Peer Review of Freight Analysis and Modelling Environment (FAME) – Stage 1

For Department for Transport

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1.0	16/2/2024	Ian Williams	Incomplete early Draft
2.0	18/3/2024	Ian Williams	Complete draft for client review
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1 Introduction

1.1.1 This report reviews the findings from the recent Freight Analysis and Modelling Environment (FAME) Stage 1 study, commissioned by the Department for Transport (DfT), which was carried out in late 2023 by MDS Transmodal (MDST).

1.1.2 The material that is the basis for this review of the MDST findings is the detailed documentation within the FAME Feasibility Report (FFR - MDST, 2024). That report describes how to produce a detailed analytical system design for FAME that could enhance the Department's analytical capability to support investment decisions, policy development, emergency responses and strategic directions.

1.1.3 The aim of this report is to document the conclusions drawn from this peer review of the approach that is proposed for FAME within the FFR. This review proceeds through the FAME topics in the same general sequence as was adopted in the FFR. Overall, this reviewer has found little within the FFR that he fundamentally disagrees with and much that he would strongly support. There are however a few topics that this reviewer feels could have been treated differently or in greater depth, so these have been identified and then discussed in the appropriate sections below, along with providing further background information on these topics within the three Annexes appended to this review.

1.1.4 Within this peer review report the level of discussion detail that is provided on individual FFR topics differs across the sections. For the many FFR topics with which the reviewer is in broad agreement, a short overview of this agreement is presented. In the remaining cases, where alternative approaches appear to merit consideration, the reasons why the originally proposed approach may be questionable are discussed and the feasibility and strengths of alternative approaches are then presented in greater detail.

1.1.5 In Section 9, the main conclusions from this peer review are summarised and the priorities are listed for the tasks that address the various data gaps that have been determined.

2 REVIEW OF EXISTING FREIGHT MODELS

2.1.1 Overall the review in FFR 2.4 of national and regional models outside the UK, provides less complete coverage than that in most other FFR sections. Other than the recently completed TRIMODE model of which MDST were part of the team, the remaining freight models that are listed for Europe all refer to work prior to 2012. There is no discussion of the use in the US of agent based models, such as within the Commercial Transport component of the Oregon Statewide Integrated Model (Donnelly, 2017) that has been in use since the early 2000s and has been regularly revised and enhanced since then. It would have been helpful to include some detail describing the Aggregate Disaggregate Aggregate (ADA) form of freight modelling as this approach has been used for many years in various Northwest European countries (de Jong and Baak, 2023). The ADA approach provides an explicit representation of alternative transport chain options when deconstructing Production-Consumption movements of goods into their sequence of intermediate modal O-D legs and intermodal transfer activities along their transport chain options from the producer to the consumer.

2.1.2 More generally, the differences in structure and methodology between the models that are listed are not discussed in much detail. In particular, it states

> "The key point in this analysis is that all these models are based on the 4-step model methodology and none of them use agent-based modelling." (FFR p.6)

While this might be true of the subset of freight models covered in the FFR, it does not provide an adequate description of the wide range of approaches in practical use around the world. A comprehensive review of more recent developments in freight modelling methodologies and applications is provided in de Jong et al. (2021).

2.1.3 FFR 2.5 discusses how the availability, or the lack of data have impacted on the model forms adopted. It correctly identifies that the lack of availability of comprehensive supply chain information on flows of consignments has discouraged this feature from being represented in many, though not all models. Nevertheless, this reviewer does not agree with the conclusion that the individual logistic legs along a supply chain can be modelled separately. This issue is discussed further below in Section 5.2. There is a clear explanation provided on why "big data" sources do not currently provide suitable support for the construction of models such as the NFTM.

2.1.4 FFR 2.8 discusses the lessons learned. This reviewer agrees with their recommendation (p.12) to avoid the use of value to volume ratios as the source for origin zone tonnage data and to use m^2 of large warehouses, rather than their rateable value, as an indicator of their level of production/attraction of freight. This reviewer is less convinced by the reluctance to introduce an explicit representation of P-C supply-chains, while accepting that the current absence of good data to support this introduction is an issue that would need to be resolved.

2.1.5 On ABM (p.13) This reviewer agrees that agent based models are unlikely at present to be an effective approach for application at the national level to cover all modes.

2.1.6 In summary, while the review of freight model applications outside the UK is rather dated and is patchy in its coverage, the broad conclusions developed about suitable approaches to NFTM development seem reasonable, except perhaps for the rejection of an explicit representation supply chains within the freight demand model.

3 Review of the freight transport market

3.1.1 The review of the freight transport market in FRR Section 3 generally is well focussed and informative about the components of the freight transport system that need to be represented within the model and how these components interact with each other in practice. A good understanding of the mechanisms that drive activity within the freight transport market is a necessary ingredient to guide the design of an appropriate freight transport model. FFR Section 3 provides an excellent overview of the activities of the freight and logistics service providers, and on the infrastructure networks that are used by these providers.

3.1.2 FFR 3.3 initially discusses the difference between a freight model and a freight and logistics model perspective. It concludes that

> "FAME is likely to be mainly focused on simulating freight transport at a strategic level rather than logistics, but attention is also needed on distribution centres because of their importance as nodes in the wider freight network, in adding value to the goods stored and in creating employment." (FFR p.17)

3.1.3 While it may well be the case that FAME will be mainly focused on simulating freight transport at a strategic level rather than on logistics, the importance of logistics within the model lies in its potential influence on freight O-D patterns through generating future changes in the spatial patterns of supply chains.

3.1.4 The FFR 3.5 recommendation seems appropriate that the NFTM should directly model the road, rail, maritime and waterborne modes of transport within an integrated fashion, but that pipelines and air freight traffic would only enter the model as potential origins or destinations of traffic for these other main modes.

3.1.5 The discussion in FFR 3.6 on freight market structure provides useful context on the mechanisms that need to be modelled in freight. In particular, the discussion on the necessity for a large volume to be moved between a pair of rail terminals in order to justify the provision of a rail freight service for them, highlights an important difference when modelling mode choice for freight as opposed to passengers. For passengers, it is reasonable to take a marginal approach whereby a small reduction in modal cost will typically lead to a small increase in mode share. For the rail freight mode share within the market of longer distance major flows, for which rail may potentially be competitive, the cost change responses are lumpy rather than marginal. When a rail freight service becomes competitive for a zone pair, a substantial volume may switch from road to rail, not just a marginal volume change.

3.1.6 More generally, the modelling of many of the choice responses for freight transport requires a high degree of segmentation in order to reflect both the heterogeneity of contexts and that many choice responses are not marginal, even though they may be highly cost sensitive. The key is to represent the full set of direct and indirect costs appropriate to each individual context, rather than representing a simplified marginal response based on a summary cost that has been averaged across quite different contexts.

3.1.7 FFR 3.7 correctly stresses that although most of the fixed infrastructure for the road and rail modes is state owned (though not for other freight modes), nevertheless most freight service provision operates within a highly competitive private sector market, so that model design decisions should enable the NFTM to represent appropriately the set of cost factors that influence transport outcomes within this competitive system. It provides a good explanation of the operation and the cost competitiveness of traditional rail freight terminals versus the more recently constructed strategic rail freight interchanges. These latter include on-site large-scale distribution infrastructure and activity, not just intermodal transfer facilities. Their emergence has enabled rail to compete more effectively with road in the market for longer distance routes between major centres in GB.

3.1.8 There is an interesting discussion in the context of network delays and congestion regarding the use in the model of the value of the cargo. While recognising that perishable goods and urgently needed deliveries might be an exception, they state

> "As a general rule, the value of the cargo is not relevant to a freight transport model, but there is an argument that for some very urgent cargo the impact of the delay is very important. …
>
> The difficulty for the development of the FAME framework would be that it is difficult to adopt a generalised approach to the value of the cargo when too little is known about the urgency/importance of individual consignments and the commodity data available is likely to be highly aggregated." (FFR, 3.7, p.32)

3.1.9 This first sentence may, perhaps, be a somewhat strong assertion. Travel time savings certainly have a major impact on personal choice options in passenger modelling. However the statement highlights that, provided the associated operating cost reductions from driver time and vehicle time related cost savings have been correctly accounted, the further impacts of travel time savings on freight choice options for a consignment, are quite limited for most, though not all freight contexts. Here again, an explicit representation of supply chains could help in the use of value of time within the freight demand model. Because those goods being shipped to consumers via national distribution centres (NDCs) may have typical dwell times at these NDCs of 3 or more weeks, it is difficult to argue that there is substantial non-transport cost related value gained by reducing the travel time on the primary logistics legs from the producer to these NDCs. In contrast, shipments from local distribution centres (LDCs or fulfilment centres) to final consumers or local retailers, may have a high travel time reliability value to ensure that the goods have arrived by the time they are needed/expected.

3.1.10 The description in FFR 4.1 of the inherent difference between how: congestion on rail routes impacts on rail freight costs and usage; versus how congestion on road links impacts on road freight routings and costs, provides guidance on aspects that NFTM should represent. FFR 4.1 also highlights the importance of the competition between ports in determining future patterns of rail freight demand for a substantial part of the rail freight market. The review of key issues in Section 4.1 is useful, particularly w.r.t. the importance of major private sector actors in decisions on the usage of the rail and maritime services.

3.1.11 In summary, this description in FFR Sections 3 and 4 of the characteristics of the UK freight transport market, provides clear, informative guidance on the set of actors, activities and issues that would need to be represented within FAME and within its NFTM. It should be read and thoroughly digested by whoever is eventually charged with the design and delivery of NFTM to ensure that NFTM adequately represents the important features of the operation of the freight market that has been outlined.

4 Recommendations: freight transport model form

4.1 INTRODUCTION

4.1.1 FFR Section 7 discusses the findings on the uses and on the characteristics envisaged for the national freight transport model form. The FFR recommendations on the scope of the NTM are summarised below in Table 1, together with links to where some of these topics are discussed further within this peer review. In those cases where alternative approaches merit consideration, these alternatives are outlined later within this peer review, along with the reasons why they may provide a preferred approach.

Table 1 Summary of FFR recommendations on FAME NFT model scope

FFR Section	Type	Comments / links to Sections in this report
7.1	Users and usage	OK
	Road congestion feedback	OK see 4.2
7.2	Exclude LGV non-delivery trips	OK see 4.2
	Include tonnage for all goods	OK
7.3	Set of modes	OK
7.4	Modelled area	OK see Northern Ireland discussion in 4.3
7.5	Zoning	OK see 4.4
7.6	Time period	OK see 4.5
	Base year	OK
7.7	Road vehicle types	No – model should use 5 HGV types, see 4.6
	Other mode vehicle/vessel types	OK
	Fuel types	OK
7.8	Road network	OK see 4.2
	Other mode networks	OK
8.2+	Transport cost models	OK see 4.7
8.4	Other models: GV fleet, driver	OK see 4.7, also needs warehouse model, see 4.8 & economy model, see 5.4
9.3	NST 20 commodity types	OK

4.2 REPRESENTING ROAD CONGESTION FEEDBACK – LINK TO NTM

4.2.1 This reviewer agrees with the view on FFR p.56 that representing road capacity impacts from freight transport is probably best dealt with outside the freight transport model itself. The greatest influence on road congestion on almost all links is from cars and LGVs, rather than from HGVs. Accordingly, congested link times are best supplied to the freight model from a passenger equilibrium assignment model run that has also included suitable O-D matrices of HGV and LGV movements.

4.2.2 The existing national passenger transport model (NPTMv5) would appear to be the most suitable source for these congested link speeds for England. However, obtaining corresponding congested link speed data for Scotland, Wales and Northern Ireland is likely to require significant effort and resources. There is little detailed coverage of the wholly internal movements within Wales and within Scotland within NPTMv5, while it has no coverage at all of Northern Ireland.

4.2.3 Because the NFTM model will provide an O-D matrix of LGV delivery trips, it will be important to ensure that the LGV non-delivery O-D matrix that is input to the NPTMv5 does not have gaps or double counting with respect to the LGV delivery O-D matrix that is produced by the NFTM. It should also be noted that the representation of LGV trips within the NTS[1] has a number of serious gaps that have been identified by the excellent analysis provided by Le Vine et al. (2013). Their insights may help in minimising gaps and overlaps within the representation of LGV trips for individual purposes.

4.2.4 In those relatively few policy analysis instances where GVs are a major influence on congestion levels on a significant number of links, then some iteration between model runs might be required to achieve convergence. However, this would not be the norm so that substantial running time would be saved by not requiring the freight model to be iterated through an equilibrium road assignment procedure. Instead a path building step would suffice that derived GV O-D times and costs, segmented by vehicle type based on the congested link speeds of cars. For LGV delivery vans the car link speeds could be used directly within this path building. For HGVs, the congested car link speeds should be scaled back on each link to take appropriate account of the HGV speed limit restrictions applicable to its combination of road type and HGV type.

4.3 REPRESENTING NORTHERN IRELAND

4.3.1 The FFR correctly identifies the need to include all RORO ferry services to the Island of Ireland, from GB and elsewhere, as part of including all UK freight movements within, to, from and through NI, as well as between NI and the rest of the world

4.3.2 Section 2.7 of FFR briefly discusses the issue of whether the model could also cover Northern Ireland on an equal basis with the rest of the UK. A full representation of internal traffic within NI implies that it would further be necessary to represent zones within Ireland (Irl) in considerable detail in areas

[1] Offsetting the incomplete and variable representation of LGV trips by purpose and in trends through the years within the NTS is important for the NPTM, because the NTS is the data source underpinning the NTEM trip rates by trip purpose that support the NPTM and other UK passenger models.

within the northern half of that country in order to represent road freight between Irl and NI and through NI to/from Scotland. It will also be important to represent the Irish domestic road freight movements that transit through NI, particularly along the A5 Western Transport Corridor, for which funding of €600m has in February 2024 been committed by the Dublin Government towards the long awaited A5 55-mile upgrade within NI.

4.3.3 The complexity with extending the model to include NI fully within the internal study area, lies in the substantial existing differences in freight data sources and data definitions between each of GB, NI and Irl. The effort required to assemble data in a suitably consistent form for the relatively small number of zones in and around NI, will be closer to the effort required for GB as a whole, rather than being proportional to the number of zones on the Island of Ireland.

4.3.4 It will be important when funding the construction of the NFTM within FAME to think through the resource implications for model development of including NI as an integral part of the internal modelled area. The strategies for inclusion of NI in the NFTM are discussed further below in Section 6.

4.4 ZONING SYSTEM

4.4.1 The recommendation for a two tier zoning system seems sound from the viewpoint of achieving reasonable run times.

4.4.2 The upper tier 2 which is proposed to be at the local authority district level would need to also append the point zones that are needed for major freight nodes. This would add in another 100 to 150 point zones in addition to the specified total of 374 zones on the tier 2 fast turnaround model. This is the zoning level at which the earlier BYFM model had been successfully developed and run.

4.5 TIME PERIOD

4.5.1 The basic time unit for the demand model of yearly freight flows seems appropriate. However, the proposed use of blanket conversion factors from annual to period in an average day for HGVs and LGVs based on the DfT table TRA0308 would need further refinement along the lines now discussed.

4.5.2 The daily pattern of LGV movements for the delivery purpose will be spread relatively evenly across the working day, whereas van commuter and to a lesser extent in course of business van trips will be more concentrated in the morning and evening peaks. Leisure trips in vans are more common outside the working day or at weekends.

4.5.3 For HGVs, it will be more productive to use detailed factors segmented by vehicle type and size. The time of day and day of week patterns are very different across the 6 HGV size/type standard classes. The factors further differ within each vehicle class by road type, so this may also be helpful to apply within congested assignment equilibrations.

4.6 ROAD VEHICLE TYPES

4.6.1 The proposed usage of just two HGV types (OGV1 and OGV2) does not appear to be appropriate. Instead the 5 class (4 rigids by size, plus all artics) system used in GBFMv5 and in BYFM and available within DfT statistics, should be adopted within the demand model component at least. It may also be helpful in the assignment, where vehicles above a certain size may have different costs or restrictions associated with them on specific types of links.

4.6.2 The advantages to this more detailed HGV classification approach include:

- Strong association between logistic leg types and vehicle class
- Improved conversion from tonnes to vehicles
- Better estimates of fuel consumption volumes
- Better representation that the usage of large artics in inner city areas is small, so the larger number of smaller GVs required for a given tonnage, gets picked up in the link congestion measurements.
- Improved representation of alternative fuel options. Small rigids moving mainly on short journeys are suited to battery electric propulsion options in a manner that large rigids used for long distances are not.

4.6.3 The FFR suggests that the use of

> "(say) five different types of HGV, would be possible based on the baseline data from CSRGT, but would make the NFTM more complex and may lead to relatively spurious or even inexplicable responses." (p.52)

This reviewer disagrees that this is necessarily the case. Provided that the appropriate vehicle operating cost functions are applied and that there is a coherent representation of the different logistic leg types within the supply chain for individual commodity types, then the representation of the split across vehicle types can be represented in an explicable fashion.

4.7 PROPOSED NFTM SUB-MODELS

TRANSPORT COST MODELS

4.7.1 The individual detailed modal cost models that were a key feature of GBFM will likewise be crucial to the successful operation of the NFTM and to its informative use within policy appraisals. There is a detailed authoritative coverage of the main components of transport cost models in FFR 8.2 and 8.3.

4.7.2 Although the development of transport cost models may play a niche role within passenger travel modelling, they have great significance for freight models because the market for freight services is largely driven by direct and indirect cost considerations. Furthermore, the future evolution of major changes in technology (e.g. fuel sources, autonomous vehicles, automation of (un)loading, etc.) is expected to impact differently for different modes and commodity types, so that it is important to adopt cost models that can enable the cost change implications of such technology developments to be represented explicitly for each competing modal service.

4.7.3 Accordingly, the proposals at the end of FFR Section 8.3 for the development of a range of 'alternative fuel' transport cost models across freight vehicles and vessels seems appropriate.

FLEET AND LABOUR MARKET MODELS

4.7.4 The outline methodology proposed in FFR 8.4 for the development of sub-models for the evolution of HGV/LGV fleets subdivided by type and by fuel propulsion type seems appropriate. The rate at which the UK sustainable road fleet expands over time will be an important input to future scenario runs within the NFTM model.

4.7.5 The recommendation of a lower priority, if resources are scarce, for the development of corresponding fleet models for non-road modes, again seems reasonable.

4.7.6 However if, as is recommended strongly within this peer review, it is feasible to include an explicit representation of supply chains within the freight demand model component of the NFTM, then the need for a model of future changes in warehouse locations, as outlined in the next Section, should have an increased priority. Much of the data needed to support such a model could be found within the VOA non-domestic floorspace datasets[2], which includes data back to 2001.

4.7.7 The proposal for an age-cohort based model of HGV/LGV driver availability over time is much more relevant now than may have been true in past decades when driver shortages had not been an issue.

4.8 FURTHER MODELS FOR CONSIDERATION – ECONOMY, WAREHOUSE

4.8.1 This reviewer believes that there is also a need for access within FAME to an economic model that could be used to drive future freight demand growth forecasts. This model is discussed below in Section 5.4.

4.8.2 There also appears to be a case for the development of a model of warehouse location. The importance is stressed throughout the FFR of the influence of the location and accessibility pattern of warehouses on the spatial pattern of the origins and destinations of freight movements and on the mode of transport selected.

> "large distribution centres, which (as an origin or destination) probably account for half of all freight moved in Britain." (FFR p.12)

4.8.3 There is a clear description in FRR 3.7 of the distinct roles within supply chains of national and regional distribution centres as well as of e-commerce fulfilment centres. It explains the procedure through which property developers

[2] https://voaratinglists.blob.core.windows.net/html/rlidata.htm

construct new warehousing. Because the optimum locations for such distribution centres are heavily influenced by the accessibility generated by the freight system of the time, major future changes to freight transport cost patterns would be likely to generate corresponding changes in the preferred locations for new warehouse capacity.

4.8.4 In particular, if the option is adopted to explicitly represent supply chains within the freight demand model, then the future pattern of location of warehouses of different sizes would be an important input to this freight demand model. Knowledge of where there will be future pressure to zone land for new warehouse development is an important input to the planning system at both the local planning level and within national infrastructure planning policy.

4.8.5 The model of the location of new warehousing should take account of the following factors.

- National (NDC) or regional (RDC) accessibility level
- Local route access to motorways, and increasingly to rail for the NDCs.
- Local labour supply and cost
- Planning permission availability and cost of large sites, etc

4.8.6 The data required to underpin the development and calibration of a warehouse location model should largely be available. The VOA non-domestic rating files provide data on the size, location, year of construction, rateable value, etc. for all individual warehouses. This coupled with information on transport accessibility, local labour costs and availability, available land zoned for warehousing development could be used to investigate the design of a suitable forecasting model and then to estimate its parameters and validate its performance.

5 NFTM METHODOLOGY

5.1 OVERALL STRUCTURE

5.1.1 The methodology to adopt for the design of the NFTM is discussed in FFR Section 9. The recommendation to avoid the use of agent-based modelling seems appropriate, given the large study area size at which the NFTM must operate, which would create long model run times to ensure that stable results are generated. Furthermore, the risk factor involved in developing an agent-based model could be substantial.

5.1.2 The proposed adoption of a four-stage model structure seems a more appropriate approach, though within this structure the specific stages of the O-D distribution model and of forecasting would benefit from substantial refinement beyond the relatively simplified treatment provided in FFR, as discussed in the following sections.

5.2 A SUPPLY CHAIN BASED DEMAND MODEL?

5.2.1 This reviewer is not convinced that the proposed gravity model approach in Section 9.3 for the estimation of O-D all-mode matrices would be adequate to meet the needs of FAME. Relatively little structured detail on the proposed gravity model approach is provided in FFR. This is a crucial stage within the model both in generating the spatial demand pattern for the base year and in estimating how this pattern might change in scenarios in the future.

5.2.2 The recommended segmentation into the NST 20 commodity type classification used in CSRGT is appropriate for use within the demand model stage, prior to the eventual conversion from units of tonnes to units of vehicles for use within the assignment stage. The typical trip lengths and types of modes and of vehicles used differs between commodity types, as does the likely future growth rate in demand for such commodity types. It is for such reasons that this segmentation is necessary within the demand model.

5.2.3 The focus on warehouses is important and there is appropriate recognition of the roles of warehouses at different scales: national, regional and local, as well as on modal terminals. However, there is no discussion on supply chains and on the need to ensure that the annual tonnage of goods entering a warehouse / distribution centre should be similar to the tonnage leaving that facility. Annex C below provides an overview of how supply chains and their component logistic legs and distribution centres operate within the UK.

5.2.4 This reviewer would strongly recommend the adoption of an alternative supply chain based approach within the freight demand model. This is necessarily a somewhat more complex model structure because it provides an explicit representation for each individual commodity type of

- Production-Consumption (P-C) supply chains that trace goods along the sequence of distinct logistic O-D legs from the original production zone through a sequence of national, regional and local distribution centres up to the final consumption zone,
- and of intermodal chains, where an O-D leg may transfer between road, rail or maritime at intermediate terminals/ports traversed between its origin and destination.

5.2.5 This would greatly increase the logical coherence of the demand model and would improve the subsequent stages of mode choice and of vehicle type choice. It would increase its ability to respond plausibly to policy tests and to provide improved future forecasts of the pattern of demand change by O-D. It is the approach that had been used in the Department's BYFM model (WSP, 2011) and in the TRIMODE model of freight transport across Europe (Noekel et al., 2018).

5.2.6 Introducing this supply chain and intermodal chain functionality may require some software development but in the age of Python and of other software development aids, this software development, if needed, should not be a huge or a very high risk task.

5.3 ASSEMBLING DATA TO SUPPORT A SUPPLY CHAIN BASED MODEL

5.3.1 The more challenging task is to assemble a suitable database to calibrate the initial demand model in the base year. The required data on logistic legs is not currently assembled via the CSRGT nor in any other DfT statistical sources.

5.3.2 There are a number of ways of assembling the empirical foundations for the representation of supply chains within the freight demand model. These are listed here, in the order of their increasing resource requirements and corresponding improvements in accuracy and coverage, together with cross-references to where each data assembly procedure is discussed in greater detail later in this peer review report.

a) Process the existing CSRGT journey records to allocate a probable land use type at each loading and unloading stop, based on their respective post codes. This allocation could be based on cross-referencing to VOA databases on non-domestic property rates[3] and on Council Tax records on dwellings. Based on the combination of: the pair of land use types; the commodity type; and the characteristics of the load and vehicle type, allocate a probable logistic leg type to the trip (Annex B, 12.2).
b) Adjust future CSRGT interview questionnaire to collect added information for each journey on the land use type at each loading and unloading stop. Use this information as in the previous option (Annex B, 12.2).
c) Develop a new automated shipment-based truck survey or perhaps even a full survey of supply chains (Annex B, 12.3).

5.3.3 This supply-chain based approach would provide a much improved representation of the present and the future decision making context within the freight industry. It indicates WHY a specific O-D movement takes place, which is missing from the simple O-D gravity model based approach-proposed in the FFR.

5.4 FORECASTING FUTURE CHANGES IN OVERALL FREIGHT DEMAND

5.4.1 The FFR does not provide detailed guidance within Section 9.4 on the manner in which future economic change is fed through to provide suitable inputs to scenario runs of the model for future years. For short-term forecasts their suggested use of trend-based forecasts may be a simple and effective approach.

5.4.2 However, the expectation is that much of the use of the NFTM will be to examine longer term transport growth patterns within an era of rapid technological and economic change and associated scenarios on the potential impacts of future policy initiatives. The FFR suggestion of an exploratory multiple regression based approach to identify potential longer term driving factors for freight demand growth

[3] VOA rating lists, including post-code, for all individual non-domestic properties for England and Wales are available for download for 2023 at https://voaratinglists.blob.core.windows.net/html/rlidata.htm, though some discussion between the Department and the VOA over the conditions of use of the dataset may be required.

might be adequate, but this reviewer is not convinced that it would necessarily be too successful, even with a major input of R&D.

5.4.3 It would seem more beneficial instead to provide within FAME a formal linkage between: the change in production and consumption levels for individual commodity types that are input to the freight demand model for forecast years; and a UK economic and trade forecasting model that maintains a detailed representation of individual industry types which can be mapped across to the commodity type segmentation in the transport model, and that ideally includes a regional or more detailed spatial disaggregation across the UK. The use of this type of national economic model to guide the future growth trends within the NFTM's inputs of zonal tonnages produced and consumed would provide a coherent mechanism to represent scenarios on future zonal changes in patterns of trade and of economic growth for each commodity type segment.

5.4.4 This reviewer agrees with the view presented on FFR p.11 about taking freight transport tonnage data, rather than economic monetary value data, as the starting point for freight demand model development. This differs from the BYFM approach which applied commodity type-specific volume-to-value ratios to zonal economic estimates measured in monetary value units to then estimate zonal freight production and consumption tonnages for each year and commodity type. Accordingly when forecasting, it appears preferable to apply commodity type-specific, dimensionless, relative economic growth factors, to the base year zonal production and consumption tonnages by commodity type. It is likely to be simpler and at least as realistic to make use of these dimensionless growth factors constructed from the outputs of the economic model, rather than using volume-to-value ratios, when bridging the gap between monetary value units and physical volume units within the freight demand growth estimation procedure in the freight model.

5.4.5 The ideal way ahead would be to interface to some existing national economic model that is already in use across Government Departments, so as to maximise in-house consistency in policy assessments between Transport and these other Departments. It would be helpful to investigate whether some such candidate in-house model might already be available or whether it would be preferable instead to interface to one of the existing external models developed by economic consultancies in the UK?

6 TWO STAGE MODEL DEVELOPMENT?

6.1 COMPONENTS OF THE STAGED MODEL

6.1.1 An alternative prudent strategy for model development could be to develop the NFTM in two stages. The first stage would aim to provide an operational model covering most but not all of the functionality that is ultimately needed, while becoming available for widespread use within a faster time frame. It would postpone tasks that are either higher risk or that require substantial resources relative to the functionality that they add. However, adding this further functionality may have important implications from the point of view of providing full uniform coverage across all of the UK.

6.1.2 It may be more productive to include both stages within a single contract with a breakpoint, rather than letting the stages sequentially and independently. This should ensure that the design decisions that are taken within stage 1 will need to also think through their potential implications for the effort required to subsequently complete stage 2.

6.1.3 The first stage would create a model of GB, that also includes the maritime ferries to the Island of Ireland but that otherwise represents NI effectively as an external zone. The second stage would then provide the substantial resources required to extend the model coverage from just GB to fully cover the UK. Developing a good national freight model for GB is certainly a challenging task. There is a real danger that the resources required to represent NI convincingly may become overextended in the course of addressing the challenges to get the model initially functioning convincingly within GB.

6.1.4 To address the challenges regarding updating the congested road links in Wales and Scotland, it might also be considered whether to postpone until the second stage, the introduction to the congested assignment of internal O-D matrices for cars and LGVs that cover Wales and that cover Scotland. It presently appears that the integration of these within a national road passenger assignment model for GB may be a significant task but this should be investigated further to clarify whether simple solutions may already be available. Accordingly, the first stage model would only use the modified goods vehicle road link flows to update the congested link speeds within England, whereas in the second stage model, congested link flows would be updated throughout the UK.

6.1.5 A third model development component that is potentially challenging, particularly given the effort required to produce adequate supporting data, is the explicit representation within the demand model of the linked logistic legs that define the supply chains that ship goods through a sequence of O-D movements and warehouses when moving from the producer through to the consumer. The inclusion of this explicit supply chain representation component within the freight demand model could potentially be allocated as a stage 2 task, due to effort required to implement it and then fully calibrate and validate its operations.

6.2 REQUIREMENTS FOR SUCCESS

6.2.1 For this two stage approach to NFTM development to be attractive, the following requirements are important.

6.2.2 Firstly, the functionality and coverage of the completed stage 1 model needs to already be sufficiently rich that it can be of immediate productive use to many of its ultimate government clients.

6.2.3 Secondly, the scenario and forecast results that it produces for those topics and geographical areas that it already covers fully, should not be expected to change substantially from those eventually produced from the finalised stage two model. It would be important to be able to identify for clients the specific subset of test results that are liable to undergo major changes later, benefitting from the extended functionality available within the operational finalised stage two model.

6.2.4 Thirdly, the subdivision into two model development stages should be able to minimise duplicated tasks and should minimise waste of resources incurred where expensive stage 1 tasks are discarded later.

6.2.5 The first two of the stage 2 tasks discussed above in Section 6.1: include NI; and introduce road congestion updates for Wales and Scotland, should entail virtually no duplication of tasks or redundancy of earlier work, nor should they create substantial changes to previous stage 1 results obtained for England. This ensures they are suited to being introduced into a stage 2 model version.

6.2.6 In the absence of an explicit representation of supply chains, considerable doubts will remain about the ability of a simple gravity based O-D flow distribution model to represent policy responses adequately. Moreover, most of the resources invested in stage 1 to achieve an adequate calibration of the gravity model would be wasted in the longer term because the introduction of explicit supply chains would necessarily involve substantial recalibration of the previous stage 1 demand model O-D matrices. To compensate for this duplication of effort, the much improved economic behavioural underpinnings for the O-D demand matrices of stage 2 should lead to more realistic spatial patterns in these matrices, together with more realistic conversions from tonnes to vehicles and more realistic choice of mode and of vehicle size and type that are appropriate to each logistic stage within the supply chain. Accordingly, the scenario results produced from this enhanced model could potentially differ significantly from those in the stage 1 model, due to substantial improvements in the realism of the model's results. Consequently, provided the required data on logistic leg patterns can be made available when needed, it may be preferable to fully include this supply chain representation within the stage 1 model, rather than postponing it until stage 2.

7 SCENARIO STUDIO

7.1.1 For passenger transport growth analysis and policy assessment, a number of standardised tools and procedures are already in place within the Department. These structure passenger model results in a manner that damps down unnecessary diversity in their underlying assumptions across the spectrum of passenger model based assessment studies undertaken across the country. The availability of information from the National Trip End Model (NTEM via TEMPro) to provide standard base year and future year demographic, car ownership and trip rate spatial patterns has been a productive influence in generating more standardised scenarios to underpin passenger transport policy assessment. However, there is no structure available at present that provides a corresponding comprehensive freight framework within which to assess freight related policies.

7.1.2 As discussed in the FFR Section 10.1 the use of DfT's Transport Appraisal Guidance (TAG) Databook and the Common Analytical Scenarios (CAS) Databooks has been a positive force for modelling, so that these should form a core part of a scenario studio to structure the results from freight analyses and assessments. However, they would need to be generalised to ensure that their level of coverage of freight is comparable with their existing level of coverage of passenger model related aspects and data inputs.

7.1.3 The Section 5.4 above has discussed the modelling benefits gained from interfacing future year runs of the NFTM to a national economic model of the UK in order to provide a structured way of estimating the required inputs that quantify the longer-term future changes in the domestic demand for freight and in international trade levels for each type of commodity. The usage of the economy model in the context of freight modelling, could play a similar role to that played in passenger modelling by the car ownership model and the national trip end model components. Three particular benefits should arise from access to a set of standard detailed economic forecasts that have been designed to support freight modelling:

- It would reduce the overall resources that would need to be spent across the country in order to develop and run freight models in forecasting mode;
- It is likely to avoid the dangers of misleading forecasting procedures being inadvertently adopted when developing such freight forecasting models;
- Akin to TEMPro for passenger analysis, it could standardise the forecasting inputs for freight modelling thus enabling findings from distinct models or studies to be compared on a common basis.

7.1.4 In this way this adoption of a preferred economic model could support the requirements of the scenario studio.

7.1.5 The proposed task to carry out a data consistency review in the form outlined below in Section 8.3 would also help in standardising the data-definitions for use when populating the different strands within the set of scenarios complied within the scenario studio.

7.1.6 Otherwise, the set of elements that are listed in FFR 10.2 for inclusion in the scenario studio, appears to be appropriate, as is the advice in 10.3 on managing scenarios and in 10.4 on scenario definition.

8 Freight Data Warehouse requirements

8.1 EXISTING FREIGHT DATA SOURCES

8.1.1 In this reviewer's experience, the biggest challenge in freight demand model development is not the model design and construction itself but instead lies in assembling sufficiently consistent datasets that cover all modes to a level of detail that then enables the model to be successfully implemented and calibrated. While freight data availability has improved somewhat through time in Great Britain, it is still not to a level that is adequate to provide strong support for freight demand model development nor for insightful analysis of potential impacts of freight transport policy measures.

8.1.2 The most important data gaps are highlighted below here and then the priorities for addressing them are summarised later in Section 9.2.

8.1.3 There is good coverage of the main current freight data sources for each mode within Section 11.2 of the FFR. However earlier within the FFR in some of its discussions regarding the data required for input to the model, there is not a clear distinction between: the input data that already exists; and data which is not currently available in an adequate form. For example

- “"Last-mile” LGV traffic (both between zones and within zones) can be estimated using survey results which provide origin, destination and journey distance.” (FFR, p.49)
- Similarly, FFR Figure 1 includes a box of “Freight van data” that is indicated to be for use in constraining the synthetic O-D flows that are output from the gravity model.

8.1.4 The source for these LGV survey data for delivery movements is not specified in the FFR. Given the need to know for such traffic that it is of purpose delivery and that it is in an LGV, it appears unlikely that this required data could be deduced from big data sources that are collected remotely. The DfT van surveys of 2008 and 2020 do not collect data on individual journeys nor on the spatial pattern of LGV trip origins or destination. The much more complete 2003-05 DfT van surveys did collect data for individual journey O-Ds and on their journey purposes, but it had very small samples, so this source would be inadequate for the level of geographic detail required within the NFTM, as well as being very dated. The benefits from carrying out a new trip based LGV survey are subsequently discussed in FFR p.101 but it cannot be guaranteed that such a survey would actually be achieved within the required time horizon, as discussed further in the next Section.

8.2 FURTHER DATA ASSEMBLY INITIATIVES

8.2.1 A number of further data collection and data organisation initiatives within the proposed Freight Data Warehouse would help FAME users to access the information needed to understand the current state and the evolving trends in the UK transport system, as well as to provide more solid foundations for model development. Section 11.3 of the FFR lists a number of current data gaps that it would be very productive to address, and it covers well the main new data collection initiatives that are likely to be most cost-effective for FAME.

8.2.2 In the course of the FFR, priorities were allocated to these potential data additions, based on their likely importance in supporting the development of the NFTM or of wider FAME functionality. To inform the assessment of priorities that is summarised below in Section 9.2, some of the key data collection initiatives are now discussed in greater depth, identifying in some cases the competing merits of alternative approaches to collecting these data.

Identifying and quantifying supply chain linkages

8.2.3 The review of access to data in FFR 2.5 identifies the major gap relating to the absence of data sources that can relate together the sequence of logistic legs comprising a supply chain. Notwithstanding this genuine data challenge, this reviewer is not convinced that

> "It may be more sensible to regard all land uses at the origin and destination of each journey as 'adding value' such that they are considered independent journeys to avoid this problem …. In that way, except where the cargo unit itself is transferred unopened (as with a container or a trailer at a port or rail terminal) individual legs can be modelled separately." (FFR p.7)

8.2.4 This is a crucial issue to be resolved for model design and is also highly dependent on the potential for the provision of data to support the identification of supply chains. A model that assumes that the linked sequence of logistic legs along a supply chain are best represented as being independent of each other, will struggle to represent how freight movement patterns change through time or from policy initiatives.

8.2.5 In order to reduce the implementation costs of the model and to improve the range and the quality of policy coverage within the freight demand model component of the NFTM, it is highly recommended to improve the supporting data so as to provide a quantified understanding of the pattern of logistics legs within UK supply chains for each type of commodity. There are various options now listed on how this might be achieved. These increase in their resourcing costs and correspondingly in the quality and scale of supply chain coverage that they would provide.

8.2.6 **Reprocess CSRGT -** The simplest and quickest initiative would be to reanalyse the CSRGT data for a few representative recent years so as to attribute a land use type (e.g. quarry, farm, distribution centre, retail, household, etc.) at each loading and unloading point. Provided that a postcode or address has been provided for this point, an automated procedure could be developed to match this post code or address to suitable domestic and non-domestic datasets of properties and their usage.

8.2.7 **Extend CSRGT** – Better information could be obtained by adjusting future CSRGT survey forms to request information on the type of activity at each loading and unloading point for every surveyed journey. This is the approach that has been prioritised in FFR 11.3.

8.2.8 The detailed methodology for these two CSRGT supply chain data capture initiatives are discussed in greater detail in Annex B.12.2 below.

8.2.9 A number of alternative options are then outlined in Annex B.12.3 below, for more resource intensive, **innovative supply chain surveys**, including the examples of the automated shipment-based truck trip diary collection exercise in the Netherlands (de Bok, et al., 2022) and the ECHO shippers survey of entire supply chains in France (Guilbault et al., 2008).

8.2.10 In summary, there is a critical need to provide access to informative data that can identify and quantify the logistic leg linkages within supply chains. The only uncertainty relates to which of the above approaches is best placed to address this need in an effective fashion.

Trip-based LGV survey

8.2.11 It is not helpful for analysts that LGVs, the segment of traffic that has been consistently the fastest growing across the last 20 years on every road type for most parts of the UK road network, is nevertheless the road vehicle segment for which the least data has been collected across this period, at either the national (DfT/NH) level or for regions or counties at lower spatial levels.

8.2.12 Although, the most recent van survey has been carried out by DfT in 2019-20 (DfT, 2021a), it is important to note that this survey did not collect van data at the trip level but only on its main usages. Consequently this survey data is not directly suited to the production of O-D trip matrices or to meeting many of the needs to underpin the development of the LGV freight component of the NFTM.

8.2.13 The need for a new trip-based LGV survey is discussed in FFR p.101. It correctly identifies that there may be difficulties in successfully implementing a detailed trip-based LGV survey in a traditional fashion. This is a freight sector where the LGV delivery drivers are under great time pressure to achieve their 100+ deliveries every day, so they will have minimal ability and inclination to delay their pressurised schedule by recording details about each individual delivery movement. Consequently, this reviewer strongly backs the FFR suggestion for DfT to explore technology-led solutions that automate the recording of the movements and stops of the surveyed LGVs. The automated truck trip diary data collection exercise successfully implemented in the Netherland, discussed below in Annex B.12.3 may provide some guidance on what could potentially be achieved through automated procedures that are linked into the software for managing delivery items in use by the delivery firm.

8.2.14 What is required is an LGV survey with coverage that is broadly similar in structure to the set of LGV surveys carried out successfully in 2003-05 for the Department (DfT, 2004 and 2008). These surveys covered all trip purposes including: commuting; employer's business (mainly service or construction related); private; and delivery (freight) trip purposes. They covered both privately owned and company owned LGVs within distinct surveys. The key feature of these surveys was that they were trip based, collecting information on the characteristics of each trip made over a few successive days.

8.2.15 Importantly, they collected information about the land use type at the origin and destination of the trip and about the purpose of the trip. This information was invaluable in terms of understanding why trips were being made as well as in the determination of suitable indicators for use in estimating LGV trip production and attraction rates for each LGV freight and non-freight trip purpose. The success in capturing and then using this data on land use type to improve the foundations for LGV modelling, indicates why it is important to also obtain analogous information about HGV trips.

8.2.16 Although the NTS does collect some information on LGV trips, this LGV component data has been shown in the past to be strongly under-reported and biased (Le Vine et al. 2013) and to not be to the high standard of other NTS components. It is also important to note that the NTS does not set out to capture the trips by those for whom driving is a significant part of their occupation, so that freight delivery LGV trips are likely to be largely unreported, aside from other sources of underreporting of LGVs on the other trip purposes.

Survey of inland mode and origin or destination of port traffic

8.2.17 As will be illustrated in the subsequent Section 8.3, the freight flow data that is collected by the three main modes of road, rail and port/maritime is collected in an entirely independent fashion by each mode. Annex A below further discusses some of the oddities in measurement units and interpretations that this independence encourages. Accordingly, it would be very informative to carry out on a common basis across modes a survey of the inland transport characteristics to and from each of the main UK ports.

8.2.18 The published official UK port statistics for the water side of UK ports have through the decades provided a high level of statistical detail and of continuity. In contrast, port statistics are almost non-existent relating to transport activity on the inland side of the port. Because ports are the locations where much of the UK competition between road and rail (and waterborne) modes occurs, they could provide an effective means for identifying those contexts where each of the inland modes is more successful.

8.2.19 The key data items to collect for a suitable sample of import and of export consignments passing through the UK ports (plus Eurotunnel) would include:

- The inland mode to or from the port
- The UK inland origin (export) or destination (import) ultimate location and postcode, ideally also the activity type (factory, quarry, warehouse, etc.) of this inland location
- The location of any intermediate intermodal terminal at which the mode is switched, plus the mode of this switch
- The commodity type (NST)
- The mode of appearance at the port
- The weight of the consignment[4] and if possible its volume m^3.

[4] Clarify what is included in this consignment weight measurement in addition to the goods, e.g. any packaging of the goods themselves, pallets, ISO containers, trailers for RORO, etc.

- The consignment dwell time at or around the port, between being on the inland mode and on the vessel.

8.2.20 If as is suggested on FFR p.102, this survey can be based on a suitably selected sample of custom returns, then the precise set of data items from the list above that can easily be extracted from such returns, will need to be confirmed.

8.2.21 The resulting port inland movement data would be informative on many fronts. It would be of use for each individual commodity type in informing the calibration of its mode choice model. It would help to identify the characteristics of a large proportion of the primary logistic legs for imported goods for each commodity type. The modal flows could be cross-checked against the corresponding flow estimates from the official modal statistics for each individual mode to highlight any inconsistencies in measurements or data definitions, that are peculiar to the published statistics for that mode.

8.3 Consistency review across modal freight data sources

8.3.1 The statistical data that is collected for each freight mode is generally designed in a form that is closely suited to the requirements and traditions of that specific mode. For those mainly working within a specific mode this approach is helpful and avoids unnecessary complications. In contrast, for those charged with assessing policies that impact across modes it is a source of inconsistency in information that needs to be recognised and understood, if errors in data interpretation are to be avoided.

8.3.2 A small selection of examples is discussed below in Annex A illustrating how inconsistencies in freight data definitions arise, and the confusion that they can cause for analysts unless they are resolved in a systematic and standardised fashion.

8.3.3 Accordingly, at an early stage in setting up the freight data warehouse a short review would be valuable that examined in detail the meta-data across the complete set of standard statistical freight data sources that are listed in FFR Section 11.2. The study would systematically identify any existing differences in data definitions, both between modes and within modes, across the different standard freight data sources. This data consistency review task would have two main aims. Firstly, it would alert analysts using the freight data warehouse to any cases where statistics on entities that have the same name in two or more data sources, may, in reality, be measuring either different subsets of, or different characteristics of, the entity in question. Secondly, for those charged with assembling data for use as input to the NFTM, it would provide standardised guidance on how best to assemble the required input data in a form that maximises its internal consistency across the set of data sources from which it is drawn.

8.3.4 For the set of datasets that have been combined together within the data warehouse, the ultimate aim of this task would be to ensure that, if possible, each of their individual data entities should maintain identical data-definitions throughout these combined datasets. Where this commonality proves infeasible, then each differing version of an individual data entity within the dataset should be attributed a distinct variable name that would alert the analyst to the inconsistencies in data definitions. For example for the LGV entity, use the names

- LGV_TC – to denote the definition of the set of LGVs included when carrying out traffic counts for, say, the AADF classified roadside count surveys,
- LGV_Flt – to denote the definition of LGV coverage used in vehicle fleet licensing statistics,
- LGV_Sv – to denote the definition of LGV coverage adopted in the Department's past LGV surveys,
- etc. for any other variant set of LGV coverage within standard datasets.

8.3.5 A second sub-task to include in this review would be to examine and resolve issues related to the subset of datasets that would be valuable in supporting NFTM and SS development, but which currently have cost, confidentiality or licencing restrictions on their use.

8.3.6 For example the detailed VOA non-domestic property dataset is available to the public for download. However, current licencing restrictions would appear to forbid its usage for tasks such as supporting NFTM development. Hopefully, the Department could resolve such licensing issues for various datasets from government agencies or the private sector, which would be of potential use within the Department's freight data warehouse.

8.3.7 For other datasets, confidentiality restrictions applied to avoid identification of respondents, may prevent their use except as totals published at high levels of aggregation. To mitigate this problem, this task would start with the full disaggregate dataset and then aggregate the contents using the classifications specific to FAME. At this stage, if any disclosive sub-categories containing too few entries still remain, these would be further aggregated or suppressed to ensure they become non-disclosive. The resulting dataset would then become available for use for analysis and for model development support.

8.3.8 Successful completion of this task would ensure the maximum range of datasets are in practice available to analysts within the freight data warehouse.

8.3.9 In summary, the main content of this data consistency review report would comprise

- Coverage of all standard dataset sources included within the data warehouse
- Listing of all mutual inconsistencies in data definitions and classifications for such sources
- Standard procedures for addressing these inconsistencies when combining distinct data sources together into
- Standard mode-independent classifications and data definitions that are adopted for universal use across the NFTM and SS.

8.3.10 This freight data consistency review study would not be expected to be a very large task. Ideally it should be carried out internally by DfT statisticians.

Alternatively, if it is commissioned externally, the study team should be in close liaison with the DfT statisticians in order to ensure that they have full and accurate information on the coverage of individual data items across all of the main freight data sources. It should be a high priority to start this study soon so that its results become available early enough to provide constructive support across other model development or data warehouse implementation tasks within FAME.

9 Summary

9.1 CONCLUSIONS AND PRIORITIES

9.1.1 The FAME Final Report (FFR) provides a good level of detail about the approach that is recommended for the development of FAME, while the material generally is presented clearly in a well-structured fashion. Most parts of FFR provide insightful information on the characteristics of the UK freight transport system and on how it might be modelled productively. This reviewer has found little within the report that he fundamentally disagreed with and much that he would support strongly. There are however a few topics that this reviewer feels could have been treated differently or in greater depth and these have been identified above and discussed accordingly. We next summarise findings on each of the main topics covered within this FFR.

9.1.2 The review of existing freight models in FFR Section 2 is rather dated and patchy in its coverage of freight model applications outside the UK. It has quite limited coverage of the structural details for the models discussed. In general, this review of model types does not provide the depth and authority of coverage that is displayed in most of the later FFR sections. Nevertheless, the coverage of the lessons learned from existing freight models seems fine for most aspects, but the reluctance to consider an explicit supply-chain representation within the freight demand model is questionable, even allowing for the data challenges that this representation would create.

9.1.3 In contrast, the overview of the operation of the UK freight transport market presented in FRR Sections 3 and 4, provides an excellent overview of the activities of the freight and logistics service providers, and on the infrastructure networks that are used by these providers. It provides clear, informative guidance on the set of actors, activities and issues that would need to be represented within FAME and within its NFTM. It should be thoroughly digested by whoever is eventually charged with the design and delivery of NFTM.

9.1.4 FFR Sections 7 and 8 discuss the findings on the scope and on the characteristics envisaged within the national freight transport model. The set of its recommendations on the freight model scope have been summarised above in Table 1 and this reviewer agrees with almost all of them. The two revisions proposed are that: 5 HGV types should be distinguished in the demand model, rather than just 2; and two further sub-models should be considered that would be appended to the NFTM. These extra sub-models are firstly, a UK national economic and trade forecasting model that maintains a detailed representation of individual industry types and of regions, would be of major use for supporting forecasts of future freight demand levels and for supporting the requirements of the scenario studio. Secondly, a warehouse location forecasting model would be complementary to the economic model and would enable the spatial pattern of one of the major generators and attractors of freight journeys to be forecast in a policy sensitive fashion.

9.1.5 The methodology to adopt for the design of the NFTM is discussed in FFR Section 9. While the 4-stage model methodology that is proposed does appear more suitable than the rejected agent based modelling approach, the details of some of the proposed NFTM model stages are not fleshed out in great detail in FFR, so some further recommendations are discussed below. The main points of difference are summarised as:

- The FFR proposes a gravity model approach to the creation of O-D flow matrices which appears to the reviewer to be inadequate for the purposes of FAME. Instead, a necessarily more complex approach is recommended that explicitly represents the sequence of logistic legs within supply chains (see Section 5.2).
- The main challenge when implementing this supply chain based approach is the current absence of suitable data on which to support it To address this gap, a task is proposed to process the existing CSRGT data so as to transform it to a structure that is well suited to supporting the implementation and calibration of this proposed supply chain based demand model (see Section 5.2).
- To provide a more coherent and consistent procedure for forecasting future year freight demand levels, a linkage is proposed to a suitable UK national economic model, preferably one already in use across Departments (see Section 5.4).

9.1.6 In other respects the model structure proposed in the FFR seems appropriate.

9.1.7 While ultimately the NFTM would be expected to provide a uniform level of coverage across all of the UK (i.e. including Northern Ireland), it may be prudent to develop the model in two stages to avoid having too long a wait until the model becomes available for practical use by the Department The advantages and disadvantages of a two-stage approach to NFTM development have been introduced above in Section 6..

9.1.8 FFR Section 10 outlines the proposed content and management of the scenario studio. This initiative appears well worthwhile as a way of making more effective use of freight models and freight data analysis, as well as damping down unnecessary diversity in their underlying assumptions, in a manner similar to that achieved by NTEM for passenger modelling.

9.1.9 The review in FFR Section 11 of the availability of UK data on which to construct freight models and to populate the data warehouse is clear and informative. It covers each of the main modal data sources and it also identifies the main current data gaps and makes recommendations on how to address these, which are briefly summarised below in Section 9.2.

9.1.10 A new data related task has been identified and is specified in Section 8.3. It recommends a short review that examines in detail the meta-data across the complete set of standard statistical freight data sources that are listed in FFR Section 11.2, which would enter the data warehouse. The study would systematically identify any existing differences in data definitions, both between modes and within modes, across the different standard freight data sources. The aim would be to produce user guidance on how to identify and avoid the many existing traps for the analyst (see examples in Annex A) when combining or interpreting freight data from existing standard data sources. The use of the resulting guidance would improve performance within the development of each of the NFTM, the Scenario Studio and the Freight Data Warehouse.

9.2 PRIORITISATION OF DATA ASSEMBLY TASKS

9.2.1 The priority that was allocated in FFR 11.3 to the six new data collection activities that it considered, is reproduced below in Table 2. These priorities also accord broadly with the priorities of this peer reviewer who has further prioritised the high priority tasks in the column headed PR.

Table 2 Prioritisation of new data collection activities

Priority	Levels	Data collection activity	Comments / links to Sections in review
High	1	Enhancing CSRGT to identify activity at pickup and drop points	See 8.2 and Annex B for a discussion on 4 alternative data collection approaches
High	2	DfT LGV trip-based survey	See 8.2
High	3	Survey inland mode & O or D of port traffic	See 8.2
Medium	4	Mobile phone data	
Medium	4	ANPR	
Medium	4	GPS data for road freight vehicles	

9.2.2 The first three items on his list in Table 2 are deemed high priority because each of these surveys has the potential to provide the type of integrated data with the high degree of segmentation that ideally is needed when setting up a demand model that could maintain a strong economic behavioural underpinning.

9.2.3 The highest priority is allocated to obtaining data to identify logistic legs within supply chains, whether by enhancing the CSRGT or through one of the other three alternative approaches discussed in Section 8.2 and Annex B. The availability of this data could greatly improve key aspects of the performance of the freight demand model and should reduce its cost of implementation.

9.2.4 Without access to a contemporary survey of LGV trip patterns, the introduction of the LGV delivery van mode into the NFTM would need to be based of

LGV trip-based surveys from 20 years back. This would not be ideal for a rapidly growing and evolving sector within the freight industry, which is why its priority is second from top.

9.2.5 Third priority is allocated to the survey of the mode, origin or destination of inland movements to/from ports. Because port related movements are where rail competes most strongly with road, they provide an excellent cost-effective potential source of consistent data across these competing modes, which would complement and provide checks on the existing datasets that cover individual modes in isolation, allowing potential inconsistencies between the modes.

9.2.6 The latter three remote sources are allocated medium priority. They have the capability to provide much greater spatial and temporal coverage. However, because of their inherent lack of segmentation detail, other than perhaps the characteristics of the vehicle, they do not generally help the analyst to understand either what is being moved or why. Accordingly, their main role is a complementary role for use, say, for expanding sampled data to the population or for local spatial disaggregation of expanded totals.

9.2.7 It may be that some of the many research initiatives underway to investigate how to make effective use of remotely sensed data, will start to provide more convincing outcomes. However, it remains unclear so far whether such sources will ultimately demonstrate a high level of utility for underpinning the development of behavioural-economic freight demand models. Instead their main usage may be within the data warehouse to provide early warnings of changes in transport trends and more generally for the investigation of short-term shocks and responses to changes to the transport system.

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11 ANNEX A: EXAMPLES OF DATA DEFINITION INCONSISTENCIES

11.1.1 To ensure that users will be able to analyse the contents of the data warehouse in a consistent and informative fashion, it is crucial that they are provided with clear guidance on how to interpret and integrate data from the many sources that will feed into the data warehouse. The following three examples for: LGVs; HGV traffic levels; and weight of goods transported, highlight just a few of the many meta-data inconsistencies that arise when interpreting combinations of standard freight data sources.

11.1.2 The meta-data supplied within the "Van Statistics 2019-2020: Technical Report" (DfT, 2021b) indicates that its analysis and its comparison with earlier surveys will need to be carried out with great care. This 2020 van survey defines a van as:

> "(Light commercial vehicles / light vans) 4-wheel vehicles constructed for transporting goods. Must have a gross weight of 3.5 tonnes or less.
> The definition of a van used in this research means that the population covered by this study is smaller than number of licensed vans in Great Britain." (page 1, DfT 2021)

11.1.3 This difference in definitions needs to be accounted for when expanding the survey results to the national fleet. More generally, the definitions of road vehicle types adopted within the statistics on the new and used national licensed vehicle fleets or in the odometer data on vehicle mileage available through the MOT, do not necessarily correspond to those used in traffic count statistics.

11.1.4 Road goods vehicle type categorisations are not necessarily consistent between the DfT traffic counts used for the AADF estimates and the counts collected by National Highways for the trunk road network. Differences between visual based classifications of traffic counts and automated counts with classifications based on vehicle lengths lead to significant differences in vehicle type splits.

11.1.5 DfT statisticians have in the past carried out an investigation into why an increasing gap had arisen between their two estimates of HGV traffic that are based on different data sources.

> "Both the Road Freight statistics series and the Road Traffic (RT) series obtain and publish estimates in vehicle-kilometres of Heavy Goods Vehicle (HGV) traffic. The Road Traffic HGV traffic estimates are consistently higher than those from the Road Freight series and **the gap has increased by nearly 11% to 29%** between 2000 and 2010." (p.1, DfT, around 2012, emphasis added)

Table 3 Summary of the main discrepancy factors between the road traffic estimates and the CSRGT HGV traffic estimates and of their impacts

Factor	Impact
ATC misclassification of 2-axle rigid HGVs, LGVs and buses	Over-estimation of the RT estimate (both total estimate and 2-axle rigid estimate)
Miscellaneous large non-goods-carrying vehicles	Over-estimation of the RT estimate (both total estimate and some sub-classification estimates)
Underreporting in the CSRGT	Under-estimation of the CSRGT estimate (both total estimate and all sub-classification estimates)
Magnification of underreporting due to methodology of grossing up CSRGT to annual estimates	Under-estimation of the CSRGT estimate (both total and all sub-classifications)
Foreign and NI-registered HGVs	Coverage difference which should be included in the RT estimate but excluded from the CSRGT estimate
Differing treatment of drawbar trailers as rigids and artics	Definitional differences causing differences in estimates at a sub-classification level only
Differing treatment of axles – by total number, or number on the ground	Definitional differences causing differences in estimates at a sub-classification level only
Increasing numbers of LGVs over time	An increasing impact on ATC misclassification (and thus increasing over-estimation of the RT estimate) contributing to the continuing divergence over time
Impact of EU expansion	Affects the proportion of foreign HGV traffic attributed to each country but unlikely to be a significant cause of continuing divergence over time
Increasing foreign HGV traffic over time	Only a slight increase in foreign HGV traffic so only a marginal contribution to the continuing divergence over time

Source: DfT (around 2012) font colouring added.

11.1.6 The DfT conclusions on impacts of data inconsistencies are summarised in Table 1. Those converted above to red font relate to differences in data definitions or of data coverage between distinct data sources. These impacts have been quantified as part of an adjustment procedure that the Department carried out to generate an improved match between the two data sources, to enable the Department to compare their trends in HGV traffic growth on the basis of a mutually consistent set of data definitions.

11.1.7 Due to the different weight measures adopted within the standard modal statistical sources, namely: **gross-gross** weight on rail; but just **gross** weight on road, sea and air, the actual weight registered for a shipment may appear to change whenever there are transfers of shipments between rail and other modes. Nor will this shipment weight match to the trade statistics definition which measures only the **net weight** of the goods, **excluding any packaging or carriage equipment.**

11.1.8 More specifically, when measured on road the "gross" weight of goods used is defined as:

> "… total weight of the goods and all packaging, but **excluding the tareweight** of any container, swap-body and pallets containing goods". (P10-B-62, Eurostat, 2016, bold added)

When measured on rail, the "gross-gross" weight measurement that is used is defined as:

> "The weight to be taken into consideration **includes**, in addition to the weight of the goods transported, the weight of packaging and **the tare weight of containers, swap bodies, pallets as well as road vehicles transported by rail** in the course of combined transport operations". (p.20, Eurostat, 2015, bold added).

Paradoxically, within the ORR rail freight statistics publications this "gross-gross" weight measurement definition for rail freight is actually termed "net" tonnage to denote

> "Freight lifted - The mass of goods (tonnes) carried on the rail network, excluding the weight of the locomotives and wagons." (ORR, 2024, p.6)

More generally for rail the term "gross" tonnage includes the weight of the locomotives and wagons.

11.1.9 For bulk and semi-bulk goods this distinction between modes in the form of weight measurement is of limited significance. However, for high value finished products, particularly light products such as textiles and equipment that generally will be shipped in unitised format, the added weight of the units used for carriage may be comparable with the weight of the goods carried themselves. Accordingly, it will be necessary to discount the tare weight of these units whenever the rail tonnages are being merged with other modes or with trade statistic's based measurements of goods flows.

11.1.10 This example of major naming inconsistencies between modes highlights the care that is needed with interpreting terminology across modal datasets, plus the great need to introduce a common unambiguous set of data-definitions throughout all datasets in use.

12 ANNEX B: IMPROVING ACCESS TO UK LOGISTICS DATA

12.1 QUANTIFICATION OF SUPPLY CHAINS AND LOGISTICS IS NEEDED

12.1.1 The core belief of this reviewer is that it is better to construct an appropriately structured freight demand model, even if that may need to be implemented in a form that exhibits some data weaknesses, rather than constructing a misleadingly over-simplified model using only the available restricted datasets. More specifically, a freight model that does **not** have an explicit representation of the freight supply chain system and of the linkages between successive logistic legs, is **unlikely** to be helpful for policy testing for many of the aspects of interest to the Department.

12.1.2 In contrast to passenger modelling, for which adequate data is generally available in the UK, freight modelling in both the UK and most other countries has struggled in recent decades to evolve to represent the major logistical changes that have been induced by the economic shift away from traditional heavy industry to an economy focussed instead on producing or importing a huge range of finished consumer products.

12.1.3 For freight modelling, the design, specification and implementation of the model structure is a significant task. Nevertheless in the UK it is not as great a challenge as obtaining access to good consistent data that is segmented by mode, supply chain stage and commodity type, with which to construct and calibrate a comprehensive, flexible freight demand model. The virtually complete absence of explicit data to quantify current supply chain structures within the UK is by far the biggest data gap for the development of a robust spatial demand model that is underpinned by behavioural-economic responses.

12.1.4 Accordingly, without improved data this gap would generate a large amount of work in order to fill this void in a meaningful fashion. For example, a major consumption of resources within each of the BYFM (WSP, 2011) and TRIMODE (Noekel, Williams & Fiorello, 2018) projects that explicitly included supply chain linkages within their freight demand models, has been the research and analysis required in order to create for each individual commodity type some coarse estimates of the actual split of observed road movements between: primary; secondary; and tertiary logistic legs; as well as to distinguish the HGV trips that act as feeder legs to or from other non-road modes. This quasi-observed, processed approximation is required for the demand model calibration procedure in order to ensure for each individual commodity type:

- that the split between the alternative distribution channels within a supply chain is plausible for the goods movements from the producer zones to the consumer zones;
- that the influence of changes in goods flows on rail, ship or air will impact correctly on road feeder flows to and from their modal terminals.

12.1.5 This data analysis and production task unfortunately is one where the actual research and analysis work carried out in previous projects, such as BYFM, would need to be reworked from scratch with the current CSRGT data. The earlier work can provide some pointers on what to look for and on the more productive avenues to explore but nevertheless a considerable volume of careful and skilled analysis work would be unavoidable. This task would add significantly to the resource cost, timescale and risk of quality reduction of this model development project.

12.1.6 A better alternative is to obtain systematic improvements in access to representative, comprehensive data on freight shipments along UK supply chains. Examples of how this could potentially be achieved are provided by the descriptions below: Section 12.2 discusses potential enhancements to the CSRGT itself or to its processing; while Section 12.3 describes various more comprehensive surveys of individual shipments that have been successfully carried out in other countries.

12.2 CSRGT REPROCESSING AND REFINEMENTS

12.2.1 To realistically represent the economic logic underpinning shippers' decisions within a freight demand model, it is important that realistic information on the observed current patterns of goods movements along supply chains is available for use during its calibration. However, explicit information on the stage in the distribution chain for road goods movements has never been collected within the CSRGT. Nor is it available for the rail or maritime modes, though this is less of an issue because most (though not all) of their flows will in practice be primary logistic legs, because of the large size of the shipments typically carried by these non-road modes.

12.2.2 The simplest and fastest option would be to explore the effectiveness of **reprocessing the existing CSRGT** data in order to allocate a land use type to the unloading and loading points of every stop.

12.2.3 It would be most resource effective to initiate this option through a small scale **feasibility pilot study** to identify the likely resulting quality of the allocation procedure and to explore the most suitable methodology and background datasets to use to support this allocation of land use type. The first step of this pilot study would extract a random sample of the completed CSRGT questionnaires over the last few years to examine the patterns of trips for which valid postcode details had, and had not, been provided for both ends of the trip. This step would identify the maximum potential for the allocation procedure to be successful. It would also identify whether certain types of commodities, vehicle types, area types or trip types have lower than average compliance rates in providing postcodes. The second step for each sampled trip with compliant postcodes, would allocate based on its postcodes a land use type to each end of this trip. The allocation is based on matching this post code to a property entry in either a suitable domestic or a non-domestic dataset of properties and of their usage. Potential datasets for examination include: the VOA non-domestic rating files; the Council Tax dwelling files; and the Ordnance Survey property files.

12.2.4 If the land use type at the start of a trip is a quarry, farm, factory, international port, etc. then the trip would be expected to by a primary logistics leg. If the land use type at the end of a trip is a house, office or retail premises, then the trip is likely to be a tertiary logistics leg. Because the VOA differentiates warehouses by size, the differentiation between national, regional and local distribution centres should be feasible. The CSRGT also now enables terminals to be explicitly identified by mode, which would help to build up intermodal chain patterns. Other similar rules can be built up to take account of the pair of land use types for the trip to determine its likely place within the supply chain for that commodity type. It will be helpful when designing the rules that identify the location within the supply chain of a trip to also make use of information on: the mode of carriage (e.g. container, pallet, bulk, packaged, etc.); the number of pickups and drops on the journey; and the type of HGV.

12.2.5 Provided that the pilot study has successfully demonstrated that the allocation procedure generates realistic land use types for a sufficiently representative cross-section of HGV trips within the sample, then the **main CSRGT reprocessing task** could be initiated. Ideally, an automated matching procedure could be developed, perhaps based on recent AI capability improvements. This allocation should be applied to all compliant trips within the CSRGT dataset covering a few recent years. To expand to the national annual set of movements, expansion factors would then need to be applied to each compliant trip. These expansion factors need to be estimated in a form that takes appropriate account of the observed differences in postcode compliance rates across the different classes of trips.

12.2.6 In this manner, there is potential to generate an improved database of HGV flows that is suited to supporting a well-designed integrated freight and logistics demand model. Clearly, the experimentation and checking of the processing methodology proposed above would be a significant task, but its outputs would provide valuable information for use more widely within FAME.

12.2.7 On the other hand, if the pilot study results are not encouraging, then better and more comprehensive information could be obtained by **extending the CSRGT** so that it explicitly collects information on the type of economic activity at the point of pick-up and of delivery of each load. This approach had been pioneered in the 2003-05 van surveys carried out by the Department (DfT, 2004 and 2008) and the information that it generated played an important part in facilitating the inclusion of LGV as a freight mode within the construction of the BYFM model. Recent improvements have been achieved within the CSRGT in explicitly identifying feeder legs to/from other modes (rail terminals, sea and airports). The Department could extend this approach from just terminals to also include on the questionnaire a list of land use types for selection at each pickup or drop stop.

12.2.8 While any such change to the CSRGT design would be of long-term major use for improving the understanding of the responses to policies of the road freight industry, it would take some years to provide concrete results and so it might not be available in time to support the initial development of this national freight model.

12.3 INFORMATIVE SURVEYS OF SHIPMENTS

12.3.1 The ideal data source to underpin the development of a supply chain based freight demand model would be a large scale shippers' survey that traces shipments through the sequence of stages from the original producer through to the final consumer. Unfortunately, such surveys are complex to design and implement so they are not commonplace. The ECHO 2004 survey (Guilbault et al., 2008) of around 3,000 shippers and 10,000 shipments in France is one of the few surveys that examined the sequence of agents and their activities along the transport chain of a shipment from its producer through to the final consignee, while covering all freight modes. Its focus was more on the movements of finished products, than on the large flows of bulk intermediate goods. It provides good insights into French supply chain structures, despite its relatively limited sample size. While the successful introduction of this type of comprehensive shippers survey to the UK would be very informative, it is likely that it would be relatively expensive and complex to implement it effectively.

12.3.2 More recently, the HARMONY Horizon 2020 research project describes the development of

> "an exceptionally large dataset of truck trip travel diaries for The Netherlands, collected by Statistics Netherlands (CBS) using an innovative automated procedure to collect the truck trip diary data. The database includes information on the vehicle, the route, and shipments that were carried, and has a high data density. First of all, the survey is mandatory: carriers are obliged to report truck trip travel diaries for the trucks in their fleet that were included in the sample of CBS. On top of that, the data was collected using an automated XML-interface with the transportation management systems that reduces the administrative burden for carriers to complete the survey." (de Bok, et al., 2022).

12.3.3 The survey data collected by CBS was for more than 2 million trips, both domestic and international. It assembled the data within a three level hierarchy:

- **Truck** data included the vehicle ownership type, fuel consumption rate, carrying capacity, vehicle type and home base address;
- **Tour** data included the distance from origin to destination of the tour, date and time of start and end; origin and destination location and zip code, haulier or own-account, vehicle capacity utilisation in %m^2 and %m^3, border crossing location;
- **Shipment** data included the distance from loading to unloading point, gross weight, cargo/loading type (solid bulk, liquid bulk, container, pallet, etc.), Loading and unloading location and zip code, loading and unloading location type (production, consumption/processing, retail, seaport, distribution centre, etc.), goods type (NST), invoice value, volume (l or m^3).

12.3.4 The truck and tour level data that was collected is broadly similar to that already collected within the CSRGT. However, the specific focus on individual shipments is not adopted within the CSRGT, which instead collects information on the total tonnes loaded and unloaded at each stop. This alternative individual shipment orientation enables key information to be assembled that provides insights into supply chain structures. The identification of the location type of the loading and unloading points of individual shipments for each commodity type, enables the differences to be quantified for each of the different types of logistic leg within a supply chain: in its spatial patterns of movements; in cargo type / form of loading; in shipment size; in vehicle size; in vehicle loading efficiency; etc.

12.3.5 If a similar breakthrough on data availability at the shipment level, could be achieved in the UK, then this would lessen the costs and risks involved in the development of a future freight demand model. Access to such data in the UK would support the identification of the relative proportions of different types of logistic legs within supply chains and the typical characteristics of each of these types of logistic legs. In turn, this data would provide the empirical foundation for the full explicit representation of supply chain activity and of its impact on transport demand patterns, which would enable major improvements in the functionality of the freight demand model component of a national freight model.

12.3.6 Commodity flow surveys have been carried out 5 times in Sweden[5], approximately every 5 years since 2001, with the most recent survey being in 2021. The focus in commodity flow surveys is on the movements of freight more than on the vehicles and vessels that transport the goods. This Swedish shippers survey measures the value and the tonnage of goods transported domestically and abroad and the sequence of transport modes that were used along the transport chain for individual shipments. The scope for automating the implementation of this survey has been explored by the Swedish Transport Administration (Petterson, 2021). Commodity flow Surveys are also carried out in the US[6] every 5 years starting in 2012, with a switch to online, rather than paper, information collection within the 2022 survey.

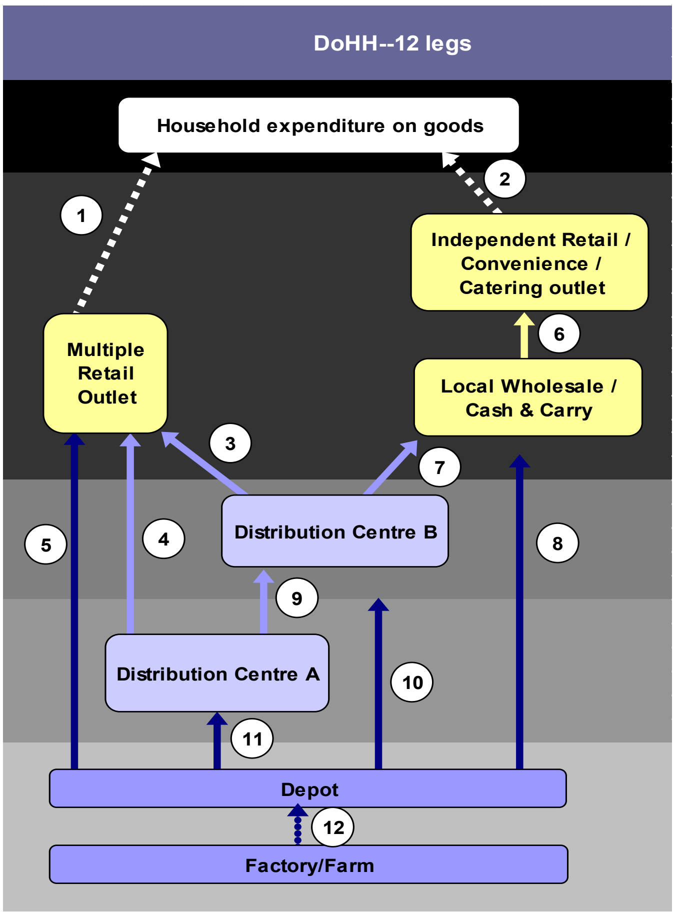
13 ANNEX C: OVERVIEW OF SUPPLY CHAINS AND LOGISTIC LEGS

13.1.1 This provides a brief overview of logistic structures within UK supply chains to provide context for the recommended introduction of an explicit representation of supply chains within the freight demand model.

13.1.2 Although some bulk primary products, such as ores or grains, may be transported directly without intermediate storage from where they are produced to where they are consumed or processed, this direct transfer is not the norm for most goods. Instead, foodstuffs and consumer goods usually pass through many

[5] https://www.trafa.se/en/travel-survey/commodity-flows/#:~:text=The%20survey%20constitutes%20official%20statistics,and%20between%20Sweden%20and%20abroad
[6] https://www.census.gov/programs-surveys/cfs.html

intermediate distribution centres within the supply chain that connects the initial producer of the goods through to their final consumer.



Logistic leg	Typical vehicle types
1	Car, LGV
2	Car, LGV, bike, robot
3, 4, 5	Artic, Medium rigid
6	LGV, Small rigid
7,8	Small, Medium rigid
9, 10, 11	Artic, rail
12	Artic, Medium, Large rigid

DC type	Dwell times
NDC - A	Weeks
RDC - B	Days
LDC, FfC	Hours

FIGURE 1 SUPPLY CHAINS AND LOGISTIC LEGS FOR CONSUMER GOODS

13.1.3 An example of some of the supply chain structures that are used to ship goods to households is illustrated in Figure 1. This chart illustrates

- Some of the different *supply chain* options that may be in use
- the intermediate *distribution centres* (warehouses) at which goods are stored
- the individual *logistic legs* travelled between each intermediate storage stage within a supply chain.

13.1.4 In general, when consumer goods leave the producer's depot they are likely to travel to a large central National Distribution Centre (NDC - A), being shipped as a large consignment within a large artic. Typically many of the items within this consignment may be stored at the NDC for some weeks before they have gradually all been shipped out to different regional locations, again mainly within large artics. The goods in a consignment will spend a few days at a Regional Distribution Centre (RDC -B) before gradually being shipped within an artic or a medium rigid HGV as smaller consignments to either a large supermarket or retail outlet or else to a Local Distribution Centre (LDC), a Local Fulfilment Centre (LFfC) or a local parcel delivery hub. From the LDC, goods may be delivered to or collected by smaller local retailers or caterers within LGVs or small rigids. Alternatively, items may be delivered from a local parcel delivery hub directly to households or firms as parcel deliveries using vans or cargo bikes doing a local round. In recent years via online ordering procedures, groceries in large supermarkets are increasingly being delivered from local fulfilment centres or from grocery shops in LGVs or even using autonomous delivery robots[7] direct to consumers, rather than being collected by retail customers in their own cars.

13.1.5 The aim underpinning the evolving design of the supply chain structures within firms is to minimise the overall cost of their goods distribution system (the combined costs of transport, warehousing, capital, etc.), while meeting the consumption needs of their customers. The most cost-effective way of avoiding temporary stock-outs is through carrying substantial stock levels in a central NDC from where items can then be distributed when and where they are needed, while minimising the requirement to carry large stocks at a regional and especially at a local level. This is why goods will typically be stored: for weeks in NDCs; for a few days in RDCs; and often for just a few hours in local parcel delivery hubs. The average consignment size required at the delivery end of a logistic leg typically decreases when progressing through the individual stages of the supply chain from the producer through to the consumer. This is why the typical vehicle size used gradually decreases through the sequence of logistic legs from the producer to the consumer.

13.1.6 A key feature of distribution centre activity that should be recognised within the formulation of a freight demand model is that the annual tonnage of goods leaving any distribution centre should be similar to that entering that distribution centre.

[7] Starship robot delivery vehicles are currently in use for local deliveries from corner shops to households in Milton Keynes (since 2018), Manchester, Cambridge, Leeds and other cities. https://www.starship.xyz/company/