URBAN FREIGHT CONSOLIDATION CENTERS. A CASE STUDY IN THE UK RETAIL SECTOR.

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(Body text = 6,218 words including abstract = 244 words),
4 figures (1,000 words), 1 table (250 words), Total = 7,468)
29 References

Paper submitted for publication in Transportation Research Record

Submission Date: 15st March 2014

ABSTRACT
In recent years, traditional urban distribution systems have undergone major structural changes as a result of the increasing power of customers demanding greater variety of quality products at a low cost. This has increased the competition between businesses and at the same time more complicated and longer supply chains have emerged as a result of the globalization of many businesses in their search for low cost production locations and access to new skills. In response hub-and-spoke systems are increasingly used to deal with product flows from numerous origins and to many destinations. As a result, a growing number of studies examine the establishment of various forms of inter-modal transshipment centers to minimize the road use in city centers and support the frequent and rapid replenishment of goods at retail and catering outlets.

To this end, this paper examines the establishment of a consolidation center servicing nearly 100 businesses that operate in an urban shopping mall in Southampton U.K. Through the review of numerous existing U.K. and international consolidation schemes and the examination of their operational characteristics, this paper aims to identify potential strengths, weaknesses and risks that would impact its operation. Various operational scenarios considering different business take-up combinations, vehicle delivery mixes, fill rates and back-load practices are examined to elucidate the potential transport and environmental effects of the consolidation scheme. To accurately quantify and verify these effects, a multi-stage analysis framework is developed including data collection, map routing, emissions assessment and scenarios building activities.

INTRODUCTION

Freight consolidation is a comparatively new concept in the logistics and supply chain management which aims to reduce transport emissions, distribution costs and unnecessary freight traffic in urban centers. Consolidation is achieved through the provision of facilities, namely urban consolidation centers (UCCs), situated close to commercial districts, shopping centers or construction sites, at which part loads are grouped together and delivered to the target area using appropriate vehicle types to achieve a high level of load utilization on the last-mile of the delivery trip and reduce the total number of truck journeys.

Freight consolidation has been widely investigated in transportation science with a focus on the use of analytical tools and simulation models i.e. (*1*), (*2*), (*3*) and (*4*). Furthermore, a number of studies have been conducted by local authorities or other commercial entities that are interested in developing UCCs (i.e. in Bristol, Heathrow Airport and Norwich), while other studies have been carried out to identify lessons learned from previous, current or recently operating UCCs in the U.K. or abroad i.e. (*5*), (*6*), (*7*) and (*8*).

OBJECTIVES

The main objective of this paper is to review a number of existing consolidation schemes in the U.K. and abroad with the aim to identify the potential demands and benefits of the establishment of a UCC servicing a shopping mall in Southampton U.K. and assess the potential transport and environmental impacts that may arise from its use under a number of operational regimes. To identify potential strengths, weaknesses and risks relevant to the operation of Southampton's UCC, a preliminary evaluation of the different forms (i.e. types, categories, classes) and characteristics (i.e. location, size, beneficiaries, modes used) of existing UCCs is required.

THEORETICAL BACKGROUND

Freight consolidation involves grouping of individual consignments or part-loads that are destined for the same locality at a consolidation center so that a smaller number of full loads are transported to their destination (*7*). Its main aim is the increase of the load factor to help reduce the number of empty trucks on the road, cut down pollution, alleviate traffic congestion and ameliorate intra-modal conflicts in urban areas (*9*). Further, logistics managers aim to minimize costs, free-up sales floor at shops and ensure better availability of stock and services (*5*). Such practices can motivate retail staff and prioritize the delivery of customer-focused services at shops, while offering retailers the opportunity to undertake value-added activities (*8*).

A review of freight consolidation schemes i.e. (*5*) and (*7*) suggested the existence of two main models. The first concerns the development of vertically integrated supply chains in terms of individual businesses, predominantly large retail groups and parcel/pallet networks, consolidating consignments through regional or national distribution centers. Goods from individual suppliers form full loads destined to the various end recipients with the aim to minimize the long distance 'trucking' mileage. The second model includes an additional step in the supply chain to enable further consolidation of all parts destined to a common destination. This is performed through logistics facilities (UCCs) situated in relatively close proximity to the geographic area that they serve (i.e. a city center, an entire town or a specific site such as a mall) (*5*). Dependent on the potential application and the split of involvement of the public and private sectors, UCCs may also be public distribution depots, central goods sorting points, single/shared-user urban trans-shipment centers, freight platforms, cooperative delivery systems, urban distribution centers, city logistics schemes, logistics centers, pick-up drop-off locations, and off-site logistics support depots (*10*).

In addition, a number of studies i.e. (*10*), (*11*) have described several routing strategies for the distribution of a consolidated shipment from an origin to a destination terminal, including (Figure 1):

- *Routing Strategy A*: Direct shipment of a consolidated load to the destination terminal using one of the available direct transport services.

- *Routing Strategy B*: Shipment of a consolidated load to the destination terminal using one of the available transport services that stop at one or more intermediate terminals to drop and pick up traffic.
- *Routing Strategy C*: Shipment of a consolidated load to an intermediate terminal where load is reclassified and further consolidated with traffic originating from various other terminals in order to be transferred as a single load to the destination terminal.
- *Routing Strategy D*: Shipment of a load using a dedicated transport service (train or road) carrying other loads, when special contractual agreements exist and load volumes are considerable.

Forms of Urban Consolidation Schemes
In a review of existing U.K. and international consolidation schemes, UCCs were divided into three main categories (*5*):
- *Site-specific*: These are developments controlled by a single entity, usually a commercial organization such as a shopping center and an airport, or other non-retail developments such as construction sites. Participation in the scheme may be voluntary or compulsory and operation may be partly or fully self-financed through rent structures and handling fees. Examples of commercial schemes include *Meadowhall* UCC in Sheffield and Heathrow airport, while examples of non-retail schemes include the construction sites in Hammerby in Stockholm and Heathrow airport.
- *Co-operative City Logistics Schemes*: Freight transport companies operating in the same urban area work together to share collection and delivery services. Goods destined for a single address or a certain geographical area, are consolidated at a common or individual business depot and are shipped in a single full-loaded vehicle. A scheme of this category was established in Fukuoka City in Japan in 1994 under the co-operation of 36 freight transport operators and the support of the public sector, resulting in significant reductions in the number of freight vehicles (65%), local freight vehicle kilometers (87%) and environmental impacts (*12*). In Europe, co-operative schemes exist in Aachen, Bremen, Essen, Frankfurt am Main and Regensburg in Germany (*5*).
- *Community Collection and Delivery Points (CDP)*: These include points between shops and residential properties that are used to consolidate goods purchased by customers from surrounding shops, deliveries destined for local stores, or products ordered remotely by customers (i.e. online purchases). Goods from these points are transported with a single well-loaded goods specialist or customers' private vehicle replacing several vehicle trips (*12*). Examples include the U.K. CDP system which operates through the Royal Mail's local collect service and has yielded 13% savings towards the amount of CO_2 produced by a traditional local depot collection using a private car (*13*).

Besides, several studies have produced classification systems based on a selection of UCC schemes. German UCC schemes were classified under six fundamental co-operation forms in which distribution companies shared their depot and vehicle capacity (*14*). German inner city cargo logistics initiatives were classified under three types including milk round-type schemes for single retailer, city logistics schemes and schemes using telematics and alternative transport technologies (*5*), (*6*). The French Ministere de l'Equipment classified UCCs under the Monaco, the Dutch and the German models on the basis of the public support given to projects and their financing (*15*). As part of the BESTUFS project, three forms of freight platforms were identified including single-company UCCs, multi-company UCCs and freight villages (*16*). In another study (*17*), UCCs were distinguished between those receiving direct deliveries by poorly loaded vehicles replaced by better loaded vehicles, and those receiving direct deliveries by large goods vehicles replaced by smaller vehicles (typical trans-shipment type of operation). Finally in a review of UCCs (5), a distinction between commercial

UCC schemes operating under the partial or full financial public financial support was drawn. Of much interest is the case of the *Broadmead* shopping center in Bristol. The scheme was initially set up in 2002 as a pilot demonstration and free of charge to retailers, under the 4-year support of the EC VIVALDI project. Since then, the scheme has been mainstreamed and secured financial support from the City Council using funds from the EC START project. Today, the scheme seeks for a 40% contribution to the costs by participant retailers using value-added services (*8*).

Main and Value-Added Activities of UCCs
The typical services offered by a UCC include (*8*):

- *Consolidation*: Multiple daily deliveries, from a single or multiple suppliers, are consolidated in a single load to minimize empty–running, transport emissions and costs, while increasing productivity.
- *Cross-Docking*: Deliveries can be made to a UCC at a time to suit suppliers, with onward deliveries at a time to suit retailers. This can reduce transport and staff costs.
- *Stockholding*: Short-time storage can reduce delivery lead times, improve product availability and customer service. Seasonal or peak storage can free-up space at retail outlets for additional retailing footage.
- *Replenishment*: Big unmanageable deliveries can be split in smaller regular deliveries throughout the day to increase response to customer needs and therefore eliminate lost sales.

Many UCCs also offer a range of additional value-added logistics and retail services, including (*5*), (*8*), (*18*):

- *Inventory Monitoring*: Information collection and analysis linked to in-store inventory systems can increase the visibility of the supply chain and lead to better availability and service levels.
- *Pre-retailing*: Pre-merchandizing activities (i.e. quality/quantity checks, unpacking, products preparation for display and price labeling) in a UCC can reduce time and space requirements upon final delivery.
- *Returns Management*: Suppliers may use UCCs to consolidate returns into a central stream ideally using the available backload capacity of delivery vehicles.
- *Gate-keeping Operations*: Screening of delivered and returned products at a UCC can help alleviate some of the problems associated with the quality of product returns and reduce unnecessary transport.
- *Packaging/Waste Collection/Recycling*: UCCs may be used as storage, trans-shipment and/or treatment facilities of waste and recyclables produced by participant retailers.
- *Business-to-Business (B2B) and Business-to Customer (B2C) Services*: UCCs may offer inter-store transfers, home delivery or customer collection of products purchased in town or by mail and online orders.
- *Staff Training Facilities*: Training of UCC staff, retailers and drivers at a UCC enables correct implementation of activities and greater consistency of performance across the network.

Main Beneficiaries of UCCs
UCCs are likely to be more effective for some types of goods and vehicle movements than others (*7*), (10):

- Retailers receiving small vehicle loads and poorly or not at all consolidated deliveries. These retailers are usually prioritized in the recruitment process.
- Transport operators making multi-drop deliveries whose size is disproportionate to parking and unloading time.
- Retailers receiving large, shared-user and low-cost deliveries, albeit geographically spread, causing significant delays in the urban delivery part of the operation.

- UCCs designed to handle the wide range of packaging used by different retail businesses, especially those selling non-perishable goods.
- Specific and clearly defined geographical areas, such as historic town centres and districts, which undergo a 'retailing renaissance' or suffer from delivery traffic congestion (*19*).
- New and large retail/commercial developments offering the opportunity to consolidate all the goods within a dedicated part of the complex as part of the total design (i.e. shopping malls).
- Consolidation schemes attracting widespread interest from a group of potential users with common interests and objectives.

Instead a number of cases where businesses are not envisaged as being beneficiaries of consolidation schemes include businesses receiving (*7*), (*10*):

- Highly time-sensitive products (i.e. perishable food and newspapers).
- Products requiring specific distribution and storage due to their nature (i.e. medicines) or high-value (i.e. jewellery).
- Dedicated visits of full vehicle loads.
- Deliveries from in-house consolidation centres and own fleet of appropriate vehicle size (i.e. major supermarkets, department stores or wholesalers).

Location of a UCC

Locating a UCC is of primary importance for the reduction of unnecessary transport movements, the minimization of administration and transportation costs and the reduction of vehicle emissions. These benefits can be achieved when the fleet running the longest part of the trip does not need to enter into the urban area and at the same time the fleet running the urban leg of the trip consists of clean freight vehicles, is allowed to enter urban areas and accesses easily the city center. In choosing the optimal location of a UCC, key determinants are the existence of access roads of appropriate capacity, well-linked to the national highway network, and the availability of existing distribution facilities with potential to incorporate freight consolidation services as part of their existing operations (20).

Size of a UCC

The scale of a UCC is determined by the volume and spread of traffic processed each day. In order to identify some indicative parameters for a UCC's size, a number of existing U.K. establishments were examined i.e. (*5*), (*7*), (*8*) and (*20*). The average floor area per retail outlet ranged between 11m^2 and 23.6m^2 including any areas used for security scanning, off-site stock-holding, chilled/frozen goods facilities and any other activities. It was also concluded that in order to keep initial cost base low, it would be strategically expedient to use a part of an existing building with expansion potential and develop potentially needed specialist cool-chain and frozen facilities over time (*5*).

Vehicle Types Servicing a UCC

In general two main mechanisms exist (*17*): deliveries made by small vehicles replaced by larger vehicles, and vice versa. A review of consolidation schemes in continental Europe (*5*), (*7*) showed that rigid trucks were most commonly used (25-40%) in the final leg of the delivery trip (from the UCC to the stores serviced), while articulated vehicles and vans were each used in the range of 17-25%. Rigid vehicles were mostly used due to the opportunity to balance out the usage of the maximum available delivery volume and ease of use in urban areas. Both rigid trucks and vans appeared marginally more common when deliveries were part of multi-drop delivery rounds (*7*). Currently many schemes make use of low-emission vehicles such as electric vans. Their use has been promoted by tax incentives (i.e. in Tokyo in Japan), special grants (i.e. in the U.K.), the establishment of environmental zones (i.e. in Sweden) and traffic restrictions on certain road sections (i.e. in Germany) (*12*).

Evaluation Framework for UCCs

A lack of consistency in comparing 'before' and 'after' situations was identified (*5*) and highlighted the importance of deciding upon the boundaries of the evaluation process, establishing the base situation, standardizing the data collection between the 'before' and 'after' phases and undertaking the evaluation in as controlled an environment as possible (i.e. consider urban access restrictions). To this end, it was suggested that the evaluation process should involve measurement of the change in the number of vehicle trips, vehicle kilometers, vehicles and goods delivered per delivery point, changes in travel time, parking time and frequency, as well as changes in load factor, fuels consumed, emissions and operating costs.

Critical Success Factors and Risks for UCCs

Experience from the *Meadowhall* shopping center's UCC showed that critical success factors included its ability to secure high retailers participation and operate without external funding. Instead *Broadmead* UCC operation was based on E.C. support to provide initial and follow-up funding. To ensure retailer participation, priority measures for consolidation vehicles, financial incentives by the landlord of the retail development, and even a mandatory participation of retailers were considered as key determinants. In order to ensure the sustainability of the scheme, further cost savings and additional revenues can be achieved through the provision of added-value activities, the integration of the development into the planning phase or a wider business model (i.e. a multi-functioning warehouse).

On the same basis, lack of funding and participation are among the most critical risks affecting the operation, and even the viability, of a consolidation scheme. The complexity of network-wide operations for different participants may turn tactical planning into a complex process for businesses (*21*), (*22*). Organizational and contractual problems may act as major barriers especially for businesses aiming to maintain competitive advantage rather than share expertise and logistics systems (*5*). Furthermore, concerns regarding the loss of control of the supply chain, additional costs and poorer service standards can lead to a general apathy to the scheme (i.e. in Norwich's UCC in Norfolk U.K.).

Ensuring the long-term financial sustainability of a UCC is easier to achieve in the case of one that serves major sites with a single landlord as a single party is responsible for financing the UCC and then attempting to recover some of these costs from those other parties that also obtain operational and financial benefits from the scheme. Achieving financial sustainability for UCCs that serve all or part of an urban area is more problematic as the decision to use the UCC is typically a voluntary one and there is no single private body that is responsible for financing the UCC or enjoying its benefits. In this case, the financial costs and benefits tend to be shared unequally between the parties involved. Obtaining high levels of product throughput at a UCC is important in achieving sufficiently low costs that business users could fund the entire UCC operation, and remove the need for public subsidy (*23*).

BACKGROUND TO CASE STUDY

The city of Southampton is located in the southern coast of England in the U.K. Southampton is a major hub for tourism, finance, business and distribution-related industries and a particularly renowned U.K. major commercial and cruise port. Retailing became one of the most notable areas of domestic economic activity following *WestQuay*'s opening in the city's center in 2000. *WestQuay* shopping center is owned and managed by *Hammerson*, one of the largest owners, managers and developers of retail property in Europe. It contains nearly 100 businesses that include a great range of top fashion and lifestyle brand stores and numerous restaurants and cafes. Its opening attracted further investments from the retail, property and venture capital industries to the city (i.e. *IKEA*) and challenged the capacity of the existing transport network. In response, Southampton's City Council carried out widening works on key road junctions, ran rail gauge enhancements and constructed enhanced pedestrian links to improve accessibility and help the network cope with the higher levels of passenger and freight activity.

Sustainable freight distribution and the protection and amelioration of the city's environmental quality have since attracted growing attention as a result of the continuous growth of port and retail activities. To this end, Southampton's City Council is currently seeking to ensure the development of sustainable measures both in the short-haul and the long-haul sector (i.e. the introduction of a trans-shipment depot). The potential establishment of a UCC in the outskirts of the city (Figure 1, Type C) for use by *WestQuay* and High Street retailers was well accepted by all local stakeholders as a means to reduce local and sub-regional congestion, pollution and intra-modal conflicts, and create a platform for both public and private profits.

To this end, this paper aims to examine the potential transport and environmental benefits that could arise from the participation of *WestQuay* retailers in Southampton's consolidation scheme.

METHODOLOGY

Analysis was conducted in four key stages (Figure 2) (*24*):

Stage 1: Data Collection

- *Survey Step 1*: Face-to-face interviews with the managers of 92 out of the 96 *WestQuay* retail and catering businesses. A structured interview questionnaire that included closed and multiple-choice questions was designed to gather data about the operations related to the deliveries of main core goods (MCGs: products that are a business' core competencies) and the collection of product returns and waste materials.
- *Survey Step 2*: Phone interviews with the 10 most widely employed logistics providers by the 92 businesses to verify the integrity of the logistics data already collected and provide additional information about vehicle choices, fuel requirements, and origin, destination and intermediate stops along a typical delivery and return trip.
- *Survey Step 3*: Face-to-face interviews with *WestQuay*'s sustainability manager to gather information about the centralized collections of general mixed waste and recyclables (i.e. paper, cardboard, polythene and plastic). Additional phone interviews with private waste contractors were made to gather information about the de-centralized collections of hazardous materials (i.e. clinical waste, waste electrical and electronic waste (WEEE), waste cooking oil and fluorescent lighting tubes).
- *Survey Step 4*: Use of available online resources and additional phone contacts with *WestQuay* businesses' Head Offices to seek views on general policy, explore attitudes towards potential cross-supply chain activities and cross-check and supplement data already obtained.

Stage 2: Mapping of Origin-Destination Data

The Microsoft MapPoint tool was selected to map all origin-destination data collected throughout the four survey stages and estimate the overall distance travelled by all delivery and collection vehicles calling at *WestQuay*. MapPoint is an accurate and versatile tool that was chosen against Google Earth and GIS because of its availability, its integration with other Microsoft Office components and its detailed coverage of U.K. postcodes.

Stage 3: Greenhouse Gases Assessment

Emissions were determined using the 'DECC's GHG Conversion Factors' methodology developed by the U.K. Department of Food and Rural Affairs (DEFRA) *(25*). This method provides conversion factors that represent the rate at which different types of Heavy Goods Vehicles (HGVs) and Light Goods Vehicles (LGVs) emit greenhouse gases (GHGs) according to the distance travelled. The conversion factors depend on the vehicle's fuel efficiency (distance travelled per unit of fuel consumed) which in turn is determined by the vehicle size and the loading of goods (tons per kilometers). For HGVs, they are derived from a combination of freight data from the '2009 U.K. Continuing Survey of Road Goods Transport (CSRGT)' (*26*) and the level of CO_2e (carbon dioxide equivalent) produced dependent the extent to which the vehicle is loaded (weight laden) in accordance with the E.U. ARTEMIS project (*27*). DEFRA provides a breakdown of conversion factors for three gross weight categories of rigid HGVs (<7.5t, 7.5t-17t, >17t, t: tons) and two gross weight categories of articulated HGVs (3.5t-33t, >33t) with different weight laden (0%: completely-empty, 50%: half-empty, 100%: fully-loaded). For LGVs, the conversion factors are derived from the combination of freight statistics from the '2004 survey of Van Activity' (*26*) and a number of estimates on CO_2e produced according to the 'U.K. National Atmospheric Emissions Inventory (NAEI)' (*28*). DEFRA provides a breakdown of conversion factors on the basis of the fuel type (petrol, diesel, liquefied petroleum gas (LPG) and compressed natural gas (CNG)) and the weight class of vans (<1,305t, >1,305t-<1,740t, >1,740t).

Stage 4: Scenarios Analysis regarding the Operation of Southampton's UCC

The following analysis steps were undertaken:

- *Step 1*: The vehicles servicing *WestQuay* businesses were classified under four broad categories: articulated trucks, rigid trucks, vans and other or D/K (i.e. vehicles of unknown mode, tricycles, bicycles, cars etc.).
- *Step 2*: The survey results from Stage 1 were used to assess the weekly and seasonal number of deliveries made to *WestQuay* businesses by each broad vehicle mode.
- *Step 3*: The total weekly and seasonal distance travelled was calculated (Stage 2) for each vehicle mode delivering products to *WestQuay* businesses.
- *Step 4*: The weekly and seasonal number and volume (m^3) of product items delivered to *WestQuay* were calculated for each broad vehicle mode.
- *Step 5*: The volumetric equivalents (m^3) were converted into weight equivalents (tons) assuming that the average recorded loads by volume were equal to the U.K. average loads by weight and that their values were changing proportionally.
- *Step 6*: The average tonnage per delivery trip was calculated for weekly and seasonal deliveries made by the different types of vehicles.
- *Step 7*: Using the emissions factors as provided in 2010 DEFRA's guidelines, produced by the four broad groups of vehicles were estimated (Stage 3) considering the average tonnage per trip and the total distance travelled in the last-mile (6 kilometers).
- *Step 8*: A number of sensitivity tests were performed for the last-mile to elucidate the potential transport and environmental effects of the operation of the UCC servicing *WestQuay* businesses. The variables examined included:
    - *Businesses Participation*: a) Mandatory participation of the 92 businesses, b) Voluntary participation with only 13 *WestQuay* stores participating to the scheme. These businesses were selected because they had branches already participating in other U.K. consolidation schemes.
    - *Vehicle Delivery Mix*: Seven main take-up combinations of the four vehicle modes (articulated trucks, rigid trucks, vans and vehicles of unknown mode) were examined (A to G).
    - *Vehicle Fill Rates*: Different weight laden factors for each vehicle mode were considered. In total 19 scenarios were developed (Table 1) considering zero loading (0%), U.K. average loading (articulated vehicles: 60%, rigid vehicles: 52%, vans 43.2% and vehicles of unknown mode: 58%) and full loading (100%). The maximum volumetric capacity of an articulated truck was considered equal to $80m^3$, a rigid truck $60m^3$, a van $10m^3$ and an unknown type of vehicle $30m^3$.

RESULTS

Mandatory Participation

This case examines the full participation of the 92 *WestQuay* businesses in Southampton's UCC scheme. Analysis suggested that prior the use of Southampton's UCC (base case scenario), 34.8% of deliveries were made by vans, 35.3% by rigid vehicles, 25% by vehicles of unknown type, while only 4.9% of deliveries were made by articulated trucks. A slight increase in the use of articulated trucks (from 4.9% to 5.2%) was noted during busy periods (when products delivered increase by more than 50% when compared to standard periods i.e. Christmas) indicating a trend towards the increase of the size of consignments rather than the number of delivery visits. These changes corresponded to a 14.2% increase in the total distance travelled (from 98,067km during a standard week to 111,975km during a busy week). Instead a much greater increase (434%) in the total volume of MCGs transported was marked (from 901.2m^3 during a standard week to 3,917m^3 during a busy week). On average, each store was receiving 9.8m^3 of products through 4.9 deliveries during a standard week, while delivery vehicles were travelling on average 1,066km (218.6km per trip).

Considering the use of the UCC, the comparison of the GHGs estimations for the 19 scenarios (Figure 3) suggested:

- The scenario with the best return (A3) both for vehicle trips and emissions is the one that assumes 100% use of articulated trucks at 100% of their loading capacity. Instead the scenario with the worst return (G1) assumes 100% use of vans at 40.3% of their load capacity. However, if electric vans were used then zero emissions would be produced.
- Scenario A3 (use of full load capacity of articulated trucks) results in 10% of the number of trips of the base-case scenario. Therefore the use of larger vehicles presents a great potential to reduce overall freight activity.
- It was also noted that when larger vehicles were used to carry a specific load then the overall level of emissions produced were reducing as the number of vehicles needed to carry the load was reducing too.
- Although the scenarios assuming the use of larger vehicles (i.e. only articulated trucks) provide the best return these cannot be realistically implemented for all deliveries due to the lower actual participation to the scheme which in turn would make it financially unsustainable and the need to process separately high-value, perishable, fast-moving and fresh products.

Voluntary Participation

This case examines the participation of only 13 *WestQuay* businesses in Southampton's UCC. Having already experienced the benefits of other successful consolidation schemes, these businesses were expected to be among the first to participate in Southampton's consolidation project. Analysis suggested that prior the use of Southampton's UCC (base case scenario), the vast majority of deliveries were processed by rigid trucks (80.7%) with only 6.4% of them being made by vans and 12.9% by vehicles of unknown mode. The four extra deliveries taking place during a busy week were processed by rigid vehicles. This resulted in a 13% increase in the overall distance travelled (from 8,858km to 10,007km). Instead the weekly volume of goods carried by articulated and rigid truck and vans increased by 350% during busy periods (from 149.2m^3 to 529.9m^3). Most of it (96.3%, 510.1m^3) was carried by rigid vehicles. On average, each store was receiving 3.64m^3 of products through 3.15 deliveries during a standard week, while delivery vehicles were travelling on average 681.4km (216.3km per trip).

Considering the use of the UCC, the comparison of the GHG estimations for the 19 scenarios (Figure 4) suggested that:

- Again, the scenarios with the best and the worst results are A3 and G1, correspondingly.

- The monthly trip reduction figure peaks at 85% under scenario A3, therefore this scenario results in 15% of the trips of the base-case scenario for the 13 businesses. Compared with the relevant figure for the 92 businesses (10%), it is suggested that prior the use of the UCC, the 92 businesses were receiving on average less consolidated deliveries than the 13 businesses and therefore presented more opportunities to increase the overall degree of consolidation achieved and reduce the total number of delivery trips by using the UCC.
- In the base case scenario, each of the 13 businesses produces on average less emissions (52.7CO_2e) than each of the 92 businesses (121CO_2e). Considering the vehicle activity and loading patterns these figures suggest that the 13 shops were receiving fewer but higher consolidated deliveries.

Both cases present a great potential to backload product returns and waste and reduce drastically the number of collection trips. Many opportunities to do so, appear in the case of hazardous wastes as their separate collection results in 6,974 trips a year despite the fact that they account for only 0.01% of the total waste volume.

RECOMMENDATIONS

As the concept of UCCs attracts increasing attention from the retail sector, Government and carriers, the following recommendations should be considered.

Recommendations for Southampton's UCC

The following actions should be taken:

Conduct a Feasibility Study

- Review newer research on UCCs, examine new case studies and study newer freight statistics.
- Validate the findings and update the content to consider the current business situation.
- Consult all key stakeholders (i.e. Local Authority, carriers, retailers, funding bodies) about the operational characteristics of the scheme (i.e. UCC target area, size and location, services offered, supporting transport measures such as access restrictions and time windows, service costs for retailers and carriers, and available funding sources (i.e. public, private, combination), among others.

Run a Trial Consolidation Scheme

A trial scheme should be put forward to understand in practice the suitability, the impacts and the measures needed to move towards its full implementation. The following actions should be taken:

- Secure the support of the City Council, *Hammerson* and other local/regional retail businesses.
- Allow *WestQuay* and other potential users to sample and experience the benefits arising from the use of the trial scheme without incurring a charge.
- Access real-time local traffic data i.e. (*29*) and develop a standard and consistent framework to record, monitor and compare urban traffic and emissions with data collected prior the operation of the trial scheme. Conduct evaluations against the objectives of local transport plans and key performance indicators (i.e. vehicle trips, emissions and retailers satisfaction).
- Identify available funding sources especially during the initial stages of the scheme.
- Run consultations with local stakeholders on setting a service cost that would not discourage retailers' participation.
- Assess the actual demand of local/regional retailers for a UCC.

Recommendations for Commercial UCCs

The following recommendations were drawn primarily from the findings of the studies concerning U.K. UCCs. (*5*), (*7*), (*8*), (*20*):

Recommendations for the Government

- Create a legal framework to support the operation of UCC schemes and synergies among stakeholders while respecting existing competition rules and fair trade laws. Publish information about new regulations.
- Promote the use of UCCs by producing planning guidances and best practice guides.
- Provide support and funding for pilot schemes.
- Develop a reporting framework to encourage UCC operators to keep a record their activities and enable critical evaluations and comparisons between schemes.

Recommendation for Local Authorities

- Incorporate the UCCs concept into local transport plans, sustainable distribution strategies, air quality standards and other policy initiatives.
- Share important information through consultations with other Local Authorities and UCC operators to ensure the suitability and the success of a UCC scheme.
- Agree with transport operators and retailers on freight routes, signage, access times and loading/unloading zones.
- Raise public awareness and support on a scheme by publishing information about its benefits.

Recommendations for UCC Operators

- Explore state-of-the-art technologies that enable more efficient transport planning, web-based coordination, access to real-time information and communication between retailers, UCC operators and logistics providers.
- Ensure sufficient support and funding, especially during the initial stages of a scheme.
- Secure the participation of a minimum number of businesses and take all appropriate steps to attract more local/regional participants in the future.
- Select an existing infrastructure with expanding potential able to fit future demand.
- Develop a good communications strategy with all key stakeholders.

Recommendations for Research Institutions

- Create a detailed database of UCCs characteristics taking into account the different UCCs forms and activities.
- Examine the effectiveness of UCCs when implemented in conjunction with wider transport measures.
- Estimate the total costs/gains of a UCC scheme by internalizing the transport external costs and benefits.
- Use simulation modelling to examine spherically the supply chain impacts that may arise from the establishment of numerous UCCs rather than isolated cases.
- Support the dissemination of best-practice examples and promote information exchange between research institutions, politicians and businesses.

CONCLUSIONS AND DISCUSSION

This paper illustrated the concept of UCCs which has been particularly embraced by the retail and the construction sector as a means to reduce business costs, increase the load balance of transport and cut down urban traffic and emissions. The aim was to identify the key issues that should be addressed during the planning phase of a UCC that will serve *WestQuay* shopping mall in Southampton U.K. and demonstrate the potential transport and environmental benefits that could arise from its operation under a number of scenarios. Following a review of U.K. consolidation schemes, it was shown that a UCC can be deemed successful when it is served by a group of environmentally friendly and flexible vehicles, the level of uptake is high and the scheme is financially sustainable.

Cross-organizational collaboration can lead undoubtedly to improved service quality and costs reduction for businesses, but it may cause several organizational challenges for retailers and carriers. Any retailer joining a UCC scheme will have to set its operational scope in forming alliances with supply chain competitors, share assets, logistics and expertise and exchange sensitive information. Especially when a UCC is introduced into an existing local transport and business plan, all participant businesses will have to adopt standardized equipment and supportive tools, receive identical services and establish new business contracts that may affect fair trade initiatives and existing corporate practices. Such rigorous requirements, along with fears about losing control of the supply chain, additional costs and poorer service standards would likely dissuade a large number of long-standing retail businesses from joining a newly set-up UCC scheme, as happened in the case of Norwich UCC in Norfolk U.K. On the other hand, newly-operating retailers would be more likely to join from the beginning a UCC that will operate integrally with a freight transport plan that will surround a new development (i.e. shopping mall).

Similarly, logistics providers will have to develop common standards, content and applications. Considering the fragmented and competitive nature of the logistics industry, there is an increased possibility that some of the operators will fail to remain economically viable in the market. To this end, any law requirements and reforms will have to ensure fair trade practices and restrain from anti-competitive activities that may hurt smaller logistics operators and financially weaker retail businesses.

For maximized results the development of UCCs should follow closely the ongoing technological advances and new logistical concepts and integrate them into their operation. For instance, the combined use of emission-free vehicles (i.e. electric and hydrogen-powered trucks/vans) with the use of UCCs as platforms for direct deliveries of products ordered online, and the establishment of local collection points and locker boxes present many opportunities to shorten further supply chains and reduce the overall number of delivery and collection trips.

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LIST OF TABLE TITLES AND FIGURE CAPTIONS

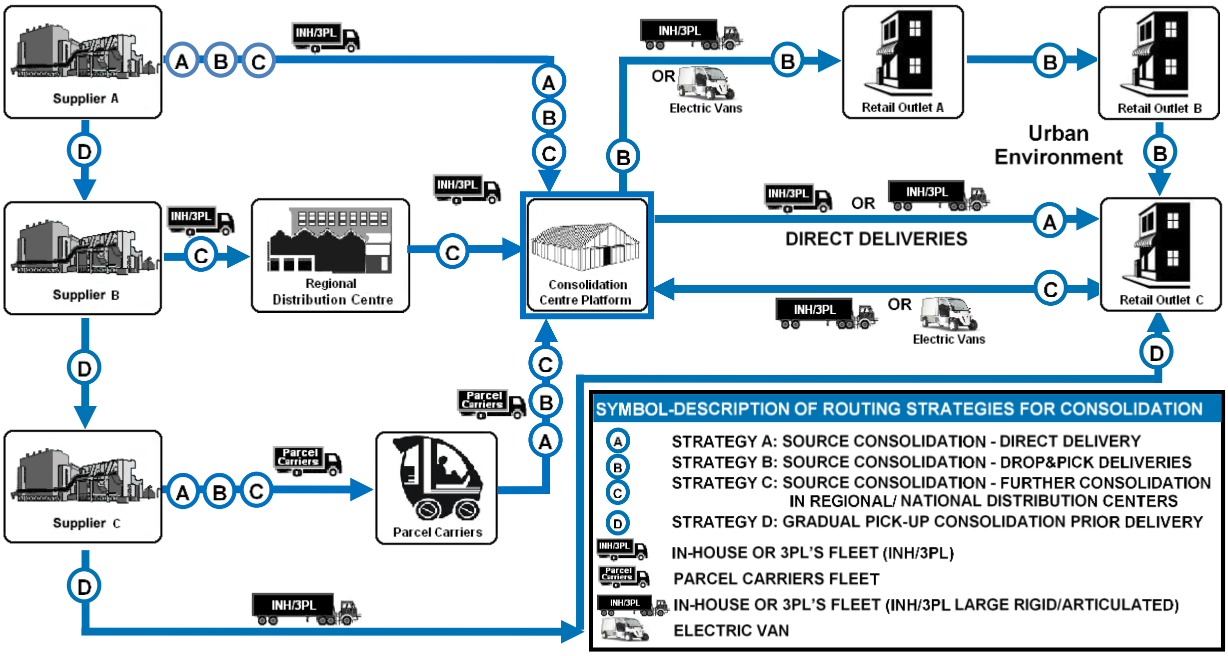

FIGURE 1 Different forms of urban consolidation across delivery channels

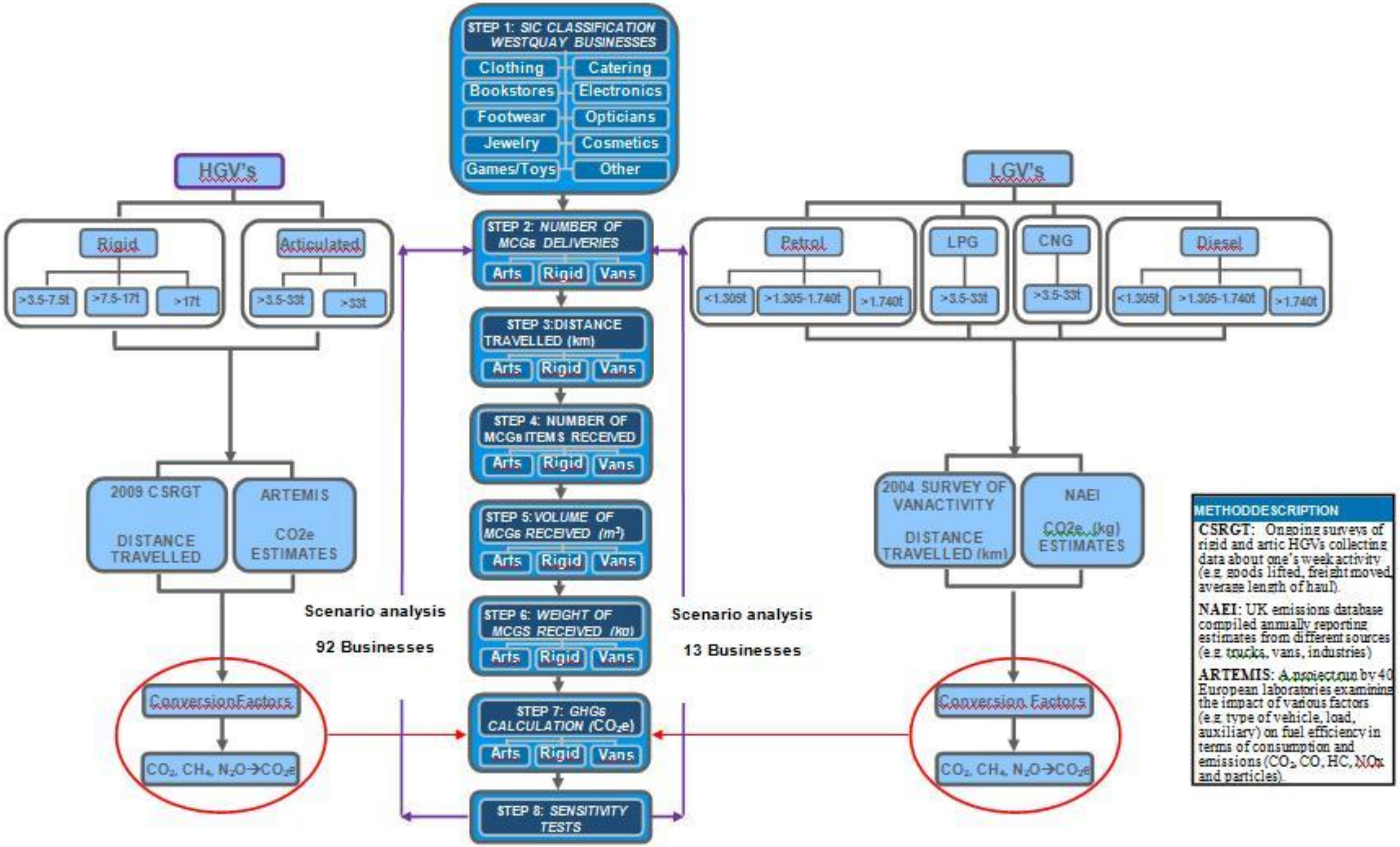

FIGURE 2 Process flow diagram and raw data used for the assessment of the greenhouse gases under various operating scenarios

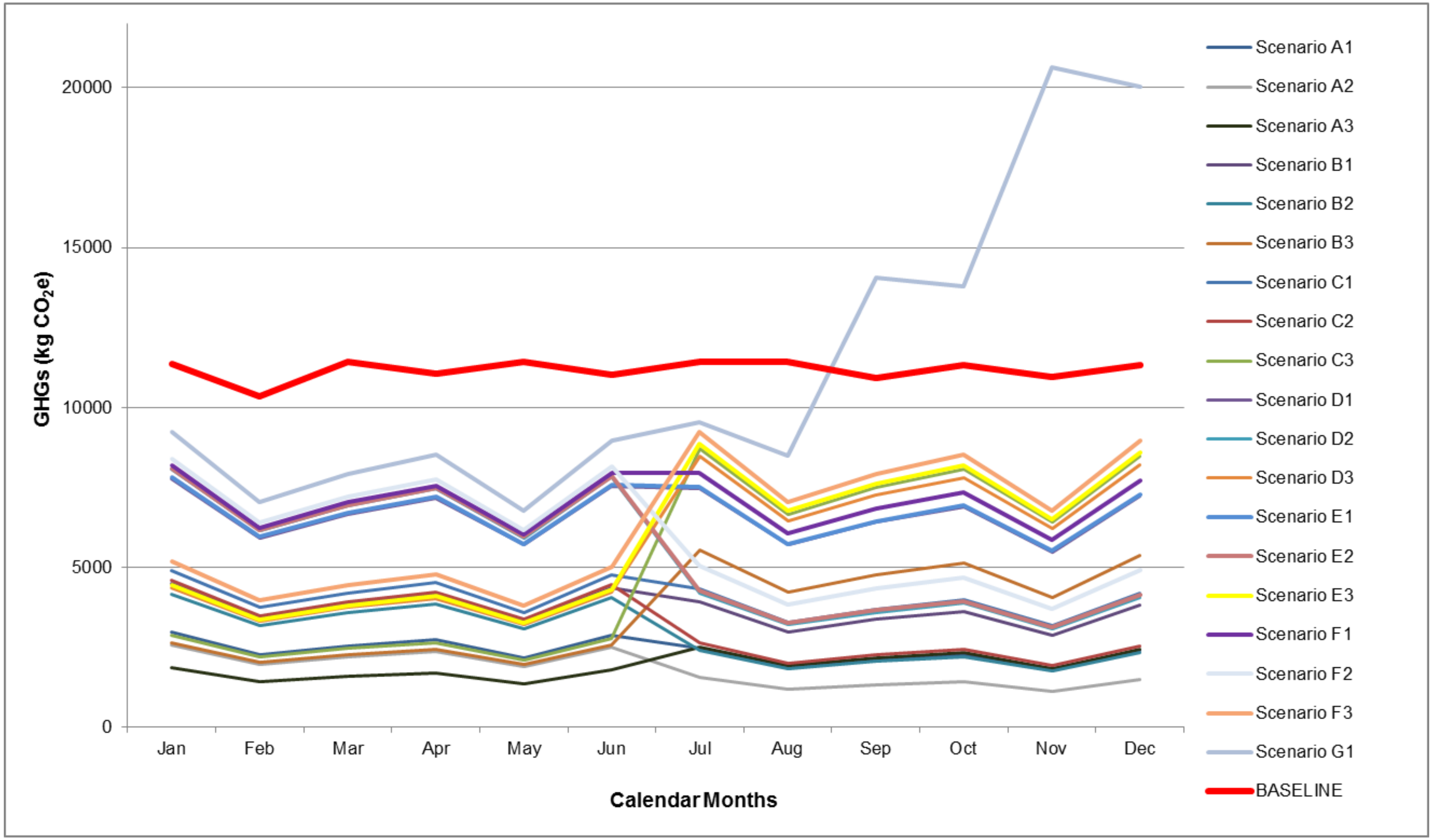

FIGURE 3 Seasonal variation in the number of GHGs produced by the 92 businesses (mandatory participation) in the urban leg of the delivery trip (6km) under a number of vehicle and load mix scenarios

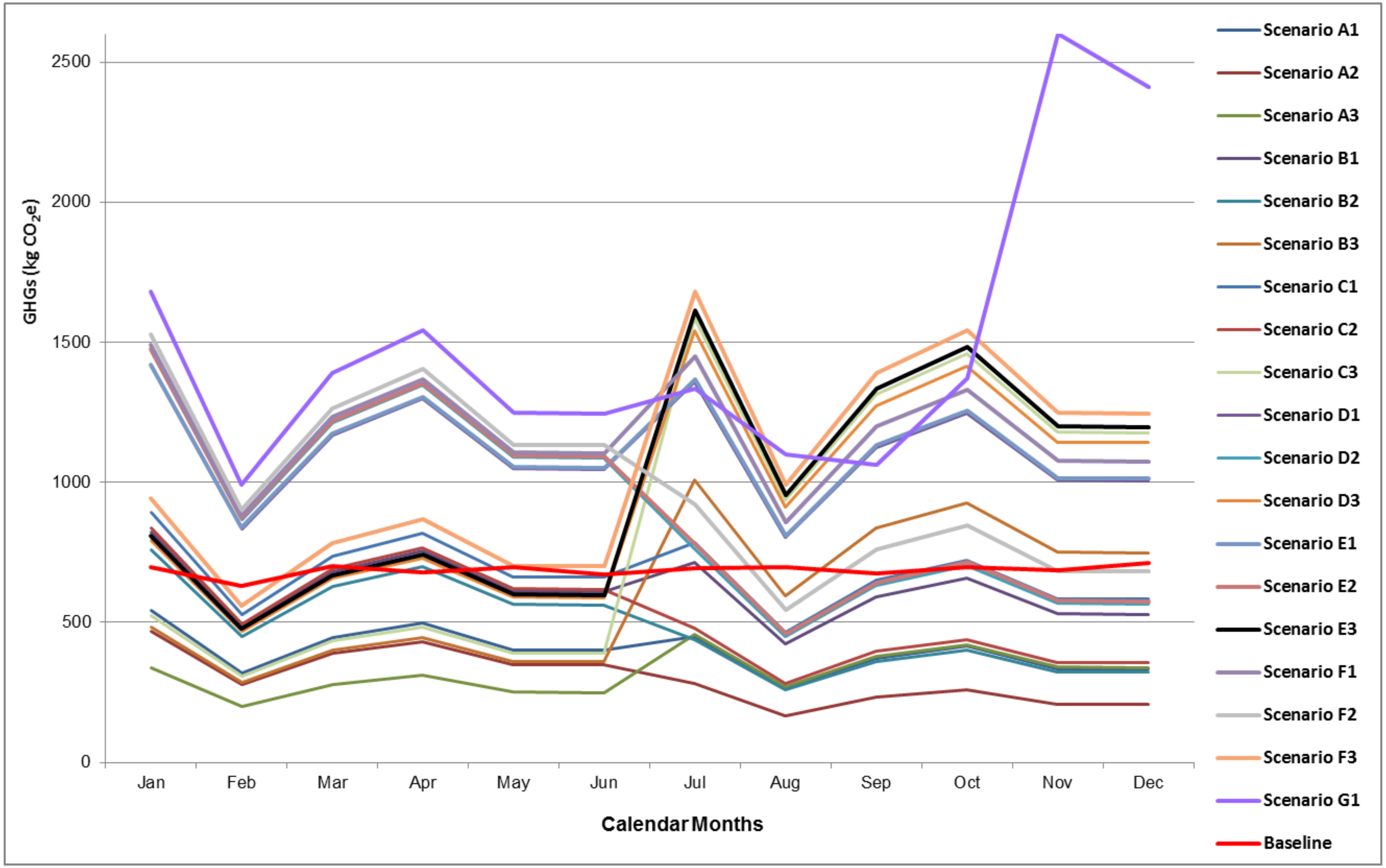

FIGURE 4 Seasonal variation in the number of GHGs produced by the 13 businesses (voluntary participation) in the urban leg of the delivery trip (6km) under a number of vehicle and load mix scenarios

TABLE 1 List of scenarios examined with regard to *WestQuay*'s consolidation scheme

Scenarios		Scenarios Description	Vehicle Delivery Mix			Vehicle Fill Rate (m^3)		
			Arts*	Rigid**	Vans	Arts*	Rigid**	Vans
Scenario A	A1	Exclusive use of articulated trucks filled at 50% of their volume capacity.	100%			50%		
	A2	Exclusive use of articulated trucks filled at 60% of their volume capacity.	100%			60%		
	A3	Exclusive use of articulated trucks filled at 100% of their volume capacity.	100%			100%		
Scenario B	B1	Combined use of articulated (40%) and rigid trucks (60%), both filled at 50% of their volume capacity.	40%	60%		50%	50%	
	B2	Combined use of articulated (40%) and rigid trucks (60%), filled respectively at 60% and 52% of their volume capacity.	40%	60%		60%	52%	
	B3	Combined use of articulated (40%) and rigid trucks (60%), both filled at 100% of their volume capacity.	40%	60%		100%	100%	
Scenario C	C1	Combined use of articulated lorries (30%), rigid trucks (60%) and vans (10%) all filled at 50% of their volume capacity.	30%	60%	10%	50%	50%	50%
	C2	Combined use of articulated lorries (30%), rigid trucks (60%) and vans (10%) filled respectively at 60%, 52% and 40.3% of their volume capacity.	30%	60%	10%	60%	52%	40.3%
	C3	Combined use of articulated trucks (30%), rigid lorries (60%) and vans (10%), all filled at 100% of their volume capacity.	30%	60%	10%	100%	100%	100%
Scenario D	D1	Exclusive use of rigid trucks filled at 50% of their volume capacity.		100%			50%	
	D2	Exclusive use of rigid trucks filled at 52% of their volume capacity.		100%			52%	
	D3	Exclusive use of rigid trucks filled at 100% of their volume capacity.		100%			100%	
`Scenari o E	E1	Combined use of rigid trucks (90%) and vans (10%), both filled at 50% of their volume capacity.		90%	10%		50%	50%
	E2	Combined use of rigid trucks (90%) and vans (10%), filled respectively at 52% and 40.3% of their volume capacity.		90%	10%		52%	40.3%
	E3	Combined use of rigid trucks (90%) and vans (10%), both filled at 100% of their volume capacity.		90%	10%		100%	100%
Scenario F	F1	Combined use of rigid trucks (40%) and vans (60%), both filled at 50% of their volume capacity.		40%	60%		50%	50%
	F2	Combined use of rigid trucks (40%) and vans (60%), filled respectively at 52% and 40.3% of their volume capacity.		40%	60%		52%	40.3%
	F3	Combined use of rigid trucks (40%) and vans (60%), both filled at 100% of their volume capacity.		40%	60%		100%	100%
Scenario G	G1	Exclusive use of vans filled at 40.3% of their volume capacity.			100%			40.3%

*Arts: articulated trucks, **Rigid: rigid trucks