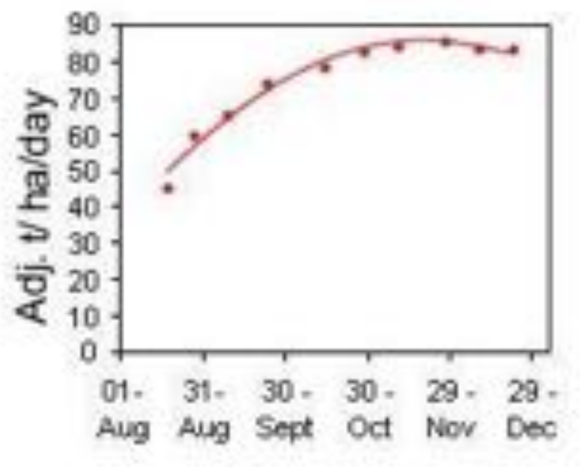


Figure 4: Effect of harvest date on beet yield in 4 experiments: Morley Research Centre 1997-1999. (*BBRO Growers Guide 2014*)

Therefore in ideal conditions the entire UK sugar beet would be harvested from mid-November to early December to maximise yield. Unfortunately this is not achievable because factors such as factory processing capacity, harvesting and transport capacity, soil type, and consideration of the following crop. As this is not achievable, some of the crop must be harvested before it has finished growing and therefore yield is lost. Sometimes the grower might, however, benefit from less soil structure damage due to better weather conditions normally experienced at the beginning of the season and lower dirt tares due to the dryer conditions normally experienced in the early part of the campaign. Early harvesting also allows the grower to drill the following crop, which is normally winter wheat, at the optimum time.

To remain efficient harvesting contractors must have a range of different variables available to them. These will be discussed later in this study but it is critical that there is coverage of a range of soil types, enabling the machine to travel and to maximise the length of harvesting period.

According to Pilbrow J (1999) the three major sources of yield loss during lifting arise from surface whole beet or crown material left on the surface (surface losses); parts of the beet that are left in the ground (breakage losses); and the sugar that is lost through leakage and respiration when beet are bruised by impacts within the harvester.

In the UK harvester assessments are undertaken each year by British Sugar area managers and, although they have showed significant improvement over time, in recent years they have plateaued. As can be seen from Figure 4 on next page, results of the 2015/16 season show the yield loss is still significant at an average total of 3.27 tonnes/hectare.

See chart on next page

Analysis of sugar beet losses during harvest	tonnes
Surface loss –tonnes/hectare	0.47
Root breakage –tonnes/hectare	2.80
Total loss –tonnes/hectare	3.27

Figure 5: Results of 2015/16 Harvester Assessments. *British Sugar 2015*.

The above chart shows that most of the loss is derived from root breakage and, to a lesser extent, from surface losses through over-topping and lost beet. Unfortunately, root damage is not recorded in the above results.

The figures can be further analysed as shown in Figure 6 below. The results confirm that, as soil conditions deteriorate, greater harvester losses are experienced with the exception of dry organic soils.

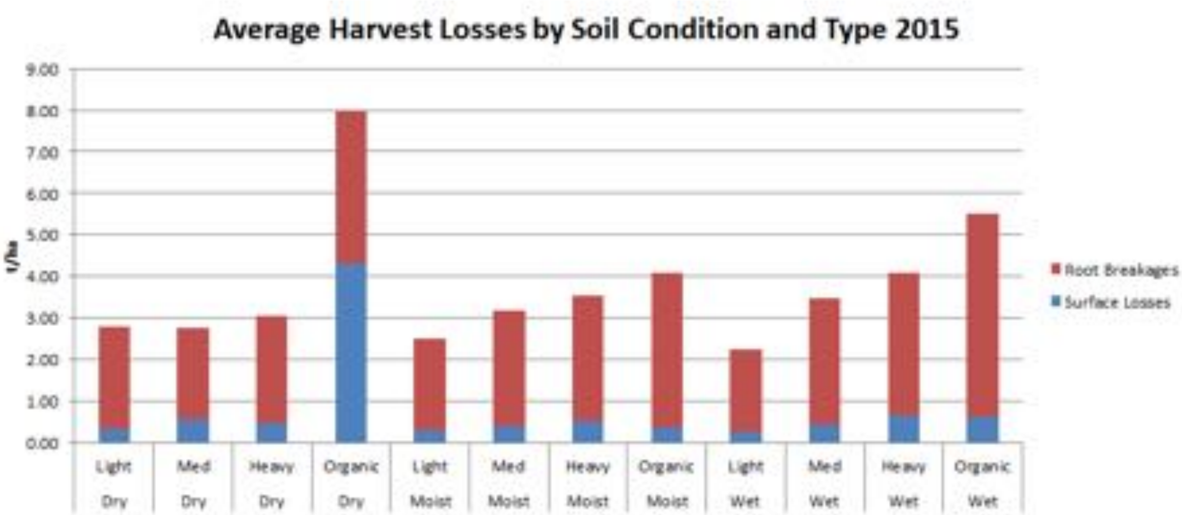


Figure 6: Results of 2015/16 Harvester Assessments showing average harvest losses by soil condition and type 2015. *British Sugar 2015*

Olsson (2008) showed that most mechanical damage to sugar beet is caused by the harvester. Although loading and unloading may increase existing surface cracks and root tip breakages, about 80-90% of the injuries originate from the harvester.

As can be seen from Figures 7 on next page, it is key that damage caused by the harvester is kept to a minimum. This not only results in less sugar loss in the field, but, in addition, beet that is handled more gently loses less sugar in clamp. Therefore, sugar beet should be handled as gently as possible and should be given more care - perhaps similar to that given to potatoes.

See figure 7 on next page

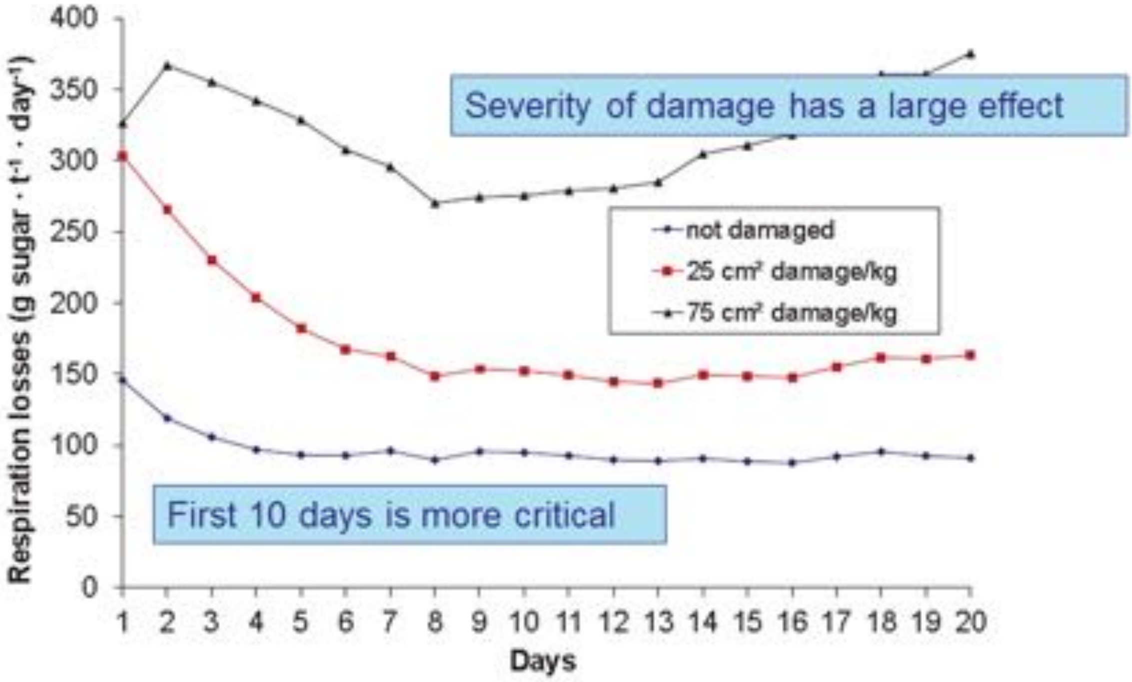


Figure 7: Effect of beet injuries - caused by a cleaning turbine - on sugar losses during storage of sugar beet at 10oC. The losses are calculated from CO2 production. (*Source Huijbregts, 2008)*

Figure 7 shows the results from Beet Europe 2012, where nine harvesters were tested, representing 87% of the machines which harvest the German sugar beet area. These tests are similar to those undertaken in the UK, but were all taken when the machines were in the same field, on the same day, which provides some very useful information pm which to base comparisons.

These results also include other characteristics including soil tare. These are beneficial, as soil tare can also have an influence on the amount of yield loss. It also affects the efficiency of the supply chain because transporting soil to the processing sites increases transport costs. Therefore, the lower the dirt tares the more efficient for transport cost. Soil is also the grower's must valuable asset so it seems a shame to cart it off farm along with the sugar beet. The results from Figure 7 indicate that the lower the soil tare the higher the root loss. Therefore, a compromise between dirt tare and root breakage must be achieved whilst harvesting.

See Figure 8 - Harvester results from Beet Europe (Ziegler, 2012) – shown at top of next page

5.2: Storage

Once harvested, the majortity of the UK sugar beet is then stored. The UK normally experiences mild winters which help maximise the length of the harvesting window; however losses can be experienced if extremes in temperature or rainfall occur.

There are several key areas of management where UK growers can continue to lose yield and these must be managed to their maximum to ensure the maximum yield of beet is delivered to the processing site. These keys areas include the management of respiration, heating and ventilation and damaged beet and mould growth.

Producer	Speed	Through-put	Harves-ting depth	Soil tare	Rel. mass losses				Topping quality		
					above ground	below ground	root breakage	total	un-topped	well topped	over topped
	km/h	t/h	cm	%	%	%	%	%	%	%	%
Agrifac BIG SIX	5.9	135.4	10	4.8	1.7	0.6	4.2	6.5	15.8	82.8	1.4
Kleine Beetliner Large	6.1	139.6	6	6.8	0.9	0.5	3.1	4.6	37.8	61.4	0.8
Grimme REXOR 620	6.5	147.9	6.6	9.2	0.3	0.7	2.2	3.2	25.0	72.8	2.2
Vervaet Beet Eater	6.2	140.3	10	15.8	0.7	0.4	2.6	3.7	23.4	74.0	2.6
Ropa euro-Tiger V8-4	5.8	131.5	7	9.8	0.3	0.5	2.0	2.7	22.2	77.0	0.8
Ropa euro-Tiger V8-4 XL	5.5	186.5	7	10.4	0.5	0.8	2.3	3.6	7.2	91.8	1.0
Holmer Terra Dos T3	6.6	149.5	6.5	9.5	0.5	0.6	2.3	3.4	16.2	82.8	1.0
Kleine Beetliner Max	6.4	145.5	8.5	12.6	1.3	0.8	2.7	4.7	17.8	80.8	1.4
Grimme Maxtron 620	6.5	147.9	10	24.8	0.2	0.6	1.9	2.6	*7.0 **	*75.6 **	*17.4 **
Mean	6.2	147.1	8.0	11.5	0.7	0.6	2.6	3.9	19.2	77.7	3.2

* Machine was equipped with a defoliation unit. Classes are therefore: Defoliation with petiole remains, well defoliated, defoliation with beet injury

Figure 8: Harvester results from Beet Europe. (*Ziegler, 2012*)

According to The BBRO Growers Guide 2014, "*beet lose sugar mostly as a decline in sugar concentration, not as a loss of weight. Average loss rates are 0.18% of the adjusted tonnage per day. Because respiration rate increases as the temperature increases, the loss of adjusted tonneage of beet harvested and awaiting delivery in September and October is likely to be greater than this winter loss rate, perhaps 0.2% per day*". These seem to be quite typical figures. However Ashfield (2008) claims that, on the other hand, long-term clamps built from aggressively-handled beet may lose up to 20% of their sugar. Therefore there is a massive risk of decreasing yield in this part of the supply chain if it is not correctly managed.

See Figure 9 on next page

In the UK, once sugar beet are harvested they are then stored for a period of time which can range from a few days to several weeks dependent on when the beet will be delivered for processing.

In 2008, as part of a British Sugar growers' survey, differences between the date on which growers stated their beet were lifted and the date when they were delivered to the factory were used to estimate the proportion of the national crop that was delivered Just-in-Time (JIT) at successive stages of the campaign. (*See figure 10 on next page*)

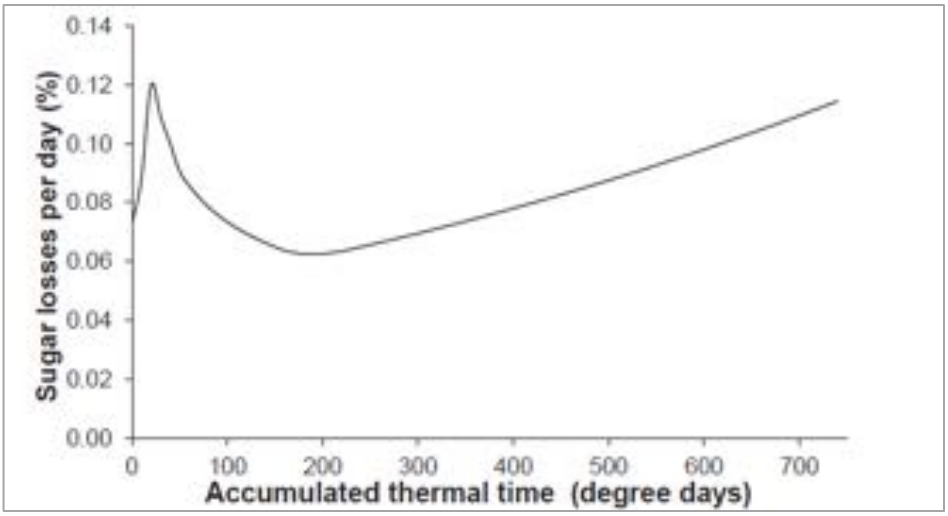


Figure 9: A typical curve for sugar losses caused by respiration during storage of sugar beet. (*Source Huijbregts, 2009*)

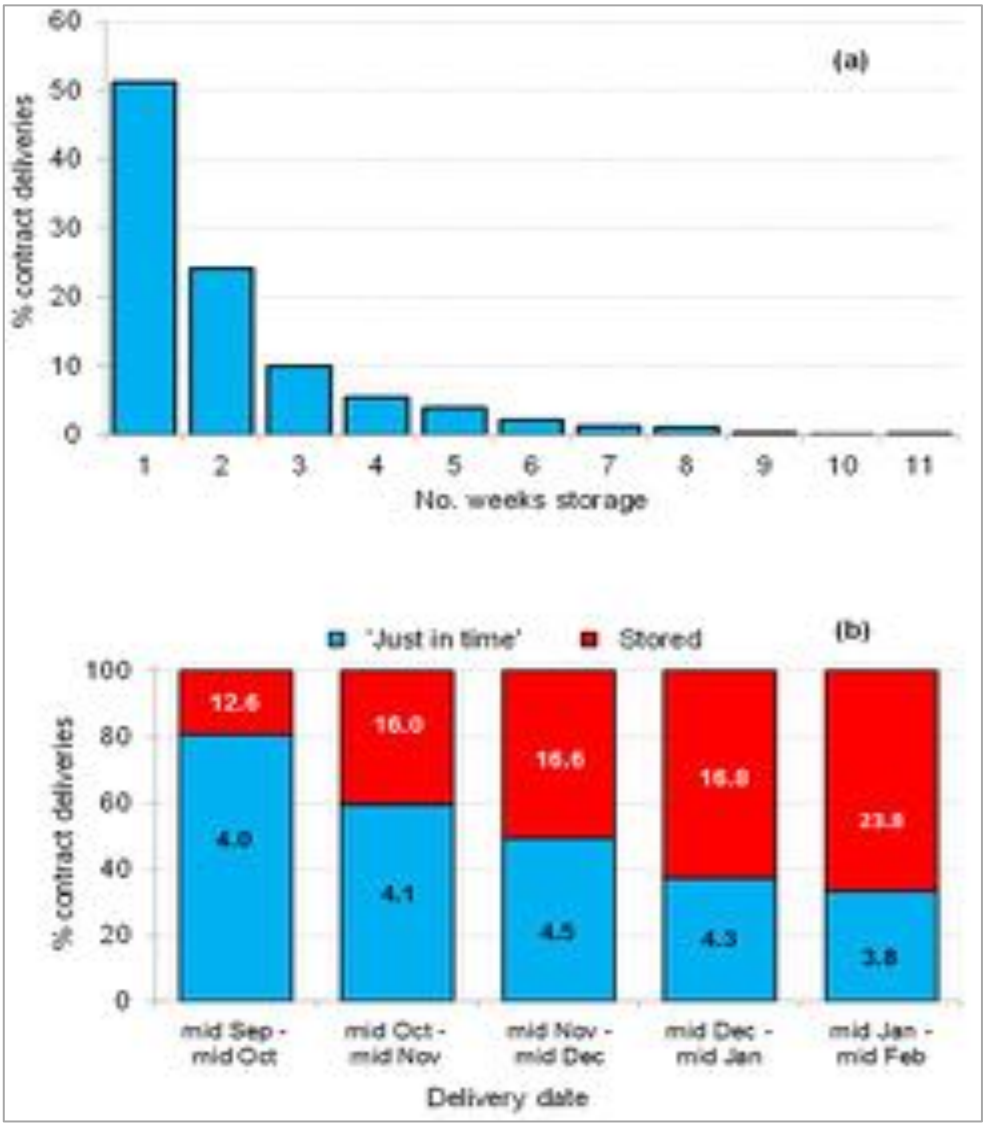


Figure 10: Lengths of beet storage in the UK: (a) and their breakdown by delivery date (b) where the numbers on each bar indicate the mean number of storage days. British Sugar 2008.

This indicates that 50% of the grower contract deliveries were likely to be delivered within a week of lifting, and that 25% would have been stored for more than 3 weeks. It also showed that, during the early stages of the campaign, almost 80% of the contracts delivered their beet within 4 days of lifting (the average length of storage being 4 days), with the proportion of 'just-in-time' deliveries decreasing and the period of storage increasing as the campaign progressed .

The length of time beet is stored in clamp has a massive impact on sugar yield loss at that point; therefore it is important to reduce the time spent in the supply chain to as little as possible. The challenge to the UK sugar beet industry is to more widely apply this knowledge as part of a more coordinated approach to beet harvesting and delivery.

5.3: Cleaner loaders

To help further reduce dirt tare and loose soil being delivered to the processing factory the final process the beet goes through is either a coventional or self propelled cleaner loader. In the UK there are around 200 conventional cleaner loaders operating in various states of repair, and around 20 self propelled machines. The self propelled machines tend to be operated by the larger haulage companies to help maximise the turnaround time of the lorries. As well as loading the delivery vehicles as efficiently as possible these machines should be set up correctly in order to not only minimise dirt tare but also prevent excessive loss. The BBRO Sugar Beet Growers Guide 2002 suggests that poorly managed cleaner loaders can lose more than 2% of yield as pieces of beet; yield can also be further lost through damage made to the beet similair to that occurring when harvesting beet. Trials by AB Sugar in 2015 suggested that between 1.2% through self propelled cleaner loaders, and 2.4% with conventional cleaner loaders, of yield loss through damage could be experienced. These results were also similar to those experienced at Beet Europe 2012 for self propelled machines only. Figure 10 shows these results and the differences between the machines with the Holmer Terra Felis 2 producing the best result – and unfortuantley this machine isn't available in the UK.

Producer	Throughput t/h	Soil tare %	Root breakage %
Ropa euro-Maus 4	523.0	5.9	4.2
Holmer Terra Felis 2	547.8	3.4	3.3
Kleine RL 350 V	388.1	5.1	3.3
Brettmeister Minimaus	179.3	6.3	4.0
Mean	409.5	5.2	3.7

Figure 11: Results of cleaner loader – initial value: soil tare – 7.5%; root breakage – 2.1% (*Ziegler, 2012*).

Figure 12: A conventional cleaner loader, loading a lorry

Figure 13: A self propelled cleaner loader loading a lorry

5.4: Delivery to the factory via haulage vehicles

The final part of the supply chain includes the delivery to the processng site. Typically this is linked to the cleaning and loading operation and, unlike many other countries processing sugar beet, the haulage company usually also owns the cleaning and loading equipment.

In the UK the delivery of sugar beet can be structured and managed in three key sectors. The majority (70%) is the **first sector**, where the grower contracts with a haulier directly for a beet delivery service which includes loading. This can typically be linked with other haulage movements on the grower's farm, such as grain delivery, so there is a high degree of loyalty and typically costs are higher due to the level of service received. The **second sector** accounts for about 25% of the tonage to be delivered and this is known as the Industry Harvesting and Haulage Scheme. This is managed by British Sugar and supported by the NFU. This allows growers to choose a harvesting and delivery, or just a delivery, profile to match their own specific delivery requirements. British Sugar competitively tenders and selects the harvesting, cleaning and loading and haulage work. The scheme provides a schedule of deliveries to be made, which helps with the planning and co-ordination between the grower and contracting parties to increase the efficiency. The **third sector** (5%) is where growers deliver their own crop on their own vehicles. These deliveries are scheduled by British Sugar and must be delivered evenly across the campaign (from start to finish). They tend to be very efficient as they tend to be managed by the growers with little overhead cost but there is much variety in the payload and age of the vehicles used.

In the UK sugar beet supply chain there are typically about 1700 vehicles employed to deliver the crop to the processing factory through the campaign, which can range in length from 16-24 weeks depending on the size of the total crop. These vehicles are typically owned by a group and managed by a haulage company with a fleet ranging from 3-50 vehicles. The haulage manager is responsible for planning deliveries and liasing with growers about their delivery reqirements. There are 232 such groups involved in sugar beet haulage.

Figure 14: A typical haulage vehicle (44 Tonne) used to transport sugar beet in the UK

An analysis of the transport fleet shows that most of the beet (86%) is delivered by 44-tonne vehicles with most carrying a payload of sugar beet between 28 and 30.2 tonnes. However a proportion of the crop (6%) is still delivered by smaller vehicles such as tractors and trailers which are only carying a payload of 21 tonnes or less and, more worrying, is that a small proportion of the vehicles carry less than a 10 tonnes payload. Over time there has been an increase in payload and this is a key area in maximising efficiency.

Over the past ten years the fleet has also been reducing in size from just over 2,000 vehicles in 2009 to around 1,700 currently. Although the overall amount of sugar beet being delivered hasn't varied significanlty over that period the number of vehicles has reduced which shows the fleet has rationalised and has naturally become more efficient. However this may have resulted in less flexibility and responsiveness to factory demand for additional beet at certain times of the season. Therefore this requies better demand planning by the processing factory. In the 2015/16 campaign 1,677 vehicles were used. The vehicle that delivered the highest number of loads delivered 694 loads during the campaign, averaging 29.79 tonnes, whilst 983 of these vehicles delivered less than 100 loads in the total campaign, which is equivalent to less than 1 load per day on average during the season.

A significant proportion of the haulage vehicles are relatively new and, according to a British Sugar and NFU Transport Efficiency Study Final Report 2009, this is important when considering the overall efficiency of the sugar beet haulage fleet. Significant technological improvements have been made in recent years to reduce the environmental impact of HGVs (in terms of engine emissions and noise), as well as to reduce fuel consumption.

Minimising the loss of sugar yield during this process is also critical in ensuring an efficient supply chain is achieved and yield can be reduced in key areas.

Figure 15 below shows an estimate from Walters 2016 where yield can be lost during the harvesting, cleaning, and loading operations. As can be seen, a good supply chain could experience a loss in yield of 16.6% compared to a poor supply chain that could experience loss of up to 37.6% -which is colossal!

Crop Potential 100%	Good	Average	Poor
Harvesting quality			
Topping	1.0%	3.0%	5.0%
Root breakage	0.6%	1.0%	3.0%
Surface losses	0.3%	0.5%	1.5%
Harvester to trailer breakage	2.0%	3.0%	5.0%
Trailer reversing into heap	0.1%	0.2%	0.5%
Pushing up	1.0%	2.0%	3.0%
Cleaner loader operation	1.0%	2.0%	3.0%
Top tare	6.6%	6.6%	6.6%
Dirt tare	3.0%	5.0%	10.0%
Total % Potential Delivered	84.4%	76.7%	62.4%

Figure 15: Showing the potential yield loss in the sugar beet supply chain. (Source unpublished, Walters, 2016)

If you add storage losses of another 0.18% of per adjusted tonne per day (*Sugar beet Growers Guide, 2014*) and assume on average the crop is stored for 12 days, this can equate to a further 1.44% yield loss.

To give an indication of the current size of the equipment resource I have estimated the current machinery employed in the supply chain. This estimate is based on current information supplied by British Sugar.

Equipment Type	Current Number in Year 2016
Harvesters	366
Cleaner Loaders (All)	220
Haulage Vehicles	1692

Figure 16: Showing current amount of machinery/vehicles employed in the sugar beet supply chain, (*British Sugar*).

In summary, the sugar beet supply chain is quite complex and in every area there is huge potential to lose yield or efficiency if not managed effectively.

However, there is a great opportunity to use the current resources more efficiently by better planning, monitoring and co-ordination.

Chapter 6: How can we make the supply chain more efficient?

Previous chapters hae shown there are numerous areas where the yield or supply chain efficiency can be improved. The aim of this next section of the report is to highlight where efficiencies can be gained based on experiences gained from my Nuffield Farming Scholarship travels.

To prioritise and help visualise areas that have the maximum opportunity to gaining efficiency within the supply chain, Figure 17 below shows these opportunities and ranks them according to the amount of effort required to implement these against the potential value this, may achieve.

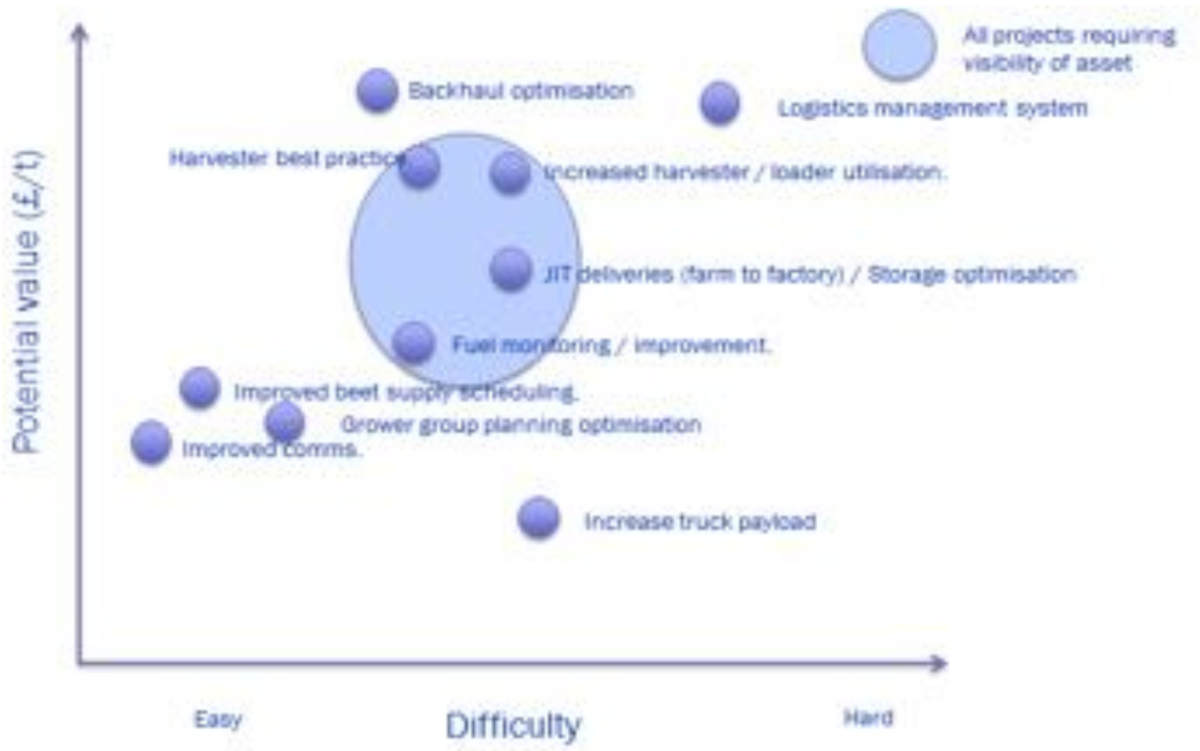


Figure 17: Opportunities to improve the UK Sugar Beet Supply Chain (*Source: the author*)

Each of these opportunities will now be discussed but there are certain opportunities that require visibility of the supply chain. In order to understand how efficient any process is, it is important to identify the level of efficiency that currently exists. To gain visibility you must be able to visualise the whole supply chain. Every sugar industry I have visited has this visibility and, for the UK industry, the best way of achieving this is to install GPS tracking devices onto harvesters, cleaner loaders and trucks. Due to my experiences while travelling, British Sugar installed several GPS loggers onto vehicles employed in the Industry Harvesting and Haulage Scheme, which I manage. The GPS loggers were sourced from Masternaut, which gave all contractors and me access to the Masternaut dashboard, which provided the vehicle's telematics information.

.. the best way of achieving this is to install GPS tracking devices onto harvesters, cleaner loaders and trucks

6.1: Harvester best practice

As previously discussed, harvester losses are a major cost to the industry in terms of surface losses, breakage losses, and sugar that is lost through leakage and respiration when beet are bruised during harvesting.

Therefore, to minimise the loss, my research suggests that a harvesting "best practice" programme could be developed. Such best practices are currently used in the UK potato and cereal industries but I witnessed one of the most comprehensive programmes whilst visiting Australia. This harvesting best practice manual was produced by Sugar Research Australia. In June 2016, the cane industry received a $5 million grant to conduct a harvester efficiency programme to research methods of reducing cane losses, which are currently estimated at $150 million per annum. The benefits of this programme to growers, harvesting contractors and the processing mills can be seen. If successful this will involve changes to the way harvesting is carried out and may involve changes to farming practices. The aim is to get to losses that are less than 5%: currently losses can be as high as 20%.

The programmes identified tended to use codes of good practices for operators, managers and advisors which cover all major topics which affect harvesting. These tend to include all components of the harvesting operation - from the initial planning stages, harvester set-up and fundamental components of the harvester through to how to assess harvester losses and damage. These codes of good harvesting practice can therefore provide good opportunities to improve operator and adviser awareness. Together with renewed training and focus from the harvester manufactures and the British Beet Research Organisation (BBRO), this should help improve harvesting best practice in the UK.

Sugar Research Australia also uses The Sugar Cane Harvest and Loss Optimisation Tool (SCHLOT) which gives growers, harvester operators and millers access to new and detailed information to help inform discussions around optimising harvester efficiency. SCHLOT works through the harvesting and milling process, from cane in the field to sugar in the bin, and highlights the different costs and benefits of any change, as well as providing analysis of harvester losses.

Figure 18: showing an example "Dash Board" used in SCHOLT

As part of this programme harvester assessments are key, and these are carried out in many of the countries visited. Currently, in the UK, this is undertaken by British Sugar area managers. They assess yield loss and advise on ways to maximise the setup of the machine. In 2015, British Sugar area managers completed 166 harvester tests during the campaign, on a variety of machines and soil types. The average surface loss was 0.42T/Ha and the average root breakage was 2.80T/Ha. The total yield loss was therefore 3.27T/Ha which equates to £67/ha to the grower or 261,600 tonnes (3.27T/Ha x80000Ha) which equates to £5.3 million or a 4.6% loss of yield!

However, this exercise might be carried out not simply by British Sugar area managers, but growers' and harvesting contractors' performance could be regularly measured and should also include a damage assessment as this is such as important area of sugar loss. Currently this is measured visually but there should be no reason why a "real time" damage assessment could not be developed which uses image analysis and perhaps could be used as an "app" on a smart phone.

Figure 19: British Sugar area managers accessing damage

As damage is an important factor in sugar loss, so is speed in regard to root breakage; as all harvesting contractors are paid on an area basis and not a tonneage basis most are incentivised by harvesting the field as quickly as possible. To help improve yields I suggest harvesting contractors should be paid on a £/tonne basis. To monitor their speed, perhaps GPS loggers could be fitted to all harvesting machines, which is common practice in the cane growing countries such as Australia and Africa. These provide live reporting on the speed of harvesting and area covered. Not only is the information useful to the processor or harvesting contractor, but also to the grower as the latter can have full visualisation of the harvesting operation without being in the field. I trialled this during the 2015-16 harvesting season in the UK and it proved to be successful, providing some very important information on how to promote harvester best practice. Agtrix produced the information shown in Figure 20 on next page.

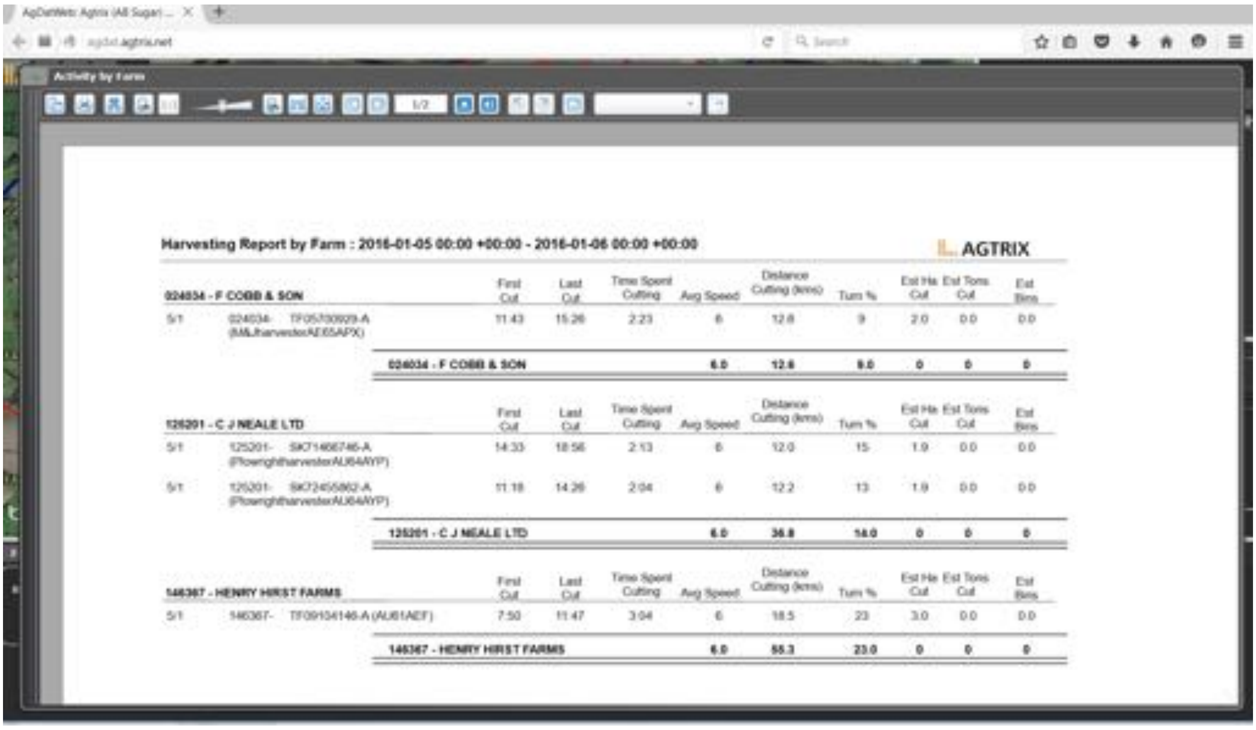
GPS loggers could be fitted to all harvesting machines, which is common practice in the cane growing countries such as Australia and Africa

Figure 20: Screen shot of real-time visualisation of harvester activity in terms of harvester location, areas harvested and speed while harvesting – available for the 2015 campaign through the web, but will be available via a click-once desktop application for the 2016 campaign.
(British Sugar Supply Chain Study, 2015-16)

In Australia this information is used by all stakeholders to help maximise the efficiency of the operation as it provides good management information such as field, variety, start time, finish time, harvesting time, cutting time, turning time, waste time, average speed, and work rate. During the visit to Australia it was evident this information has been used and found beneficial by all stakeholders so once I returned to the UK I put it into practice and the Figure 21 on next page shows a screen shot of what was developed, showing all the attributes required to monitor harvester best practice.

In order to develop and adopt a faster uptake of harvester best practice it may be beneficial to incentivise the contractors or operators. Perhaps through a sugar beet harvester "operator of the campaign" competition based on their performance, this could operate similarly to the "combine driver of the year" competition, which is based on machine performance and settings during the harvest period. In 2013, the "combine driver" competition covered 44 operators across the UK, using 15 different models of combine from 6 different manufactures. There were 293 in-field checks in 6 different crops with a large range of different harvesting and weather conditions, varieties, weeds, soils and management regimes.

It may be beneficial to engage with the machine manufacturers more frequently to ensure they fully understand the customers' requirements in terms of minimising field losses and reducing damage, thus leading to improved harvester design. Regular meeting of growers, harvesting contractors, BBRO and British Sugar would encourage this to happen more quickly, perhaps through some form of "brain storming" sessions held on a regular basis.



Harvesting Report by Farm : 2016-01-05 00:00 +00:00 - 2016-01-06 00:00 +00:00 AGTRIX

024034 - F COBB & SON		First Cut	Last Cut	Time Spent Cutting	Avg Speed	Distance Cutting (kms)	Turn %	Est Ha Cut	Est Tons Cut	Est Bins
5/1	024034- TF05700929-A (AMLharvesterAE65APX)	11:43	15:26	2:23	6	12.8	9	2.0	0.0	0.0
	024034 - F COBB & SON				6.0	12.8	9.0	0	0	0
125201 - C J NEALE LTD		**First Cut**	**Last Cut**	**Time Spent Cutting**	**Avg Speed**	**Distance Cutting (kms)**	**Turn %**	**Est Ha Cut**	**Est Tons Cut**	**Est Bins**
5/1	125201- SK71466746-A (PloweightharvesterAU64AYP)	14:33	18:56	2:13	6	12.0	15	1.9	0.0	0.0
5/1	125201- SK72455862-A (PloweightharvesterAU64AYP)	11:18	14:26	2:04	6	12.2	13	1.9	0.0	0.0
	125201 - C J NEALE LTD				6.0	36.8	14.0	0	0	0
146367 - HENRY HIRST FARMS		**First Cut**	**Last Cut**	**Time Spent Cutting**	**Avg Speed**	**Distance Cutting (kms)**	**Turn %**	**Est Ha Cut**	**Est Tons Cut**	**Est Bins**
5/1	146367- TF09104146-A (AU61AEF)	7:50	11:47	3:04	6	18.5	23	3.0	0.0	0.0
	146367 - HENRY HIRST FARMS				6.0	55.3	23.0	0	0	0

Figure 21: Screen shot of activity summary reporting for harvester activity in terms of farms and fields harvested, areas harvested and speed while harvesting.
(*British Sugar Supply Chain Study, 2015-16*)

> I believe a harvester best practice programme can deliver significant yield benefits. If an additional 1% (0.75T/Ha) could be saved through some of these principles being adopted, payment on a tonnage basis together with full visisbilty of the harvesting operation via GPS loggers could deliver savings in the region of £1.25 million based on £20.30/adjusted tonne.

6.2: Increased harvester utilisation

To optimise the efficiency of harvesters it is important that the contractors operating these machines are achieving maximum utilisation. This is not only to help the contractor reduce running costs but to also ensure the beet are harvested and delivered to the physically closest factory to reduce yield loss.

From visiting many countries throughout the study tour, it was clear that to be able to measure any utilisation, GPS loggers would be required to measure the current situation and highlight areas of improvement. To measure the harvester utilisation in the UK, GPS loggers were installed in 17 harvesters for the 2015/16 season. Following my visit to Agtrix in Australia, they were employed to analyse and help interpret the results from the GPS loggers. These results are shown in Figure 22 on next page and are based on a 24-hour day.

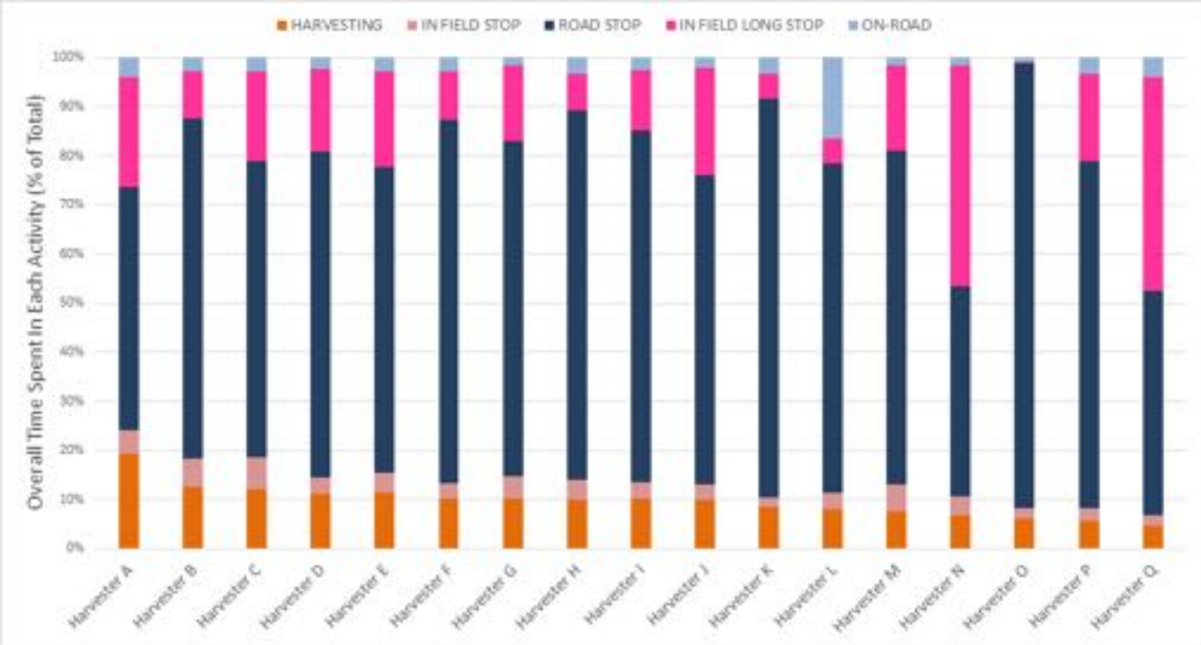


Figure 22: The percentage of time each individual harvester spent in each operational state over the 2015/16 Campaign, 24/7. (*British Sugar Supply Chain Study, 2015-16)*

In terms of time spent actually harvesting, the best performing contractor was returning 19% compared to 5% for the poorest performing contractor. The average was only 10% and, for such a large investment, this cannot be sustainable.

To increase this utilisation, time must be spent with each of the contractors to investigate the reasons for such a low percentage and suggest options which can improve this. The issue of low utilisation was compounded in 2015/16 when the sugar beet crop was reduced by British Sugar, as shown in Figure 23. These fluctuations were due to a build-up of surplus stock and the plan is to return to normal volume in 2017/8.

The GPS loggers also provided data on how much area each harvester was harvesting per day. This information is shown in Figure 23 on next page and, as can be seen, the best harvester is averaging 11.3Ha while the worst is averaging less than 7 hectares per day.

Many factors of course contribute to the variation in harvester utilisation which can be out of the harvesting contractor's control: for example the reduction in the beet grown in the UK or weather conditions, soil type and delivery requirement of the customer/grower.

The weather and soil type can be related as some soil types allow harvesting to continue even during a period of wet weather while some soil types (heavy) will not tolerate lifting during wet weather. It is however very difficult for the contractor to control these factors unless he can have a customer profile covering a wide range of soil types allowing harvesting to be carried out even during bad weather. All countries visited suffer from similar issues and they have resulted in mill stops in Australia and Spain, as not enough stock was harvested before the change in weather.

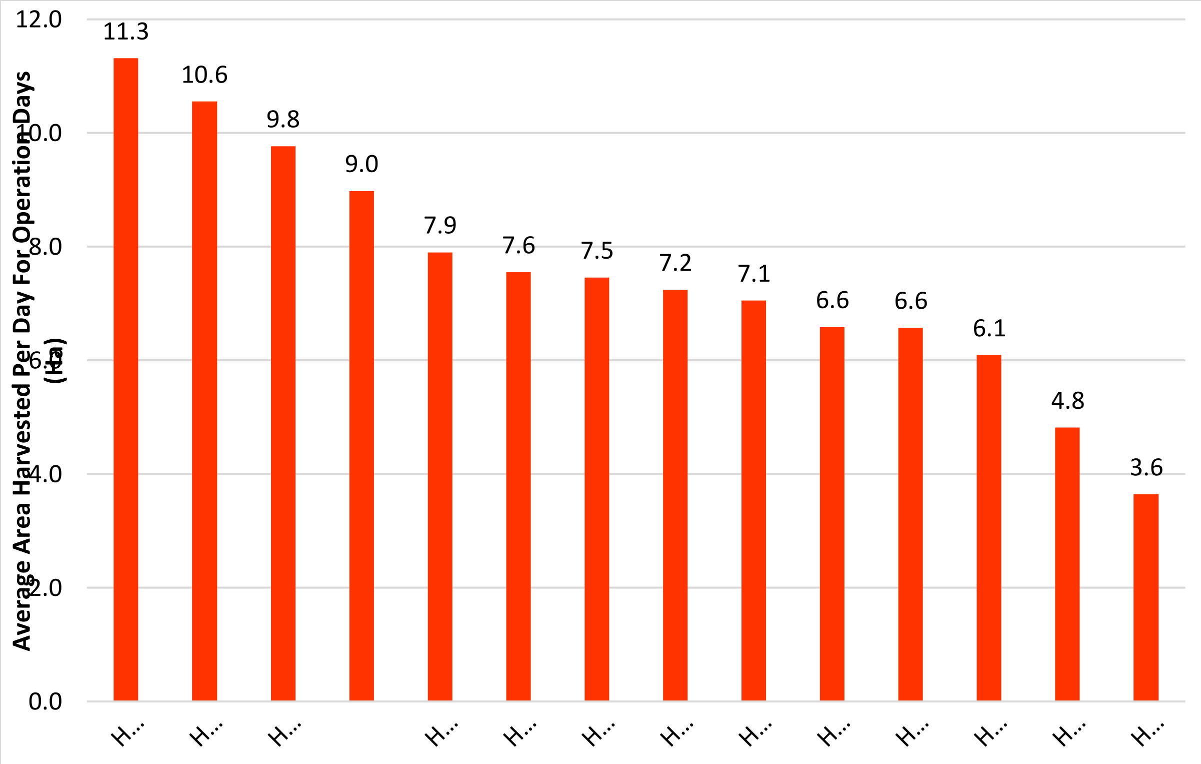


Figure 23: Average area harvested per day by each harvester. (*British Sugar Supply Chain Study, 2015-16*)

The customer normally dictates when they want the crop harvested and these decisions can be based on several factors including soil type, following crop, delivery requirements or cash flow. All these factors can lead to a reduction in contractor utilisation, as requirements tend not to be co-ordinated, which reduces both parties' efficiencies. The grower traditionally does not know or understand the harvesting contractor's plan, and neither does the harvester contractor understand the grower's plan. Therefore, a significant improvement is required here to facilitate increased efficiency for both parties.

Figure 24 on next page shows the average distance between consecutive harvested fields for different harvesters. It is obvious that most harvesting contractors spend a lot of time travelling on the road. In one instance, a harvester completed a round trip of 92 miles to harvest 10 Ha of sugar beet. Again, from this data it is clear that the harvester contractor is reacting to grower's requests and there is no overall plan so contractors are criss-crossing across the harvesting areas and passing one another on the road. Therefore, a more planned and co-ordinated approach must be explored to reduce this unnecessary road mileage to increase harvester utilisation.

See figure 24 on next page - showing the average distance between consecutive harvested fields for different harvesters (*British Sugar Supply Chain Study, 2015-16)*

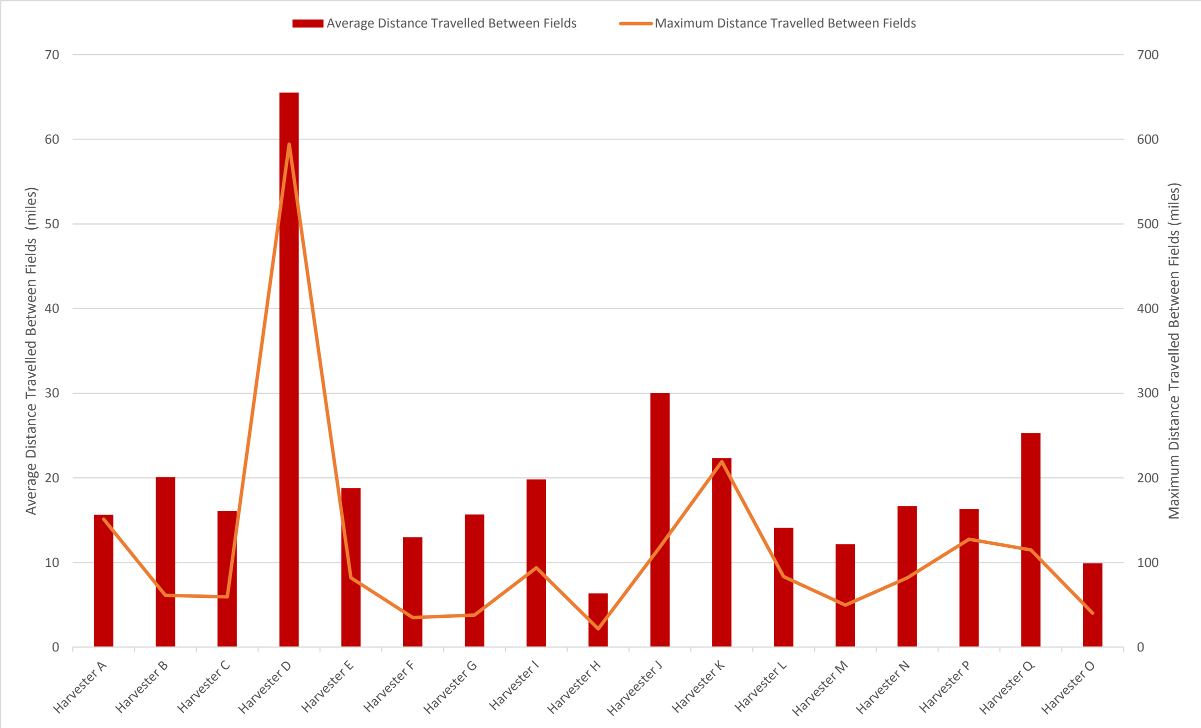


Figure 24: showing the average distance between consecutive harvested fields for different harvesters ***(British Sugar Supply Chain Study, 2015-16)***

The number of times that a harvester returned to a field was also analysed. Figure 25 on next page shows the number of times that a harvester started in a field, and then went away to work in another field before returning to the original field. This may indicate when a harvester found ground conditions unsuitable, possibly due to the weather, and moved to another field that may be in better condition to harvest, or when the grower only wanted a proportion of the field harvesting to suit their delivery requirements. However this practice should be reduced to avoid the harvester making multiple trips to the same field and reducing efficiency.

Again, from investigating the data, to increase the harvester utilisation the harvesters need to be running for longer periods. Operators should consider running machines over longer periods by introducing shift patterns to increase utilisation. In Spain, utilisation of harvesting machines has been increased by operating in two regions of the country, north and south. These regions have two different harvesting seasons (October–March in the north and June-August in the south). This allows harvesting contractors to work their machines over a longer period of time during the year but, in the south, the processing site accepts deliveries twenty-four hours a day which encourages contractors to utilise their machines more efficiently as they are loading the sugar beet directly from the harvester into the lorry: it cannot be stored due to the heat.

This section of my report has shown there are many areas where harvester utilisation can be increased. The best performing harvesting contractor is achieving 11 hectares per day and this should be the benchmark for the remaining harvesting contractors. Although the weather does play a huge part, harvesting contractors need to plan and co-ordinate their moves more efficiently to ensure they spend more time harvesting and less time traveling on the road.

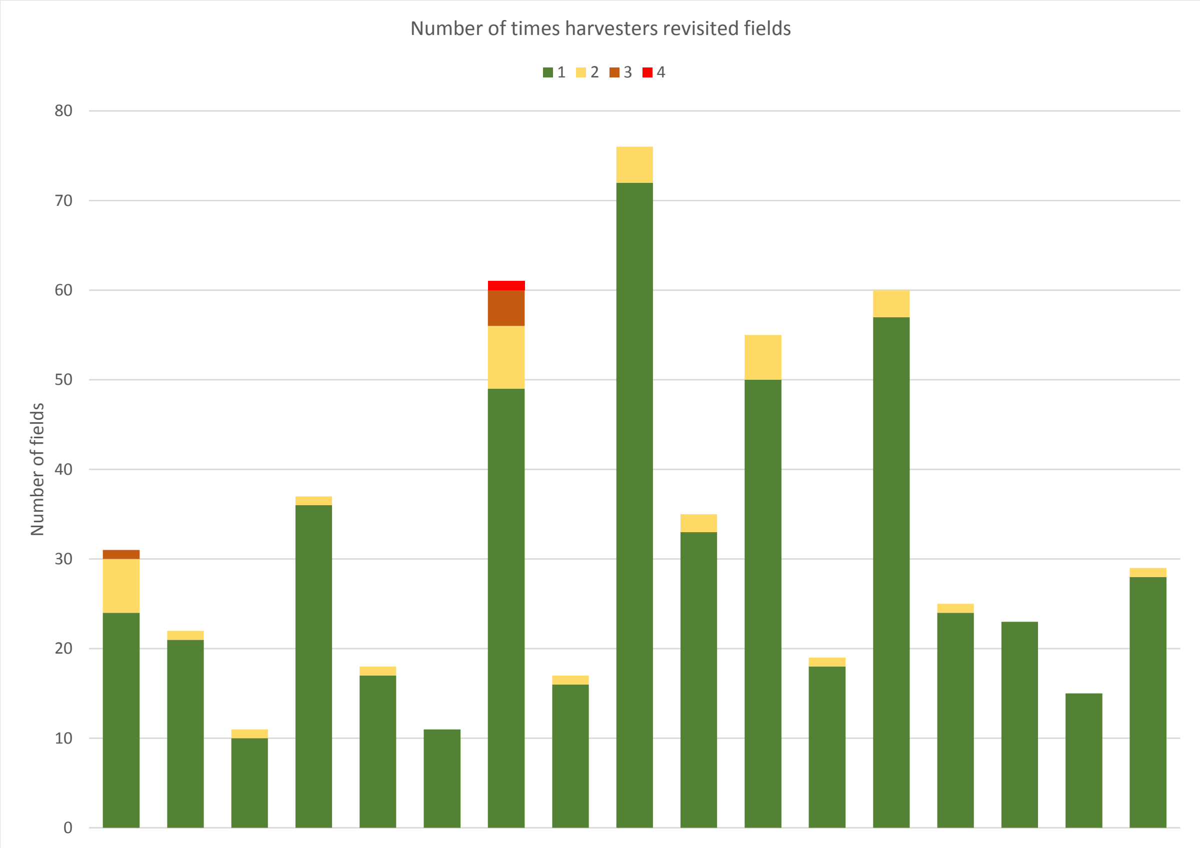


Figure 25: showing the number of times a field was revisited during the 2015/16 season.
(British Sugar Supply Chain Study, 2015-16)

6.3: Increased cleaner loader utilisation

As with the harvester utilisation, the aim when operating a cleaner loader should be to maximise the volume of beet it loads and the amount of time it is working. After seeing on my travels the value of adding GPS loggers, 29 cleaner loaders had the same type of GPS logger fitted to them to determine how well they were being utilised. Figure 26 shows the results from the GPS loggers after they were analysed by Agtrix. Unfortunately, it is difficult to conclude too much from this data as the GPS loggers were not capturing all the data required and hence the variation in the results. The data did show that the cleaner loaders spend a large amount of their time on the road and a relatively small amount of time loading.

Cleaner loaders tend be run by the haulage contractors an there is often over capacity as all contractors have a minimum of one, and some contractors might have up to ten. There is little sharing of cleaner loader machinery which restricts the degree of utilisation; although in some of the countries I visited during my study tour, such as the USA and Slovakia, the haulage and loading contractors are separate - which tends to increase the efficiency of both as one isn't supporting the other. The contractors are allocated defined geographic areas which maximises their efficiencies, and there is a high level of planning and co-ordination.

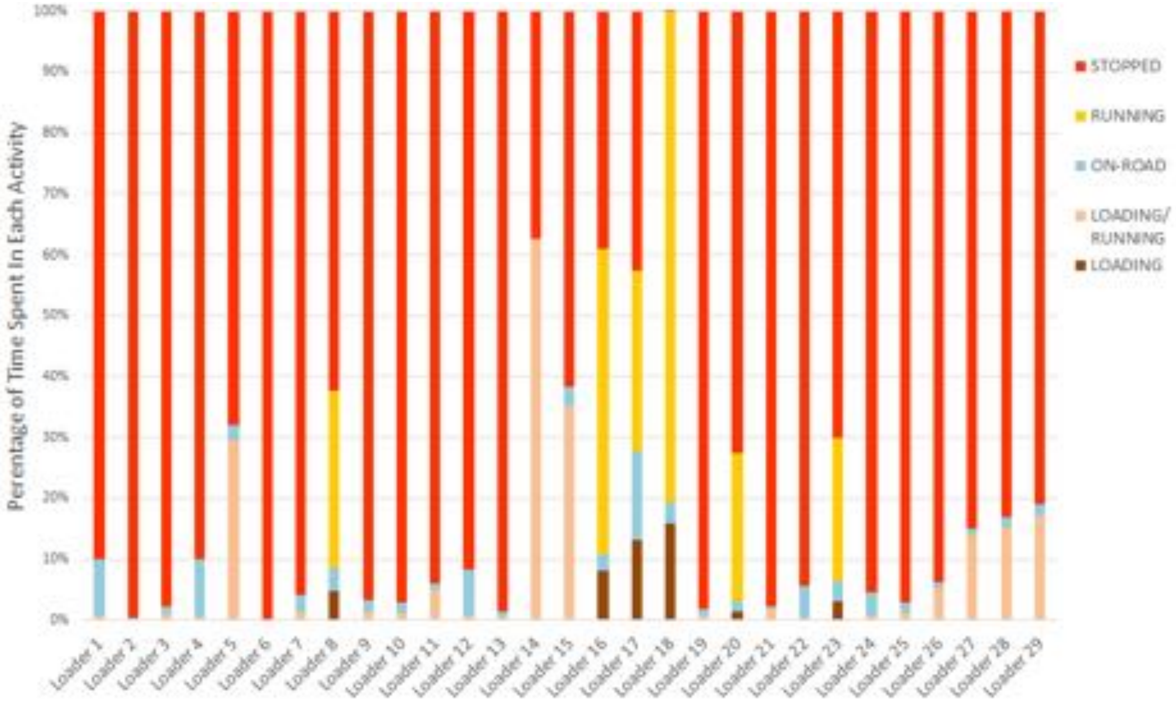


Figure 26: percentage of time each individual cleaner loader spent in each operational state over the 2015/16 Campaign, 24/7. (*British Sugar Supply Chain Study, 2015-16)*

6.4: Haulage optimisation

During the past ten years an average of around 280,000 loads were delivered to British Sugar's four processing sites each campaign. Unlike harvesting, which can be measured by sugar loss, the aim of an effective supply chain in relation to haulage must be aimed at maximising the efficiency of the whole operation, from when the vehicle is loaded through to delivery at the factory. This can be achieved in a variety of different ways and the aim would be to maximise the potential of each element to ensure best practice can be achieved. These elements will now be briefly but separately discussed.

6.4.1: Haulage utilisation

In order to improve this area of the supply chain, as with the harvesters and cleaner loaders, it is important to be able to monitor the current situation to assess how efficient it actually is before improvements can be suggested. To achieve this during the 2015/16 sugar beet campaign GPS loggers were also installed in 118 trucks to measure vehicle utilisation and use. Again, Agtrix were employed to analyse and interpret the data. As well as providing location details of the trucks, the tracking software provides information such as fuel consumption and driver behaviour. This was achieved because the software was connected to the CAN bus, the vehicle computer which provides all the data about the vehicles' performance.

One of the key principles of efficient haulage is to keep the truck moving as, if it is not moving, it is costing someone in the supply chain money and therefore reducing efficiency. The GPS loggers were used to record the information. I developed a trip event cycle of beet vehicle movements as shown in Figure 27 below.

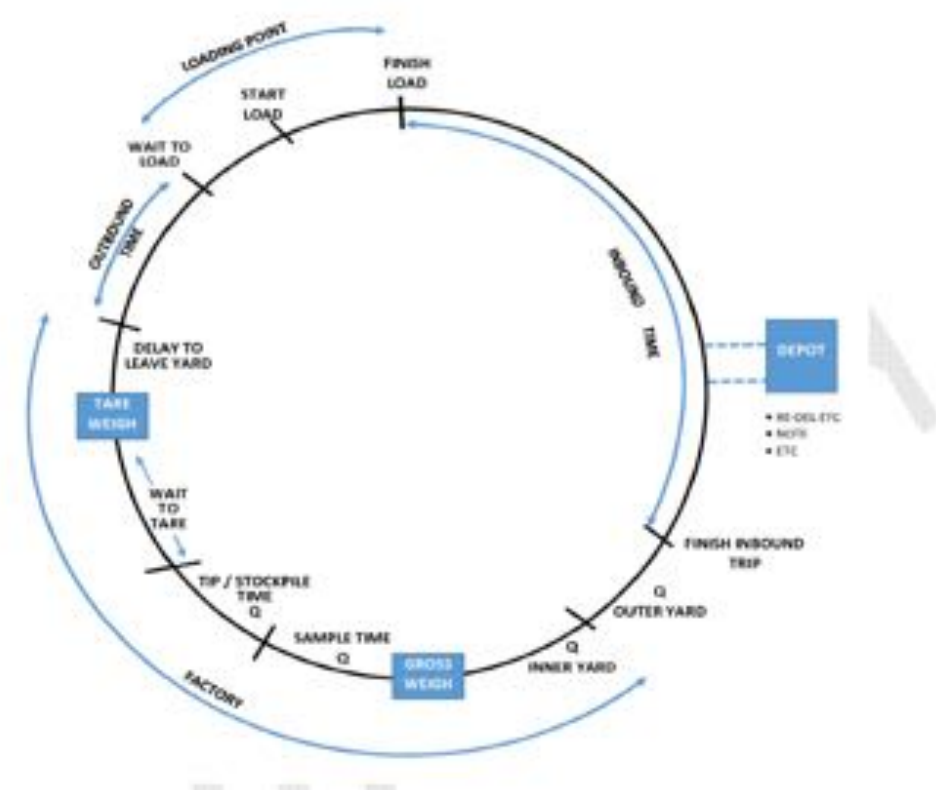


Figure 27: Typical trip event cycle – generated from the GPS loggers

In the UK there are four key areas in this process. These are: time at the loading point, inbound time, time in the factory, and outbound time.

The trip cycle begins at the loading point where the vehicle is loaded with either a self-propelled or conventional cleaner loader and, on average, as seen on the GPS data, this takes about 17 minutes. Again, a self-propelled loader seems to be able to load vehicles more quickly on average, so could lead to more efficient loading. The length of time spent at this part of the trip can also be determined by how well the trucks are spaced out during the day. If trucks all arrive at the loading site together, the first may get loaded in five minutes but the one at the back of the queue may have to wait up to 45 minutes, therefore reducing efficiency. Some drivers also load themselves, which is slower as the driver needs to move between the two vehicles regularly when loading; they also check that the weight loaded is legal, wasting valuable minutes in the loading cycle. Some drivers just like a chat, which all adds to the loading time, reducing the efficiency of the trip cycle.

The truck then has to travels to the factory (inbound time) and the length of this part of the cycle is determined by the distance to the factory, which is shown in Figure 28 overleaf.

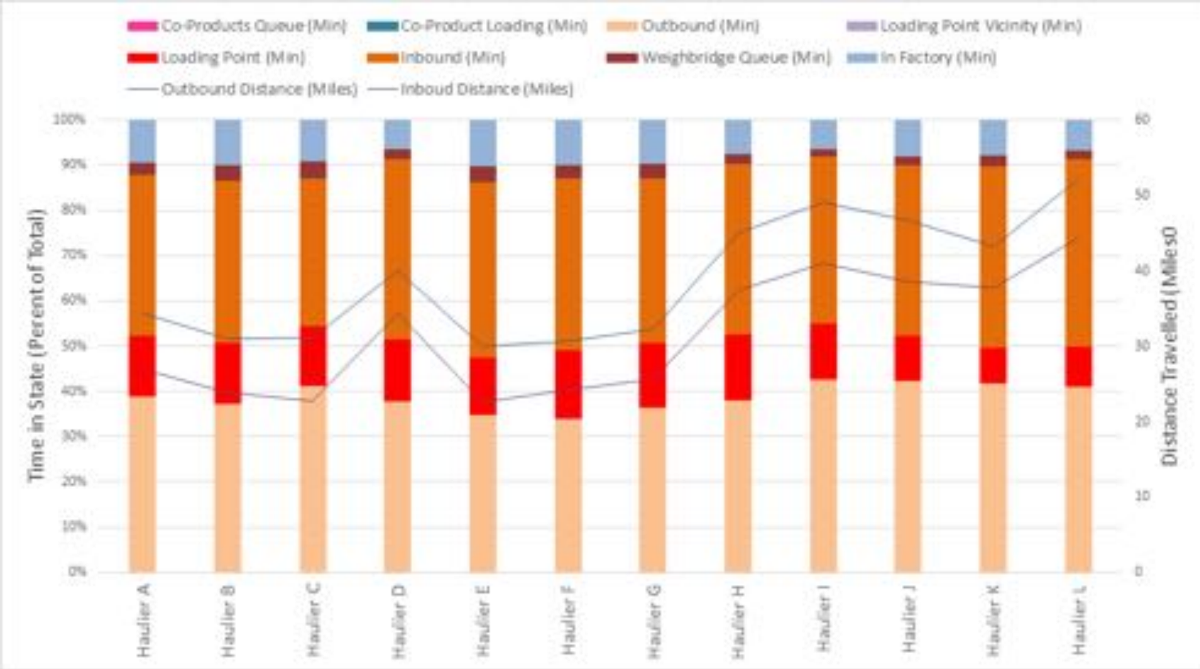


Figure 28: shows the trip cycle broken down by time in each part of the trip cycle for the 2015/16 campaign using a sample of haulage contractors. (*British Sugar Supply Chain Study, 2015-16)*

The vehicle then enters the factory and the average turnaround time is about 12 minutes from weighbridge to weighbridge, but my research suggests this can be further improved: some sites in Europe can turn vehicles around in less than 7 minutes. Work is ongoing at the British Sugar sites to improve this. As can be seen in the Figure 30 on next page, the outbound times tend to have the largest variance as this depends on how and where the vehicle is parked at the end of the day.

One of the main variances can be due to how haulage companies manage their drivers at the end of the day. If companies have a large proportion of drivers who night out, this part of the cycle is reduced compared to those who travel home every night. Drivers who night out will set off at the beginning of a week and return to the haulage yard at the end, having slept in their cab for the week. It is the most efficient way to run a fleet of trucks, if they are not based at the processing site or near to it, or they are always loading close to their yard, as it removes all the dead mileage travelling from processing site to their home and back to the start of a job in the morning. Nevertheless, the haulage company will have to pay the driver a night out allowance. In some instance, trucks have been witnessed driving 20 miles out of their way. This dead mileage is reducing their efficiency and costing the haulage company in driver wages, running costs, fuel, driver hours and is ultimately losing them the income from potentially a load of beet or two a day.

As well as minimising the trip cycle time it is also important that the haulage company seeks to maximise the number of trips a vehicle can deliver as these optimise the efficiency. The two are obviously related: once the trip cycle time is minimised, it is key that the haulage company maximises the opportunity to deliver more loads per day. In practice this is normally achieved by having a range of loading points at various distances from the factory to try to fill the available driving time. However due to the nature of the work with haulage companies operating in relatively small geographic areas, the opportunities to achieve this are limited.

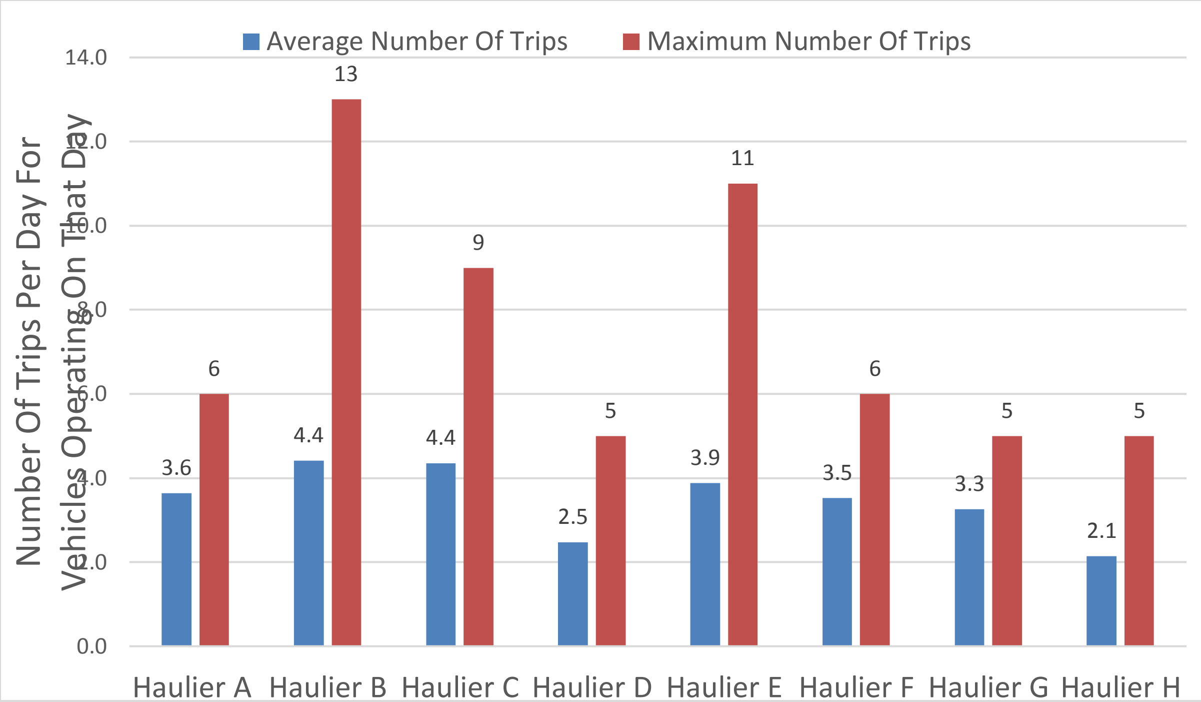


Figure 29: showing the average number of trips and maximum number of trips from a selection of hauliers during the 2015/16 Campaign. *(British Sugar Supply Chain Study, 2015-16)*

As can be seen in Figure 29 above, there is a huge variance between haulage companies, with the hauliers (B and C) achieving a higher average number of loads as they are located near to the factories and have little wasted mileage, whilst hauliers (Band E) have a large quantity of sugar beet a short distance away from the factory, allowing them the opportunity to deliver a large amount of loads per day when they are loading close to the factory.

> My experience from visiting several sugar beet and cane supply chains throughout this study suggests that the trip cycle time and number of trips per day can be maximised when the supply chain is centrally controlled. This enables good planning and coordination of the vehicles throughout the day, which promotes an efficient supply chain by reducing fixed and labour costs by working the vehicles more efficiently over the same period.

6.4.2: Fuel efficiency

One of the key areas in the cost of running a truck is fuel. It is estimated that, typically, a third of the cost of running a truck can be equated to fuel: therefore, any potential saving can be significant.

There are several options available to help improve fuel consumption. One method is to manage driver behaviour and promote fuel-efficient driver techniques through training. Many software options are available to help demonstrate and manage this. The option I used from Masternaut gave this information and was linked to the CAN bus data. The driver can be scored on their driving behaviour, normally based on:

- Acceleration – Rapid increase in speed over a short distance
- Braking – Rapid decrease in speed over a short distance
- Cornering – Rapid change in direction over a sort period of time
- Idling – Engine running whilst stationary
- Speeding – Over defined limit

This information can then be fed back to drivers to help identify improvements via one to one contact, league tables, or directly through visual feedback in the cab via a "light bar". If these techniques can be employed, it is claimed by Masternaut that a fuel saving of up to 5% can be achieved and make reward schemes and training programmes easy to implement.

Reducing the amount of time a vehicle is idling can also improve fuel consumption and telematics companies such as Masternaut claim using management software can reduce idling time by 33%.

Figure 30: Showing an example "dashboard" used to manage driver behaviour. (*Masternaut 2016)*

Figure 31: Showing an example league table used to manage driver behaviour. (*Masternaut 2016)*

Another example of improving fuel consumption is by ensuring the specification of the vehicle is correct. This could be achieved by using draught efficient cabs on the trucks, or smooth sided trailers instead of ribbed, or by using a sheet at all times to reduce drag and improve fuel efficiency. Another option is to employ a "screen gate" as used by Tereos, a French sugar beet processor. The "screen gate" is fitted to the trailer instead of a tailboard and it offers less air resistance when the trailer is empty. Tereos claim this innovation has resulted in savings of 2-3 litres of fuel per 100 KM, or 5.5 % less fuel consumption as well as other benefits, which will be discussed later in this report.

Figure 32: Figure 31 – Showing the screen gate (on the right compared to conventional on left) used by Tereros in France. (*Sugar Industry, November 2015*)

During a recent visit to the USA, Transytems, who transport millions of tonnes of sugar beet, also use a similar plastic mesh on all their trailers, which not only reduces fuel consumption but also increases payload.

6.4.3: Maximise payload

Many countries visited throughout this study - including Australia, USA and Africa - allow vehicles to carry significantly more than the UK weight limit of 44 tonnes, and as the latter is a legal requirement, it is unlikely it will be changed to enhance efficiency of the UK sugar beet supply chain. Therefore, the aim must be to enhance the payload carried by each vehicle to a legal maximum. The average payload of vehicles delivering sugar beet in the UK is 28.7 tonnes with a range from 14 tonnes to 30 tonnes. If this average payload could be increased by only 1 tonne the vehicle movements could be reduced by over 9300 vehicle movements (1 X 280000 = 280000Tonnes/30tonne payload).

This could be achieved many ways. Firstly the vehicle specification could be changed to use lighter (day cabs) tractor units if there was not a requirement to night out. In the main, day cabs are not used in the UK as the vehicles are not dedicated to sugar beet haulage and therefore have to have flexibility for the driver to be able to sleep in when required. There are also a number of accessories added to vehicles, which increase weight and therefore the amount of sugar beet, which can be hauled such as bull bars, additional lights, and microwaves. Running the vehicle on a low level of fuel can help reduce some of these effects providing the vehicle will pass a fuel station when required and using alloy wheels can also help reduce weight.

Figure 33: Figure 32 - A DAF day cab unit (*DAF UK 2016*)

A typical light weight tractor unit weighs 7660 Kg (DAF as shown in Figure 33 above weighs 7668Kg) and then a Fruehauf base model trailer which is regularly used for hauling sugar beet in the UK weighs 6000kg, giving a total weight of 13668Kg. if this combination was used in the UK this would allow 30332kg of sugar beet to be transported, thereby increasing the payload by 1632 kg compared to the current average.

There are various different vehicle specifications that can be trialled but overall weight of a standard trailer can also be reduced with some modifications. Following a meeting with Fruehauf in the UK, it was agreed that a saving of 337Kg could be achieved, as shown in Figure 34 on next page, which refers to a standard UK trailer. Most trailers also carry sheets which are not required for sugar beet haulage in the UK and this could save an estimated further 250Kg

See chart on next page

Base Model 67 yd^3 10.2mtr Tri Axle Bath Tub Fruehauf Bulk Tipper	6000 Kg
Remove landing legs	-150 Kg
Remove rack and pinion grain hatch	-15 Kg
Fit lighter weight brake disc and calliper	-15 Kg
Fit lightweight ram	-30 Kg
Remove lift axle	-15 Kg
Reduce floor thickness to 4mm aluminium	-90 Kg
Remove dump valve	-1 Kg
Remove body paint	-20 Kg
Remove one set of rear tailgate clamps	-1 Kg
New total unladen Fruehauf trailer weight	**5663 Kg**

Figure 34: weight saving by making alteration to a Fruehauf trailer

Figure 35: A typical Tri Axle bath tub Fruehauf bulk tipper

As well as increasing fuel efficiency the "screen gate" - as used in France by Tereos - can also help increase payload at it is lighter, weighing 150kg or 300kg, depending on whether it is made of aluminium or steel. Traditionally tailboards weigh 150-200 Kg in the UK and are lighter than those used in France but a similar design may save up to 50kg in the UK. I have currently asked Fruehauf to design a similar tailboard for the UK.

A similar idea was also witnessed whilst visiting the Red River Valley area of the USA. One of the main contractors hauling sugar beet in this area is Transytems who use mesh-sided trailer cages, which reduce the empty weight of the trailer and allow greater payload.

During my study tour it was also evident that, during the campaign, mud builds up on the trailers and tractor cab, and can weigh up to 600kg. Therefore a weekly routine cleaning of vehicles can be beneficial.

Figure 36: A mesh sided trailer used to transport sugar beet in the Red River Valley - USA

In the Red River valley the contractors deliver around 36,000 tonnes of beet per day to the processing factory, which equates to 1171 loads per day. They deliver around 11 million tonnes of beet each year and the trucks cover around 13,700,000 miles every campaign, so any increase in payload has significant benefits in maximising their efficiency. According to Transytems, their introduction of a very fine mesh on the trailer cages not increased payload but it reduces drag and improves fuel mileage (*Transystems.com*). Their design of the trailer cage frame was also a major innovation and the principal structural component of the trailer cages is chrome moly tubing. '*Whilst more expensive than steel and aluminium, the chrome moly's light weight more than compensates for the additional cost but improving payload'* (*Transystems.com*). Transystems has patented the trailers' design.

6.4.4: Longer opening hours

During my visits to Africa, Australia, USA and many parts of Europe, it was common practice to operate 24 hours/7 days (24/7) a week. This lends itself to increased efficiency of the supply chains because less equipment is required but it works over a longer period. For example, a sugar mill visited in New South Wales in Australia, which required 300 tonnes per hour of cane, was serviced with just eight trucks – 24/7. In the UK, the factories are currently open 7 days a week for a 12-hour period. As can be seen from Figure 37 on next page there is a peak of deliveries and queuing when the factory opens - usually around 6am - to receive deliveries because all drivers want to make a good start to their day by arriving when the factory opens. There are also time periods which control when beet can be delivered throughout the day. Trucks queue at the beginning of these time periods as there is little flexibility to delivering loads earlier.

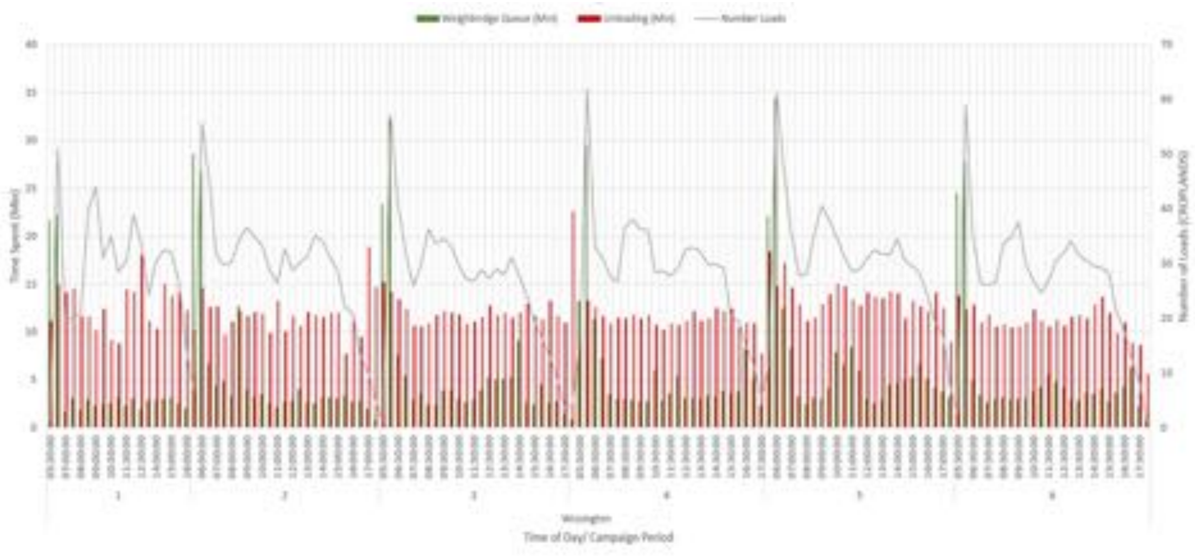


Figure 37: Time spent in weighbridge queue and unloading in the factory for Wissington factory, plotted against the time of day for each Campaign Period. ***(British Sugar Supply Chain Study, 2015-16)***

Whilst visiting similar operations around the world this increase in loads around certain times of day was not experienced. There just seemed to be a steady flow of vehicles with no queues, as vehicle utilisation seemed to be optimised. Extending site receiving hours in the UK could help overall operational efficiency and help reduce operating costs for hauliers.

Haulage contractors would experience higher wage costs for their drivers but these additional costs could be offset by increased utilisation of vehicles, leading to reduced fixed cost per load carried. Operational efficiency may also be experienced, as vehicles will be operating when there is less road congestion, which could lead to faster journey times, and more reliable average speeds which could also improve fuel consumption and vehicle efficiency.

It is also worth noting that there may be some concerns from the hauliers re extending the receiving hours as this would be seen as a new way of working, increasing driver costs, and also having to load and operate in the hours of darkness. There would also be potential impact on the local community from noise when loading and, although this would help cleaner loader utilisation, this could be offset by pre-loading trailers during the day and shunting the trailers during the night. This principle is used in New South Wales, Australia, where all the bins are owned by the sugar mill, loaded by the harvester during the day, and shunted to the mill during the night-time.

All factories in Idaho in the USA receive sugar beet 24 hours a day, 7 days a week and beet is delivered directly to the factory just in time (JIT) from the storage pile. Not all factories have the capacity to store beet on a flat pad similar to practice in the UK. Each factory operates with a zero flat pad so there are no flat pads at any site; although they do have small storage areas for use in case of factory breakdown as their aim is to ensure the trucks are fully optimised. Therefore logistics planning is critical in ensuring the factory always receives beet in line with the slice profile of the factory. At Paul Factory in Idaho they receive a truck every 2.5 minutes to keep the factory supplied. There is no beet intake system like the UK's and all trucks discharge their beet through bottom discharge trailers and supply the factory directly. All beet is handled through dry beet handling –

rubber elevators. The maximum payload on a truck is normally 42T of beet which is normally transported in two trailers towed by one truck.

Figure 38: Showing beet been unloaded to supply the factory direct in Idaho, USA

Figure 39: Showing beet handled from beet unloading to the factory via rubber conveyors in Idaho, USA

I have witnessed many great examples of increased haulage optimisation during my study tour and by adopting some of these techniques the UK sugar beet supply claim can become more efficient. A GPS logger can be used to visualise the supply chain for those prepared to change the way things have traditionally been done.

These opportunities include managing driver behaviour, which can save 5% in fuel usage, adopting the use of screen gates, which can save 5.5% in fuel usage plus increase vehicle payload. Changes to vehicle specification could allow a payload of more than 30 tonnes to be carried and longer opening hours would enable better utilisation of vehicles.

6.5: Just in Time (JIT) harvesting and delivery

As I have previously discussed, the length of time that beet is stored in clamp has a massive impact on yield loss and therefore it is key to reduce the time spent in the supply chain. Anything that can be done to reduce this time has a huge impact on increasing the efficiency of the supply chain.

One of the main hindrances to better efficiency is the lack of planning and coordination between harvesting contractor, haulier and grower. Traditionally this is normally well managed at the beginning of the harvesting season, but from the mid-season onwards becomes less efficient. This is due to the requirement of the grower to plant a following crop as soon as possible (normally wheat) and therefore large quantities of sugar beet have to be stored. As this is not well co-ordinated currently in the UK, it is difficult to ensure storage times are kept to a minimum. A lack of knowledge of when the beet is harvested further restricts other growers who want to keep their beet in the ground to maximise the length of grower period and hence yield.

Previously in this report I discussed the length of time that beet is harvested and delivery to British Sugar sites. This was conducted by a survey previously, but as GPS loggers were installed on all parts of the supply chain it is possible to measure the time it takes to harvest a field till delivery. Ideally, to maximise yield, this time should be as short as possible.

As can be seen in Figure 40 on next page, this is from a very small data set but the range in time to get sugar beet varies tremendously and now it can be measured by the GPS the aim is to reduce this time to maximise efficiency.

During a recent visit to Australia, one of the best examples of JIT harvest and delivery practice was witnessed at New South Wales Sugar in Queensland. They use a logistics management system to co-ordinate harvesting and haulage and they achieve an average cut-to-crush time of between 4-8 hours. According to Beattie & Crossley, (2007), "this system had been developed over time but was initiated by the need to develop innovative techniques for cane supply management, access and to promote harvester group optimisation. Their aim was to achieve the world's best practice harvest costs. During the initial set up cane supply staff rated the following three areas as critical for efficiency and cost saving (*see next page*):

- Electronic transfer of harvest data
- Integrating harvest and transport
- Automatic collection of harvest data, blocks cut and yield"

The Australian model demonstrated cane being harvested and tipped directly into transfer bins, which were then hauled directly to the cane mill. These bins were owned and managed by the sugar mill. Elsewhere around Australia, a similar principle is used whether loading bins for transportation by road or by rail. The harvesting and delivery of cane in Australia is all JIT and it is the "norm" unlike the UK.

> The typical supply chain in the UK includes multiple processes such as sugar beet being harvested, unloaded into a trailer, carted to a storage area, stored for a period of time, loaded and cleaned and then hauled to the factory for processing. The UK must learn from these examples of best practice around the world, and not only reduce the number of processes in the supply chain but also the length of time this takes.

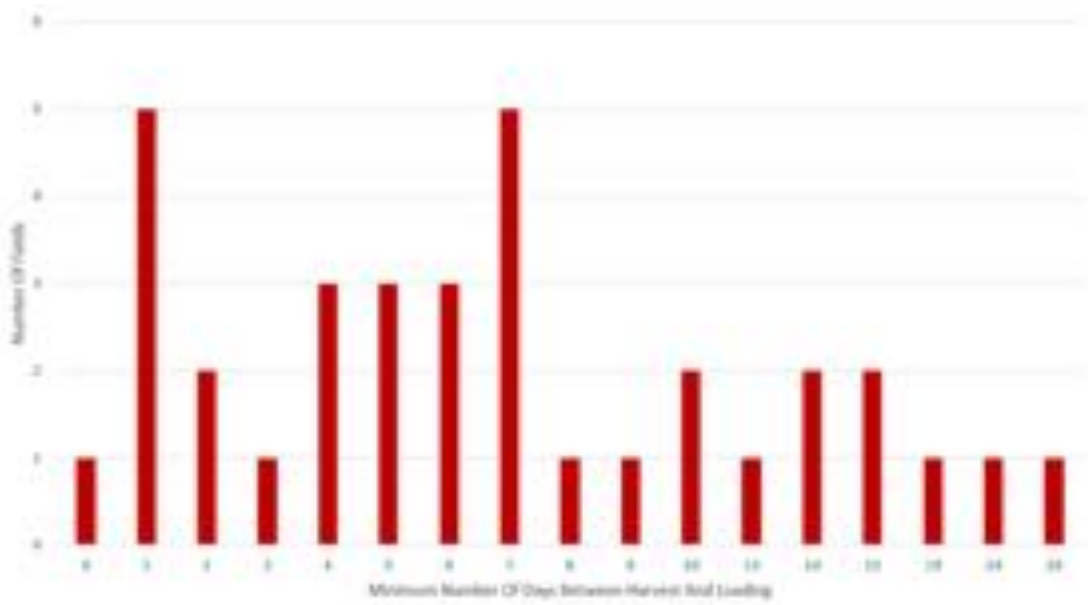


Figure 40: Number of fields that had various minimum number of days between harvesting activity and loading activity from GPS tracking. (British Sugar Supply Chain Study, 2015-16)

Photographs of various handling and transport operations in Australia, Zambia, Malawi, USA, Spain and the UK can be seen on next 6 pages.

Figure 41: Loading cane bins direct from the chaser in New South Wales, Australia

Figure 42: Cane bin on its way to the mill – JIT Harvest and Delivery in New South Wales, Australia

Figure 43: Cane bin being unloaded at the mill in New South Wales, Australia

Figure 44: Harvesting cane Mackay, Queensland, Australia

Figure 45: Harvesting cane Mackay, Queensland, Australia

Figure 46: Loading cane onto the rail trucks. Mackay, Queensland, Australia

Figure 47: Loading cane onto the rail trucks. Mackay, Queensland, Australia

Figure 48: Rail trucks being unloaded by Goliath. Mackay, Queensland, Australia

Figure 49: Rail trucks being unloaded. Bundaburg, Queensland, Australia

A similar system was also witnessed in Africa and, although not as advanced as the Australian model, was significantly more efficient than the UK, achieving an average cut-to-crush time of 12-36 hours.

Figure 50: Harvesting sugar cane by hand in Zambia

Figure 51: loading sugar cane just after it has been cut in Malawi

Figure 52: Unloading sugar cane in the mill. Malawi

A principle of loading lorry trailers directly could help reduce processes with sugar beet and this has been witnessed in the USA and Europe. It would reduce the potential yield loss through breakage and storage loss but, as the amount of processes in the supply chain would be reduced, there is a potential saving of at least a £1/Tonne for most growers. This was trialled in the UK during January 2016 and, although a very small-scale trial, it proved successful with no issues around beet quality and no significant difference to dirt tare. A similar practice was also witnessed in the USA where they either load lorries direct or use a chaser bin to load the lorries on the headland, which in turn then deliver the beet to the piling station or directly to the processing site.

Figure 53: Loading sugar beet into directly into the lorry in Minnesota, USA

Further photographs overleaf

Figure 54: Loading sugar beet into a Big Bear Chaser reading for loading directly into the lorry in Michigan USA

Figure 55: Loading sugar beet directly into the lorry from a Big Bear Chaser in Michigan USA

Figure 56: The true principle of JIT harvesting and delivery in Michigan USA

During a recent visit to Jerez in Southern Spain, where they harvest beet in the summer months during temperatures of about 40^{O}C, JIT harvesting and delivery is critical to avoid sugar loss and the beet completely breaking down due to the excessive heat. The processing site's team tightly manage this process and all sugar beet is delivered within a twelve-hour period. This can be achieved because of the tight co-ordination between the sugar processor, harvesting and haulage contractors, and the growers. The sugar processor allocates the grower a delivery pattern which is determined before the campaign begins, and the harvesting and haulage contractor follows these plans. During the visit it was evident that this process was working exceptionally well and, unlike in the UK, no cleaner loaders were used due to the dry soil conditions which not only saved cost but reduced damage and loss to the sugar beet. Due to the dry conditions sugar beet were loaded directly into the lorry from the harvester and the lorry drove alongside the harvester on the field to reduce the loading time.

On next page see two photographs taken in Spain

Figure 57: Loading sugar beet directly from the harvester into the lorry during temperatures of 40°C in Jerez, Spain

Figure 58: Loading sugar beet directly from the harvester into the lorry in temperatures of 40°C in Jerez, Spain

In the UK during the 2015/16 campaign I trialled loading lorries direct from the harvester, and although this was a small scale trial, it proved to be successful with no adverse effect on dirt tare or beet quality witnessed. The tractor unit and trailer were loaded successfully and a powered dolly was used, towed by a tractor. It proved this concept could be used in the UK although it would be very dependent on weather conditions and soil type.

Figure 59: Loading sugar beet in the UK directly into a lorry trailer, ready for delivery to the factory

Figure 60: Loading sugar beet in the UK directly into a lorry trailer, ready for delivery to the factory

Figure 61: Loading sugar beet in the UK directly into a lorry trailer being towed by a tractor, ready for delivery to the factory

Figure 62: Loading sugar beet in the UK directly into a lorry trailer being towed by a tractor, ready for delivery to the factory

I have seen many great examples of JIT harvesting and delivering around the world. It is clear that the UK must trial some of these practices to further develop the efficiency of the supply chain, and to see which best fits with the UK conditions. It is clear that a one-system approach does not necessarily suit all and perhaps several different approached may be best.

> Loading vehicles directly from the harvester to the lorry is achievable in the UK when conditions are suitable. This could save in the region of £0.90/tonne as a cleaner and loader would not be required. Loading directly from the harvester would also increase yield by reducing the number of times the sugar beet is handled - and therefore damaged - and by minimising the amount of time the sugar beet will be in store.

6.6: Strategic long term storage

During my study tour, I also witnessed long-term storage of sugar beet predominately in the USA. They have to long-term store most of their sugar beet in piles or purpose built buildings. They do this as they cannot harvest sugar beet once the ground has started to freeze, normally from mid- late October.

6.6.1: Beet storage - conventional piles

During my study tour to Idaho, Michigan, Minnesota and North Dakota, I witnessed long-term storage. Construction of each pile varies but is on average 170–270ft wide by around 21ft high. Once harvest is finished, Amalgamated Sugar can have up to 28 miles of piles that are 21 ft. high! The piler will reach on average 90 ft. When piling the piler produces dirt rings, which can cause hot spots due to the reduced ventilation in these areas. Dirt shoulders are also produced on the edges of piles and again these must be monitored and are usually delivered first.

There are two main methods of storing conventional piles in Idaho.

1) **Without fans or plastic sheets** – these are large piles of around 80 -100kt tonnes that are similar to our clamps. These heaps are purely dependent on the weather conditions and must be located in an area that gives maximum ventilation so the prevailing wind direction must be considered. A comment was that piles on hills are best as you can get free ventilation! Care must also be taken to consider surface area as the sun is major threat and can cause hot spots.
2) **With fans and plastic sheets** – these are constructed by the same method; however, pipes are laid in the heaps about 15ft apart and are connected to fans that are used to ventilate the piles. The aim is to store the beet at 35-36^{o}F and, ideally, the pile needs to be in an area that cools below this at night allowing the heat in the pile to be reduced to 34^{o}F. Once the target temperature has been achieved, the aim is to use the fans every day/or every other day to ventilate the heat out as the beet respire. A polyethylene sheet is then used to cover the beet; it is white on the outside to reflect the heat and grey/black on the inside. Each sheet has circular holes which are 2.5-3" in diameter to help ventilate the pile – being circular they do not rip or tear as easily.

These piles are constantly measured for temperature and infrared is used to identify any hot spots. If hot spots are found the agricultural teams instruct the logistic contractors to remove these as soon as possible. All the piles are measured for temperature at night by plane and this is because it shows any hot spots better at night and the plane is quick. If the piling station has more than one pile, care must be taken with the centre piles as these do not have as much ventilation and can therefore heat up faster. In an average year, shrinkage of 5% can be expected on average although this varies. Each pile is scrapped and rotten beets are discarded: this season it is expected that 50K tonnes of beet will be discarded due to the higher-than-average temperatures. The discarded beet are chopped and normally given to livestock growers.

Figure 63: showing the construction of outside long-term storage piles in Michigan USA

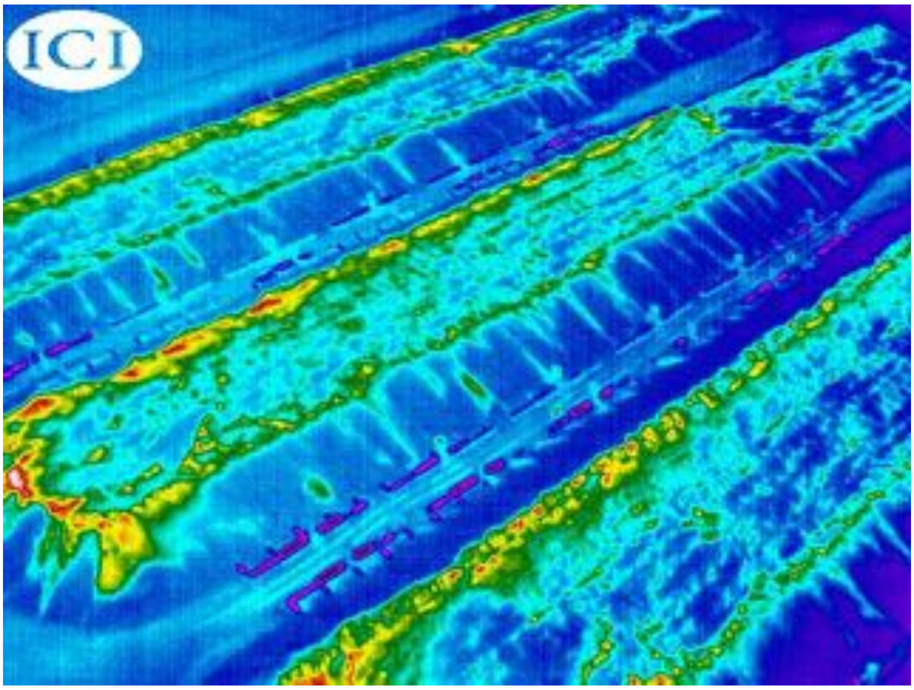


Figure 64: showing an infra-red photo to measure any hot spots within piles Michigan USA (*Image supplied by Michigan Sugar 2015)*

Figure 65: showing the construction of outside long-term storage piles in Minnesota, USA

Figure 66: showing the long-term storage piles, covered with sheeting
and with air ducts for ventilation - in Idaho, USA

6.6.2: Beet storage – storage sheds

Several of the American sugar companies have long-term storage sheds. They typically measure 800x184x35ft and can hold 80,000 tonnes each. The aim is to keep the sheds at 35^{o}F and beet can be stored for up to 140 days providing the temperature does not exceed 40°F. They have found that after 40 days the beet start to respire and grow! There are 22 fans per shed, with 11 on each side. They are each controlled independently and most run for about run for about 30% of the time. Each shed is fitted with several temperature probes that constantly measure temperature.

Figure 67: showing long-term beet storage building North Dakota USA

Figure 68: showing long-term beet storage building in Idaho USA

Figure 69: showing a brand new long-term beet storage building in, Michigan USA

Due to the extreme conditions experienced in the beet growing regions of the USA, long-term storage piles and buildings are a necessity. They also provide the opportunity to lengthen the processing campaign, which allows a reduction in processing costs as they can run the factories over a longer period. However, the cost of building and managing such large piles and buildings can be significant, and they require constant monitoring by the agricultural team to avoid any serious losses due to temperature gains.

> I currently believe strategic long term storage is not necessary in the UK sugar beet industry as the aim must be to achieve a more JIT harvesting and delivery approach. Having a fully planned, co-ordinated and efficient supply chain, which minimises the amount of time the sugar beet is in store, is crucial. At present the UK industry cannot justify such investment in long term storage.

6.7: Back loading

Back loading is the act of transporting goods on the return journey of a vehicle that has delivered goods to a location, so in the sugar beet supply chain a backload is when any product can be delivered from the factory site to another site once the sugar beet has been delivered.

Currently in the UK little back loading is achieved (less than 5%), as there tends to be a separate fleet which hauls the sugar beet to that which hauls the co-products and other materials. The main reason for this is that the more back loading you achieve the less sugar beet can be delivered, as it inevitably takes too long to re-load with another product. This situation has also been experienced in other countries (particularly Spain) where similar problems exist - so they prefer not to backload Backloading not only restricts the number of loads of sugar beet that can be delivered but, if a vehicle is waiting in a queue, this could be costing up to £30/hour. Therefore, if the amount of backloading during the campaign is to be increased there must be a bigger focus on the turnaround of vehicles on site when collecting co-products.

Figure 70: A lorry that has delivered sugar beet has been re-loaded with animal feed at Newark Sugar Factory UK

There must be continued focus for this campaign to reduce turnaround even more by using continuous improvement techniques. Some of these include showing the visibility of the queue, being able to weigh vehicles on the beet bridges reducing the need to weigh in at the sundries bridges, therefore reducing time on site and increasing the loading capacity of the shovels used to load.

> If turnaround time can be further reduced this will make backloading more attractive to the sugar beet transport fleet and it gives the haulage companies excellent opportunities to maximise their efficiencies: it would reduce empty running and enable them to offer competitive haulage rates on both legs of the journey so everyone gains a benefit if this can be achieved.

6.8: Logistic management systems

So far, all the separate components of the sugar beet supply chain have been discussed and areas highlighted where efficiency can be gained or equipment optimised. A logistics management system strives to pull all these components together and generate an efficient supply chain.

There are many companies which offer solutions: whether they operate on cane or beet they all strive to deliver a fully efficient and optimal supply chain. These systems are becoming increasingly available because mobile technologies and the infrastructure required to operate such systems are themselves becoming more available and affordable.

During visits to both Africa and Australia, systems produced by Agtrix were seen in operation and, as well as planning logistics, these systems integrate the whole supply chain from field through to delivery at the processing mill. This has big potential benefits, as the whole supply chain can be visualised which enables better communication and co-ordination. Most systems available tend to consider each part of the supply chain separately.

The Agtrix supply chain tool is called FREDD, which facilitates the integration of the inbound supply chain from a central location, which continuously optimises the supply chain JIT to be as efficient as possible given all current circumstances.

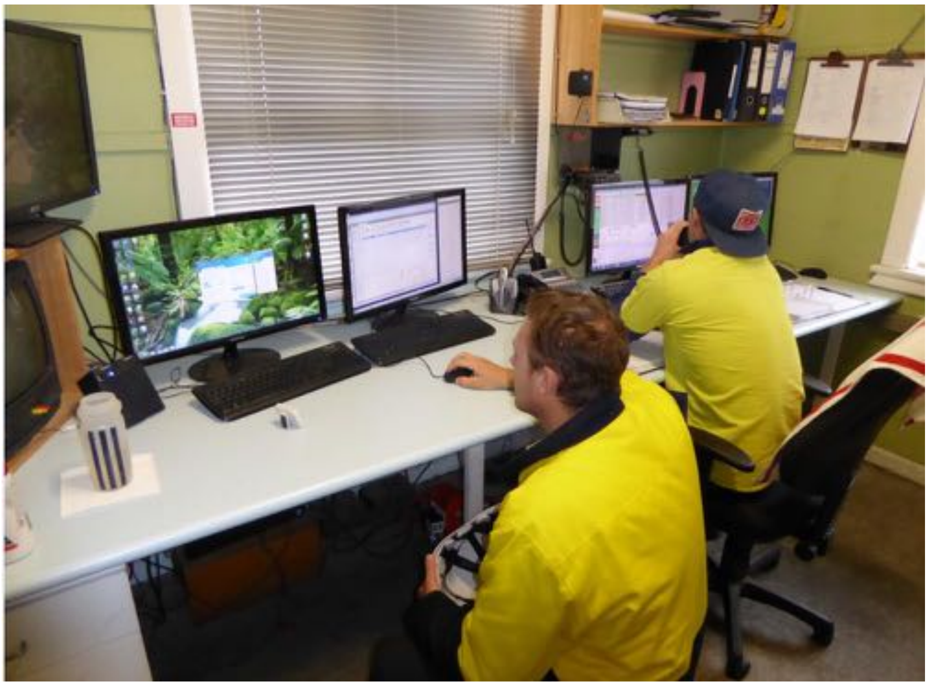


Figure 71: Operators using a logistics management system in New South Wales, Australia

Agtrix claim this system has improved fleet capacity by 30% in South African and Australian sugar mills, whilst reducing cut-to-crush times and mill stops caused by lack of supply.

When I visited Nchalo sugar mill in Malawi, FREDD had just been implemented and was immediately delivering benefits to the supply chain. These included full visualisation of the supply chain for the first time, a reduction by 12.5% of the vehicles used to haul cane with further savings anticipated, reduction in the amount of cane stops, and savings in fuel consumption.

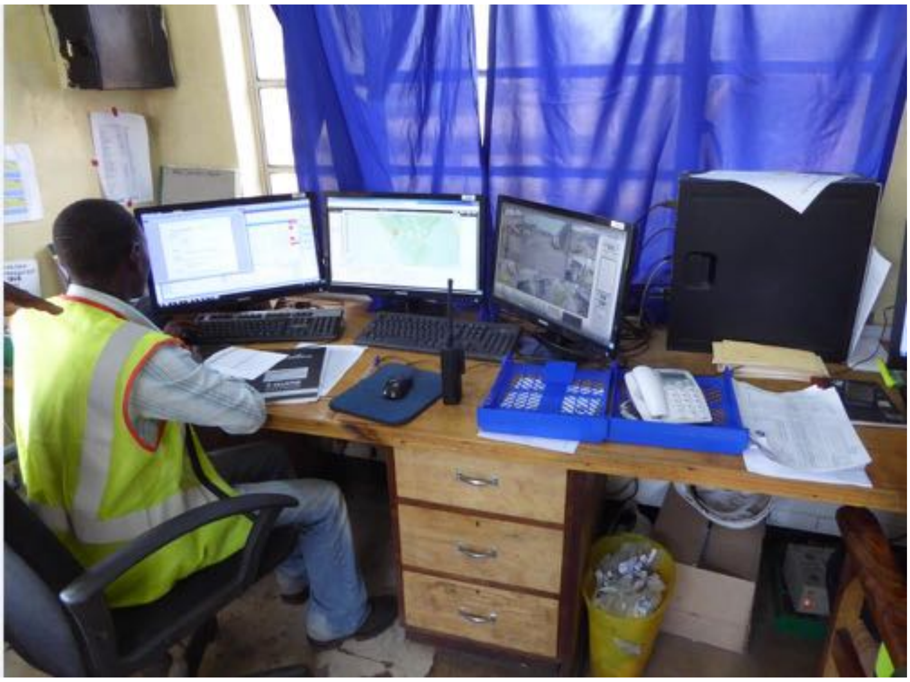


Figure 72: Operator using a logistics management system in Nchalo, Malawi

Many sugar beet processors use similar technology/software to optimise the beet logistics in Europe, but no such system is currently used in the UK. In Slovakia, a solution called AdOBel (Advanced Optimisation of Beet Logistics) is used. This system is based on a daily or multi-daily plan of raw material bulk supply, and uses mathematical algorithms to generate trips - based on maximising the optimisation of the supply chain using the least number of vehicles possible. To accomplish this all the components are joined into a system driven exclusively by the processing capacity of the sugar factory.

This system does not include harvesting or loading components similar to FREDD, but it claims an increased overall efficiency while maintaining/increasing level of system reliability and a substantially increased ability to avoid and solve critical situations. Similar to FREDD it also provides information and reports on the supply chain. Evidence also shows that during a trial vehicle downtime was reduced by 10% and vehicles travelled 50000 kms (3%) less due to better navigation provided by real time information on the driver's tablet.

Various other companies also offer similar solutions in Europe but they do not seem to be as integrated as Agtrix's systems in terms of the whole supply chain - harvesting, cleaning and loading and haulage - which will have the maximum benefit on improving the supply chain.

These systems provide great opportunities to further maximise the efficiencies of the supply chain and during my study tour I have witnessed some very efficient examples. There is no reason why these should perhaps be trialled at least in the UK.

Figure 73: Showing real time information on the driver's tablet – Slovakia

Figure 74: Tablets showing an example of a logistics management system

6.9: Improved beet supply scheduling

The quantity of beet which can be harvested and delivered is governed by the slicing capacity of the processing sites and this is experienced all over the world in terms of sugar processing from either cane or beet. Therefore, inefficiencies in the processing site then cause inefficiencies in the supply chain, because it has to react to the increase or decrease in factory slicing performance. An increase requires more resource, which is not always available, and a decrease results in the resource having little to deliver. Therefore an even slice profile throughout the campaign must be achieved and, if not for the whole campaign, periods where resource can be deployed accordingly. In the UK, and in all countries visited, the slice/cut rates per day vary massively and the processing sites which have less variability are not any more efficient themselves. However, they do also have a more efficient supply chain, as the resource can be planned to maximise the efficiency without risk of having nothing to do the following day. The sites which are more successful tend to be those that set a consistent slice/cut rate and keep to it, in contrast to those which try to break records every day or are less consistent, as this has a negative effect on the supply chain.

It is inevitable that there will be variation throughout the campaign. However it is important to be able to manage the supply chain to ensure inefficiency has a minimal effect on it. To help minimise the negative effects, communication is critical so that both the processing site and supply chain know how to react to changes. In the UK the supply chain is expected to react immediately. There is quite often a delay in this communication as the supply chain is complex and involves many stakeholders: unlike some of the sugar plantations visited in Africa where there is one processing site, a minimal number of growers, and one completely managed supply chain. Therefore adaptions can be rapid. The African supply chain also has full exposure to the processing requirements and each afternoon a plan is made for the following day: how much cane to burn and cut to keep the mill crushing.

The UK does not have this luxury, and so it is important that changes are communicated rapidly so the supply chain can react, but ideally there must be flexibility for both parties to be able to adjust accordingly. In the UK this could be achieved by altering what sugar beet is required over a longer period of time and not just for 24 hours ahead, which is currently common practice. This would require the processing site to store more beet on its flat pad but it would enable the supply chain to react over a longer period.

Giving the haulage company more flexibility would also enable them to increase their efficiencies by minimising the amount of trucks in the fleet. Following last campaign one haulage contractor described the need to run additional trucks at one site to ensure all deliveries required on that day were delivered, as there was no flexibility if these loads were missed on the day of delivery. To avoid missing any loads, two additional vehicles were added which would not have been required if flexibility were to be allowed.

See photos on next page

Figure 75: Burning sugar cane in the afternoon just after the plan has been made, to then be cut the following day. Malawi

Figure 76: Showing 50000 tonnes of beet been stored on the flat pad at Wissington

I believe beet supply scheduling in the UK can be more difficult due to the increased number of haulage contractors delivering to the sites, which leads to queues at peak periods. If this number was consolidated this would reduce the number of vehicles delivering to sites, which would result in deliveries spread out over the delivery window, thus further increasing the efficiency as less vehicles would be required; and those vehicles would also achieve more loads per day at witnessed throughout Australia, USA, Africa and Europe.

6.10: Better planning and grower group optimisation

A key theme throughout this report is the need for better planning and communication as I feel that the lack of planning by growers, harvesting and haulage contractors, and British Sugar leads to last minute decisions been made in the UK. This leads to inefficient use of contractors' resources as they tend to dart all over their areas and often meet one another on the road.

The planning and organisation could be improved by operating grower groups with a range of soil types, allowing harvesting and delivery throughout the campaign. There are a small number of grower groups operating already in the UK, such as the Bury Beet Group, and a lot could be learnt from their operation to benefit other growers in the UK. In practice, it is ideal to have a haulage contractor following the harvesting contractor with both parties having the same capacity to ensure efficiency is achieved. Alternatively, British Sugar could coordinate and plan the growers' harvesting and haulage collection schedule, which happens in France, Germany and Spain. This would involve a huge change of mind-set for the UK industry, as some growers may not appreciate relinquishing control to a third party or even to British Sugar. Harvesting and haulage contractors have expressed an interest in such a scheme as it has the potential to reduce their "waste mileages" and increases their efficiencies. Ideally, the beet growing areas could be divided by harvester capacity (1000Ha) and each harvesting contractor allocated 1000Ha in as tight as block as possible to reduce road mileage; and the haulage contractors would then be allocated on their capacity. Ideally cheese-wedge-shaped geographic areas should be formed to ensure the haulage contractor maximises the amount of loads delivered per day.

To introduce this would involve a lot of negotiations and work but it has been successful in other crops such as pea vining, and the potential benefits to both growers, contractors, and the processor are huge. I believe it must be considered as an option for further improving the sugar beet supply chain efficiencies. It has proved successful in many of the countries I have visited as part of this study, so why not in the UK?

I have estimated what could be achieved by maximising the efficiency of the supply chain compared to the current machinery utilised in this operation. *(Figure 77 below).* I have indicated a minimum of one hundred harvesters could be required by 2020 if they were all fully utilised. This estimate is based on a UK crop area 100000Ha, assuming a harvester could harvest 1000 ha evenly throughout each season. With cleaner loaders I have estimated that each loader could load 150000 tonnes, if fully utilised based on a total crop volume of 7.5 million tonnes. The number of haulage vehicles required is based on calculations from the Transport Efficiency Study Final Report (2009), which calculates that just 256 dedicated vehicles would be required to transport 7.5 million tonnes of beet 7 days a week, averaging six loads per day.

Equipment Type	Current Number Year 2016	Potential Future Number Year 2020	Potential Percentage Reduction
Harvesters	366	100	366%
Cleaner Loaders (All)	220	50	440%
Haulage Vehicles	1692	256	661%

Figure 77: Showing what could be achieved by maximises the efficiency of the supply chain

This chapter (the entire Chapter 6) has demonstrated that we can make better use of our current resources to maximise the efficiency of the sugar beet supply chain; and that efficiency can be increased through the adoption of new working methods and techniques.

Figure 78: The meaning of JIT harvest and delivery

Chapter 7: Conclusions

1. The UK sugar beet supply chain is hugely complex and contains many stakeholders. Due to these factors, progress towards efficiency can be slow and difficult at times. In every area of the supply chain, from the field to factory flume, there is the potential of losing significant yield and a reduction of efficiency if not managed effectively.

2. Total visibility of the whole supply chain is critical to improving its efficiency. The use of GPS loggers is widespread across the cane and sugar beet growing areas of the world.

3. A harvester "best practice plan" can deliver significant yield improvement. A 1% saving in harvester loss could deliver savings of £1.25 million to the industry.

4. Harvesters and cleaner loaders are massively underutilised and different working practices need to be adopted. A better-planned and co-ordinated approach also needs to be adopted to improve machinery utilisation and efficiency.

5. Haulage is key to the whole supply chain and, through the adoption of new working methods and techniques, efficiency can be increased. A reduction in fuel usage of up to 10% can be achieved through the adoption of new techniques; payload can be increased to 30 tonnes reducing the amount of vehicle movements by 9300 per campaign, and longer opening hours can increase vehicle utilisation.

6. My research in USA, Spain, Australia and parts of Africa has shown that just in time (JIT) harvesting and delivery has potential for further yield improvements for the UK industry, together with the opportunity for not using a cleaner loader which could offer savings of £1/T where not used.

7. Strategic long term storage is not necessary in the UK sugar beet industry as the aim must be to achieve a more JIT harvesting and delivery approach. At present the UK industry cannot justify such investment in long term storage.

8. A controlled number of vehicles delivering sugar beet to the factory and backloading co-products can increase efficiency provided they can be turned around quickly.

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9. Logistics management systems can provide excellent opportunities to further improve efficiencies in an era where mobile communication is readily available to all. These systems allow full visualisation of the supply chain, have improved fleet utilisation, and provide very detailed and accurate management reports.

10. Co-ordination, planning, flexibility and communication are key to improving beet scheduling in the UK. The instigation of more grower groups may further increase efficiencies.

11. Resource employed in the supply chain can be made more efficient: reductions of 366% for harvesters, 440% for cleaner loaders and 661% for vehicles could be achieved if the supply chain was operating at maximum efficiency.

Chapter 8: Recommendations

1. It is apparent from my travels that the UK has significant opportunities to increase its efficiency in the beet supply chain. If the Industry wishes to stay competitive in the future, I believe it must inject urgency into making changes that involve all key stakeholders.

2. Gaining total visibility of the whole supply chain is critical to improving its efficiency. GPS loggers need installing across the supply chain. This allows you to measure your current efficiency, visualise what is happening in real time, and allows you to plan and communicate future changes more effectively.

3. A harvester "best practice" plan can deliver significant yield improvement by reducing harvester losses and a tool similar to The Sugar Cane Harvest and Loss Optimisation Tool (SCHLOT) needs to be developed to aid UK growers and harvesting contractors. A code of good practice for operators needs to be developed and an operator-of-the-campaign competition for next campaign could be introduced. A real-time damage assessment should be developed by the BBRO. To maximise yield, harvesting contractors need to be paid on a £/tonne basis instead of an area based payment which potentially encourages the wrong behaviour.

4. This report has shown that harvesters and cleaners loaders are massively underutilised and that different working practices need to be adopted. A degree of rationalisation also needs to take place to ensure the investment made in such machinery can show a return. A better-planned and co-ordinated approach also needs to be adopted to improve machinery utilisation, efficiency, and this should be controlled centrally, perhaps by British Sugar.

5. With haulage, new working methods and techniques need to be adopted. Areas of improvement include: reduction in time of the trip cycle; increased number of loads per vehicle per day; increased fuel efficiency through improved driver behaviour and using lighter weight screen tail boards; increased payload through better vehicle and trailer specification; and longer receiving hours for sugar beet been delivered to the factory.

6. Just in time (JIT) harvesting and delivery has potential for further yield improvements to the UK industry. This is dependent on soil and weather conditions throughout the season but could be trialled more in UK conditions, together with the opportunity of not using a cleaner loader, which could further increase yield. Growers who have soil types suitable need to be selected and asked whether they would consider participating in a trial.

7. Logistics management systems should be trialled on the 25% of the crop that is delivered under the Industry harvesting and haulage scheme that is managed by British Sugar; this could potentially then be rolled out further.

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8. The number of vehicles delivering sugar beet to the factory and backloading co-products should increase from the current level of 5% to at least 40%. To achieve this, focus must be targeted in this area by British Sugar to reduce turnaround times. The GPS loggers are key to highlighting potential bottlenecks in this process so the results from these needs to be analysed and fed back to highlight improvement areas.

9. Beet scheduling should be better communicated, offer more flexibility and not have to react to changes in slice so rapidly, allowing the supply chain to become more efficient. This process begins by the factories slicing at a more even slice rate and, if breakdowns occur, they must be able to store surplus beet on the flat pad (storage area) allowing the supply chain more time to react. Flexibility must be given to the haulage companies when breakdowns or slowdowns do happen.

10. I believe the adoption of grower groups may further increase efficiencies by promoting geographic areas for both harvesting, loading and haulage, controlled centrally to enable the maximum utilisation of their equipment.

Chapter 9: After my study tour

Since being awarded my Nuffield Farming Scholarship in November 2014 it has been a whirlwind eighteen months, and I have experienced and seen so much that will help me continue to improve the efficiency of the UK sugar beet supply chain.

I have certainly returned from my study tour inspired and buoyed with enthusiasm to ensure I can continue improving the UK sugar beet supply chain. Following each country I visited, I returned and eagerly tried to put into practice what I had experienced, witnessed and learnt during the last 18 months.

As a result of this enthusiasm and keenness to put in practice what I had learnt, my team and I have been awarded an AB Sugar Focus award in April. The award recognised the work involved in trying to optimise sugar beet haulage in the UK and recognised areas of work I implemented from my experiences during my study tour. This involved conducting visibility studies, trying to maximise back loading of co-products, using continuous improvement techniques to highlight areas of operational excellence and ultimately it delivered a more efficient supply chain with UK growers saving a minimum of £3 million. This project presented growers with more haulage options and better customer service. The cross-business approach also inspired others to run similar projects and deliver additional value. The benefits are sustainable, greater visibility of the supply chain is already delivering significant benefits and further improvements via GPS technology are underway. The work has delivered better planning, co-ordination and integration of harvesting & haulage to help maximise yields and efficiency, but it is important this work continues to ensure the UK is competitive and has a future post 2017.

To build on the work already achieved it is important to continually involve all the stakeholders involved in the supply chain: growers, harvesting and haulage contractors, and British Sugar This report demonstrates what can be done to maximise the efficiency of the supply chain and the benefits of working towards the same goal!!

Chapter 10: Executive Summary

Competition in the European sugar markets has increased because to the abolition of quotes in September 2017. This has resulted in many of the most efficient European sugar processors looking to expand their current market share, positioning themselves in the market for when sugar quotes disappear, and be able to capitalise on this newfound freedom. EU prices have fallen over recent years, requiring European processors to maximising all their opportunities. Inefficient producers will simply not be able to survive in this more competitive climate. Therefore, the UK must become more efficient within its supply chain to ensure they continue to be one of the most efficient sugar producers. This includes areas such as harvesting, loading, cleaning and delivery of the crop to the processing site in order to maximise yield for both the grower and processor.

The primary goal of my report was to determine how to operate the most efficient supply chain, from field to processing site in the UK sugar beet industry. A series of both cane and sugar beet processors, growers, and industry experts who are the most efficient in the world were visited and benchmarked against the UK industry. These included stakeholders in USA (Michigan, North Dakota, Minnesota and Idaho), Australia, South Africa, Zambia, Malawi, Slovakia and Spain.

From my study tour, it is apparent that the UK has significant opportunities to increase the efficiency if the Industry wishes to stay competitive in the future. I believe there are immediate changes that can be executed. The UK sugar beet supply chain is hugely complex. In every area of the supply chain, from the field to factory flume, there is the potential to lose significant yield and a reduction of efficiency, if not managed effectively to ensure all aspects of this supply chain are optimised.

Gaining total visibility of the whole supply chain is critical to improving its efficiency. A harvester "best practice plan" can deliver significant yield improvement, and by working with all stakeholders further improvements can be made.

Harvesters and cleaners loaders are massively underutilised and different working practices need to be adopted. A better-planned and better co-ordinated approach also needs to be adopted to improve machinery utilisation and efficiency. "Just in time" harvesting and delivery has potential for further yield improvements in the UK industry, together with the opportunity of not using a cleaner loader.

Haulage is key to the whole supply chain and through the adoption of new working methods and techniques, efficiency can be increased.

Logistics management systems can provide excellent opportunities to further improve efficiencies in an era where mobile communication is readily available to all. These systems allow full visualisation of the supply chain, have improved fleet utilisation and provide very detailed and accurate management reports to help facilitate change.

The number of vehicles delivering sugar beet to the factory and backloading co-products can increase efficiency provided they can be turned around quickly.

Flexibility, planning and communication are key to improving beet scheduling in the UK. Grower groups may further increase efficiencies by offering a range of soil types and lifting dates to maximise the utilisation of equipment.

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