ART3 Task 2 Preliminary Studies

Scope

These are initial tasks, involving analyses of the survey data, designed to confirm the early modelling decisions and to clear uncertainties concerning other aspects of the overall model or its structure.

Table 1 Index to Preliminary Studies

Study Task	
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Task 2.1 Trip Purposes and Escorts/HOVs and Car Availability

Purpose

The objective is to confirm on the basis of the sample the classification of trips by purpose, including escorts and the car ownership/availability segment definitions and to investigate the contribution of subsidised motoring with a view to representation as a separate segment[1]. Because of the interactions, this task, the choice of time periods and the treatment of tours will be done concurrently.

Inputs

Household Survey (unexpanded)

Processing

Trip Purposes

Household survey tabulations/graphs:

- % of trips by each proposed purpose: check for very large or very small categories
- average trip length and trip length distribution (using crow fly distance) by purpose: check for systematic distribution differences (for HBW/EB, also check variations by socio-economic group)
- % of trips by mode for each purpose: check for systematic mode share differences (for HBW/EB, also check variations by socio-economic group)
- number of sample trips by purpose x mode: check adequacy for calibration
- compute zonal trip productions and attractions by purpose: check correlations between individual purposes (for HBW/EB, also check variations by socio-economic group).
- the distributions of full time and part time worker HBW trips by mode and trip length.

Escorts/HOVs/Car Passengers

Escort/car pooling issues seem to be of most interest for work and education trips[2]. Mode choice models either treat car passenger as a separate mode or factor out such trips on assumed car occupancies. Neither approach appears to replicate the likely choice behaviour, but research into this area suggests very substantial model complications to represent the real behaviour[3].

The purpose of this sub-task is to carry out some analyses of the household survey as an aid to considering the most appropriate escort/HOV/car passenger model structures. Recognising that little is achieved in this area in other models, this task may well not lead to any change.

Household survey data manipulation/processing:

- preliminary manual review of the data to establish the main classes of escort/car passenger trip; for the purposes of this report, it is assumed that these might be:
  - for work and education, either:
    - a pure escort trip in which the driver does no other activities (i.e. a simple out-and-back tour),

[1] Essentially a question of sample size, to eliminate trivial segments.

[2] For other personal and business trips it would be our view that car occupancy factors would be sufficient to represent household car sharing and car sharing on business.

[3] We will nonetheless check that there is no international evidence of applicable methods of a simpler nature.

        - for commuting, a common purpose and/or destination for the car occupants;
        - the escort trip is part of a larger tour involving in which the escort carries on for their own purposes (e.g. a drop-off at school en route to work, shopping, recreation etc);
    - other purposes:
        - joint family activities pursued by driver and passengers,
        - escorting children or other family members to social/recreational activities;
- identify the frequency of escorts by each class for each purpose sub-code; analyse by mode (it would be expected that these are mainly car driver/passenger trips); Table 2 shows the frequencies in Wellington, with the main purposes being education and other, the latter presumed to be children being taken to social and recreational events.

Table 2 WTSM Escort Trip Distributions

Purpose	Proportion of Escort Trips for Each Purpose	Distribution of Escort Trips by Purpose
HBW	7%	5%
HBEd	26%	11%
HBSh	3%	3%
HBSo	6%	2%
HBO	32%	33%
NHBO	28%	45%
HBEB	3%	0%
NHBEB	4%	1%
Total	-	100%

Finally, short reviews of the latest research/modelling approaches for HOVs will be undertaken.

Car Availability

We need to decide on whether to distinguish 3+ car-owning households and we need to check our planned car availability segmentation (based on car ownership, licensed drivers and cost subsidies).

Household survey tabulations/graphs:

- initially, we need to establish a definition for company-assisted motoring and its importance for each trip purpose:
    - analyse the distribution of vehicles by the 3 types of subsidy: ownership, running and workplace parking costs and devise a vehicle classification;
    - then add to the trip file an identifier for subsidised vehicles;
- for each purpose, the trips and mode shares (car driver + passenger, public transport, active modes) cross-classified by household car ownership (0,1 ,2 3+) and number of adults in household (1,2,3+);
- repeat the above replacing number of adults by number of persons with a full driving licence;
- for each purpose, the trips and mode shares (car driver + passenger, public transport, active modes) by the adult-based car availability categories in Table 3 below;

- repeat the above tables grouping by the car availability surrogates below.

Table 3 Car Availability Groups

Car Availability	Definition
Captive	residents of non car owning households
Competition	residents of households where no. of cars < no. of adults/licences; no subsidised cars
Competition/Subsidised Motoring	As above, at least 1 subsidised car
Choice	residents of households where no. of cars in household ≥ no. of adults/licences; no subsidised cars
Choice/ Subsidised Motoring	As above, at least 1 subsidised car

In other studies, we have found that car ownership subsidies increase multi-car ownership, for a given income level.. This should also be tested. Household survey tabulations/graphs:

- group household incomes[4] into bands; for households with subsidised vehicles and all other households, tabulate average cars/household in each income band.

Consider the implications of these statistics and develop model specifications in regard to car availability.

Outputs

Note giving recommendations on the treatment of these issues in ART3.

[4] This will be established in the HTS data processing.

Task 2.2 Park and Ride

Purpose

Decisions of how and where park-and-ride is handled will need to be considered in relation to the interface with and role of the APT model networks. The purpose of this task is simply to obtain statistics on park-and-ride activity in Auckland to support these decisions.

Inputs

Household travel survey

Public transport survey

Classification of stations from ARC/ARTA based on their parking facilities (and price, if appropriate)

Rail station and ferry terminal geo-codes and zone codes (ARC/ARTA).

Processing

HTS:

- Tabulate for each public transport mode the distribution of access (home end of trip) and egress (attraction end of trip) modes by location (TLA).
- Tabulate the incidence of paid parking.

PTIS:

- Tabulate for each public transport mode the distribution of access (home end of trip) and egress (attraction end of trip) modes by location (rail station/ferry terminal – assumes we get boarding alighting stations/terminals in PTIS).[5]
- Tabulate access/egress mode shares by access/egress crow-fly distance (by TLA).
- Tabulate the incidence of paid parking.

Output

Note.

[5] We will also investigate whether it is possible to do comparable analysis for the Busway stations now open on the North Shore.

Task 2.3 Walking and Cycling

Purpose

The objective is to understand the distribution of walk and cycle trips in the data base.

Inputs

Household Survey

Processing

Tabulate:

- trips by mode by purpose
- trips by mode by trip length
- walk and cycle trip (separately) by purpose and trip length
- household bicycle ownership distribution

Investigate variations in walk and cycle trips by location, particularly for commercial and sub-regional centres

Outputs

Note on these tables.

Task 2.4 Time Periods and Time-of-Day Choice

Purpose

This task is to provide information to confirm the precise time of the modelled time periods.

Data Sources

Household Survey (expanded or unexpanded[6])

Traffic counts by time of day

Bus, rail and ferry counts by time of day (may just use our survey counts if there is nothing else conveniently available)

Research into time-of-day choice

Processing

Road and public transport count data:

- plot by 15min time periods for different parts of the networks (specifically: near CBD then moving away from CBD)
- identify the peaks at each location.
- Household survey graphs/tables (personal travel, ignore CVs):
- for defined trip purposes, tabulate/graph % of daily all-mode travel for each trip purpose (and all purposes together) by time of day in 15 minute time periods;
- repeat for car (driver + passenger) and public transport separately, with purposes aggregated to HBW, HBEd, EB and all other, plus all purposes combined ('super-purposes');
- identify how purpose composition varies by time of day; specifically relate the HBW, HBEd proportions to the peak periods identified in the counts.

Review latest time-of-day choice research and model specifications.

Propose a definition of the modelled time periods which relates to the count profiles, the different purpose compositions by time of day and the planned approach to modelling time-of-day choice:

- AM peak, interpeak, PM peak;
- consider whether a pre-PM school peak is identifiable.

Outputs

Note confirming model time periods and approach to modelling time-of-day choice; definition of trip times (start time, mid time etc) and compatibility across surveys.

[6] While expanded data tabulations are preferable, in most of this initial analyses unexpanded data are acceptable if this would enable an earlier start (the location stratifications of the household survey sample are not such as to be likely to affect the conclusions from these broad analyses.

Task 2.5 Parking

Purpose

The purpose is to understand the distribution and nature of parking activities: paid parking, workplace parking etc in order to confirm this aspect of the model structure.

Data Sources

HTS data

Parking supply data

Processing

HTS analyses[7] of parking demand:

- for each purpose and for each TLA (preferably also identifying separately the CBDs), tabulate the proportions in each category of:
  - parking place,
  - type of parking fee,
  - walking time,
  - parking duration
- these tables need to be developed further to group these parking activities by the main differentiating factors
- for those who incur a parking charge, the analysis then needs to draw in the vehicle subsidies to determine the proportion whose charge is paid by their employer – so this will probably mainly focus on HB work trips
- the above analyses needs to include analysis of commuting parking which occurs in a different zone from the final destination with the rest of the trip made by walking; this needs to establish the extent to which this is occurring in order to avoid paying parking charges (that is parking outside the CBD) as opposed to is paid parking in a different zone (that is within the CBD) and which segments and zones this applies to.

Analyse the data on parking supply and cost processed under Task 1.10.

On the evidence of these data develop the specification of the treatment of parking costs, supply and location in the model.

Outputs

Note reporting on the analysis.

[7] Notes: for home-based trips, only tabulate the parking characteristics at the destination end of the trip (the non-home end). For non-home based trips, tabulate the destination end of the trip.

Task 2.6 Tours

Purpose

An initial analysis of the characteristics of tours is required, covering frequency by type, times of day, purpose and mode, the particular concern being that for peak pricing tests the appropriate price is that for the tour.

Inputs

Household survey

Processing

Household survey data manipulation/processing:

- classify all trips into tours;
- tabulate distribution of tours by number of component legs; define the tour type as the number of legs;
- append an identifier to each trip for the tour type; append a tour purpose to each trip involved in a 3 or more leg tour (this would be the dominant purpose, probably based on a purpose hierarchy – possibly also related to dwell times at each tour destination);
- tabulate trips by purpose, mode and tour type;
- for tour types involving 3 or more legs, identify and group purpose and mode sequences; specifically analyse relationships between HB and NHB trips and consistency of modes within tours;
- for all tour types, identify the midpoint time of the first and last legs and cross-tabulate the to/from time distributions by tour purpose.

Outputs

Note.

Task 2.7 Commercial Vehicle Modelling

Purpose

This preliminary studies task is to assemble some basic statistics on CV travel from the surveys and to determine the proportions of EB LCVs.

Inputs

Household travel survey

CV Operators Survey

Classified automatic and manual counts from the traffic count survey on all screenlines and CV generator cordons

Results of External Cordon Survey (ECS)

Data on growth in LCVs and goods versus other traffic and economic indicators (GDP) [it is likely that there will be little or no data on LCVs available]

Processing

HTS: tabulate sample of vehicles by type.

CV operators survey: tabulate trip length distributions.

Counts: tabulate proportions of vehicles by type in the traffic streams, by road type and distinguishing generator cordons from other areas. For this two steps are proposed:

- Compare the intercept survey (ECS) results with corresponding manual counts to understand differences between vehicle type proportions, in particular light vehicles being split into cars and LCV (EB purpose); spatial and temporal differences should be investigated. Based on this analysis, devise an approach for adjusting the car-LCV (EB) split in the manual counts and apply.
- Analyse the adjusted manual counts to understand the spatial and temporal variation in the car-LCV (EB) split. Hence devise an approach for separating automatic (tube and loop) counts of light vehicles into car and LCV (EB), and then apply.

Specify the GDP growth elasticity applicable to EB LCV trips, if feasible by reference to historic data, but otherwise on the basis of judgement and international experience.

Outputs

Note, including any implications of the data.

Car-LCV (EB) proportions for application to particular count datasets

Additional growth factors for EB LCV in forecasting

Task 2.8 Sensitivity of Attraction Trip Rates to Location

Purpose

This task will simply document the data collected on this topic.

Inputs

Household travel survey

Counts

Existing data

Research

Processing

Define each commercial/sub-regional centre and tabulate HTS interview samples and traffic counts.

Repeat for each specific generator and also record key statistics from existing data sources.

Investigate growth centre-related research.

Outputs

Note including any implications of data.

Task 2.9 Education Modelling and School Buses

Purpose

The purpose of this task is to gain a good understanding of what is going on with education trips in order to consider alternative modelling approaches.

The conventional model structure appears to offer little for education trip modelling: trip distribution is very constrained by discrete school locations and involves comparatively short trips while children by definition cannot drive a car but may have wider car availability through parents and lifts. The treatment of school bus travel in the model needs also to be considered given that such services are not included in the networks.

Recognising that little is achieved in this area in other models, this task may well not lead to any change in model specification.

Inputs

Household survey

Public transport survey

School bus survey (to be confirmed – the ARC, with ARTA, are presently considering this)

Existing data sources

Processing

Household survey tabulations/graphs:

- % mode shares by age of school child and /or school grade
- trip length by age of school child and /or school grade
- mode use by distance from school
- the graphs and tables need to be redone aggregating grades to primary, secondary and tertiary.

Public transport survey tabulations/graphs:

- trips by purpose by corridor
- school/university trips by age of respondent by corridor
- school/university trips by age by distance (crow fly)

School bus survey tabulations/graphs:

- trips by corridor.

Outputs

Note specifying analysis and modelling methodology

Task 2.10 Foreign Students and Student Accommodation; Institutional Residents

Purpose

The objective is to understand the coverage of the HTS and other data sources.

Inputs

Household survey

Census

Other available sources of data

Processing

From the HTS, establish distribution of tertiary students living with own family and living in other household.

Review student statistics in other data sources and seek to reconcile with HTS.

Review distribution of institutional residents (i.e. not resident in households)

Outputs

Note on student and other population coverage in the data, and any modelling implications.

Task 2.11 Generalised Cost

Purpose

The generalised cost specification is set out in **Table 4**. The attribute weights will be defined in this task (i.e. they will not be calibrated).

Table 4 Generalised Cost

Mode	Attribute	Comment
Car and CV driver	Time[1] Direct operating cost Parking charges Tolls and pricing	Values of time and operating costs will be based on standard NZ values. Parking charges are halved (the charge being shared between the out and return trips). For some tolling and pricing schemes, the charges may need to be halved; e.g. inbound cordon
Car and CV passenger	Time	The sharing of costs between driver and passenger will depend on the structure of the model.
Public transport passenger	In-vehicle time Other time (access & egress time) Interchange Waiting time at boarding and interchange Fare	Values of time will be based on standard NZ values. PT access/egress time: usual weighting is 2, but slight concern in using a high weight where this time is measured inaccurately (on centroid connectors) ; however this would only be an issue when centroid connectors are changed Interchange penalty may be set to vary with type/quality of interchange if it can be identified, similar to the process in APT LTNZ/APT values for interchange and waiting time Waiting time wait will be 2.0

1. For road user charging/tolling applications an income segmentation will be required. So far as possible, this will be based on data available in NZ from central sources, and informed by international experience.

Task 2.12 Airport

Purpose

There are the following types of personal traffic accessing the airport:

- air passengers, non-residents,
- air passengers, residents,
- meeters and greeters,
- airport worker commuters,
- other business and sightseer trips.

The principal reason for giving the airport special treatment is that the first of these, the non-resident air passenger traffic, is not included in the household survey. Note that commercial vehicle model will deal with commercial (i.e. non-personal) trips to/from the airport.

Inputs

Household travel survey

Processing

A first task is simply to establish how much data is included in the HTS for the airport and verify these presumptions.

We can construct a supplementary model for travel demands from the airport if we have annual air passenger numbers and forecasts, current information on access mode shares (distinguishing car driver and passenger and taxi particularly) and preferably information on where air passengers live (i.e. residents or non-residents of Auckland region). We would also like the time profiles of passenger arrivals and departures (or alternatively flight arrival and departures so we can map time profiles onto the data. Model 'calibration' would be assisted by obtaining traffic counts (by time of day) on the airport approach roads and car parks.

So the second task is to find out what data are available – the ideal would be to be able to commission some simple tables from an air passenger survey.

Outputs

Modelling strategy

Task 2.13 The External Model

Purpose

This preliminary studies task is concerned with identifying any implications arising from the surveys and historic data for the treatment of trips external to the ART3 study area.

Inputs

Combined or individual survey data bases

Processing

- review trip end interface with ASP3
- obtain historic trend data on external cordon sites and tabulate trends
- pre-analyse the survey data base to identify:
  - the data samples available for estimation
  - the trip distribution and mode shares in key corridors
  - the distribution of trips external to the region

Outputs

Note, including any modelling implications, including a recommended approach to the distribution of trips external to the region.

Task 2.14 Road Pricing/Tolling

Purpose

The purpose is to finalise the model specification/design insofar as it relates to road pricing/tolling applications.

Discussion

With these policies arise a number of issues which are discussed in turn:

- peak pricing or differential pricing by time of day, which causes change in time-of-day choice,
- the sensitivity of travel demand to tolls and charges (VoT),
- segmenting the travelling population throughout the model for the differences in charges experienced (e.g. tolls vary by vehicle type) and the differences in response to charges (essentially variations in values of time); the interface with roading project models.

Time-of-Day Choice

A time-of-day choice module[8] will be included in the model, which will respond to differential pricing by time period (i.e. congestion charging) but there will be constraints on the performance of this model because:

- the strategic model will operate for aggregate time periods (detailed "micro" time-of-day choice models typically divide the peak period into many time slices),
- international research on time-of-day choice is still in its infancy,
- there is little/no NZ research on the topic.

Values of Time

The average value of time for car users obtained by Land Transport NZ (Transfund) in recent research seems appropriate for use with road user charges as, although it does not specifically relate to tolls, it was focussed on increased trip-specific out-of-pocket costs (for fuel and parking). The values of time for CVs and cars on employer's business are based on the marginal productivity of labour (MPL). It is not clear whether this is the appropriate value of time for routeing decisions and the effects of tolls on them. The values of time used in recent studies in NZ which have investigated road tolling will also need to be considered. Segments that need to be considered are:

- vehicle type: cars and medium/heavy CVs,
- private car trip purpose: EB and other (perhaps distinguishing commuting);
- for personal trips, an income segmentation.

Travel Demand Responses

Responses to tolls/pricing include:

- for projects/individual road tolls, the major response will be re-routeing; there is therefore a need to consider how re-routeing should best be included in ART3, particularly the role of multi-user assignment enabling, for example, different routeings to be attributed to CVs and Employers Business cars;

[8] In this report the term time-of-day choice is used in place of peak-spreading and trip re-timing.

- for congestion charging policies, change in choice of time of travel is likely to be the first response, and this will be represented in ART3;
- more broadly, charging may impact on car demand (distribution and mode shares), also represented in ART3;
- the ART3 model will not be able to model the sensitivity of MCV/HCV demands, other than re-routeing (it is far from clear what this sensitivity might be).

Project Model Interface

We also need to consider how to facilitate the ART3 interface with tolling project models. The key issue is the segmentation of the trip matrices likely to be required for the project models in multi-user assignment procedures.

The model will explicitly segment the matrices: car trips by purpose by time period and there would be a combined medium and heavy CV matrix. It is also likely that a project model would seek to allow for the income distributions of car users in a multi-user assignment procedures, for which data from ART3 would be needed.

The Workshop on the Technical Specification

At the workshop on the draft technical specification, the above issues were debated and we were encouraged to incorporate an income segmentation and multi-user assignment in the strategic model. We were also asked to consider whether the distribution and mode choice models might take generalised cost inputs segmented in some way by time period (instead of a 24 hour average cost). There are a number of technical options.

The first, and potentially the most straightforward, would be to include an income segmentation of travel demand after the demand models but prior to assignment, enabling multi-user highway assignments to be segmented by income group in addition to vehicle type and business/leisure classes.

The second option was to include an income segmentation throughout the model system, encompassing the demand model. There would be very significant issues relating to such an approach in terms of:

- the complexity and increased risks of model estimation, the adequacy of the survey samples and the resources required;
- the probable need to drop or reduce the proposed car availability segmentation;
- not all the relevant surveys can provide the required income data;
- how best to develop the segmentation consistent through the model, affecting also car ownership and trip ends.

A third refinement was to include an income segmentation in the public transport assignment. This was argued to be beneficial for spreading passengers across the available routes/models, leading to a better reproduction of route loadings, but is of course unrelated to road pricing/tolling issues.

In all of these options there is the issue of defining the income segmentation in the base year and forecasting it for future scenarios.

The fourth refinement related to the average 24 hour generalised costs which are input to the distribution and mode choice models (DMS). In other, otherwise much simpler models we have used tour generalised costs which are segmented by classifications of the out and return times of travel. At its simplest this might be (i) out and return journeys in the peaks, (2) one of the tour legs in the peaks, (3) both out and return legs of the tour in the off/inter-peak. The advantage of such an approach with road pricing studies is that the different prices and degrees of congestion faced on a tour are distinguished. In practice more segments than the three mentioned above are usually required and similar complications to the income segmentation would need to be faced.

Past experience of ART is that a very small proportion of applications have involved road pricing. While this could change in future, there is little doubt that the income segmentation, multi-user assignment and tour time of day segmentation refinements will substantially increase model run times and the complexity of analysing and model outputs. A fifth option would consequently be to provide refinements along the lines described above which could be switched on or off according to the nature of the application.

Processing

This task involves studying the aforementioned workshop options carefully and reaching conclusions as to what could be done, in the context of the capabilities and coverage of the data, the costs and risks in developing the approach and the model application implications.

Output

A specification of the preferred methodology.

Task 2.15 Review of Household and Person Segments

Purpose

The purpose is to confirm the household/person segmentations used in the car ownership and trip end models

Data Sources

HTS data

Processing

Using the HTS, tabulate households/persons by household/person segments to gain an understanding of sample sizes of each.

From this decisions on the need for aggregating segments for the car ownership and trip end models can be made.

Outputs

Note on final household segments for car ownership and trip ends.

Task 2.16 Model Specification Conclusions

The implications of the preliminary analyses for model estimation and the model specification will be brought together in a report with the headings given in **Table 5**.

Table 5 Preliminary Studies – Modelling Implications

Topic	Description
Model segments	Trip purposes, escort trips, car availability including car subsidies and the approach to HOV modelling, and income
Park and Ride	Representation of park-and-ride and the APT model interface
Active Modes	Representation of walking and cycling
Time periods and time-of-day choice	Modelled time periods, the modelling of time-of-day choice
Parking	Representation of parking
Tours	Tours and the relationship between NHB and HB trips
Commercial Vehicles	Any modelling implications
Sensitivity of Trip Rates to Location	Any modelling implications
Education Modelling & School Buses	Modelling approach
Foreign Students and Student Accommodation; Institutional Residents	Any modelling implications
Generalised cost	Specification
Airport	Modelling strategy
The External Model	Any modelling implications
Road pricing/tolling	Model specification

Task 2.17 Inputs to Model Calibration

This paper notes the data that we will need prior to starting model calibration.

All sub-models:

- matrix sectorisations for diagnostic analyses, including CBD definitions;
- time period, purpose and segment (person type, household type, vehicle type, car availability) definitions.

Trip production model:

- household survey: processed, unexpanded.

Trip attraction model:

- combined survey data base: processed, expanded and bias corrected[9];
- planning data: zonal population and employment by category, land area and other zonal activity indicators (shopping centres by type, key recreational attractors etc).

Household car ownership model:

- household survey: processed, unexpanded;
- census vehicle ownership by zone[10] (for each of the 5 household types: no. of 0 car, 1 car, 2 car, 3+ car households and total cars);
- processed networks: if we are to examine accessibility;
- expanded household data for sample enumeration?

National car ownership trend model:

- update the data bases on which this was based
- specify required data

Distribution/Mode Choice:

- combined survey data base: processed, expanded and bias corrected[11];
- processed networks.

Time period factors

- household survey: processed, expanded and bias corrected.

Processed networks:

- completed networks;
- base road network calibration to get journey times; requiring validation counts and speeds;
- specification of generalised costs, including units (time or dollars, most likely the former), and in turn covering such issues as parking, fares etc.

This is summarised in **Table 6**, with obvious nomenclature.

[9] Note: we must consider whether to synthesize the internal NHB trips of non-residents.

[10] Data needs to be ordered from Stats NZ.

[11] Because of combination of sources with different sampling rates, the expanded data will be used as the basis of calibration, divided by the overall average sample weight for the combined data set.

Table 6 Data Requirements

Data Source	Sub-Model				
	P	A	CO	DMS	TPF
Household survey, unexpanded	X		X	X	
Household survey expanded		X	X?	X	X
Combined survey data base		X		X	
Planning data		X			
Processed networks			X?	X	
Census data			X		

Following the above, the need for further data processing is to be reviewed, after which the extraction of data files for calibration, Task 1.12, can be completed.