Department of Agriculture, Food and the Marine
An Roinn Talmhaíochta, Bia agus Mara

CoFoRD

Final Report

'Developing a GIS based Agreed Routes Map for Sustainable Timber Transport in Ireland and Mobile App "RouteTagger" (MARTT)

DAFM Project Reference No: **13 C 487**

Start date: **02/01/2014**

End Date: 31/12/2016

Principal Coordinator and Institution: **Dr Ger Devlin (formerly UCD)**
Email: **gerjdevlin@gmail.com**

Collaborating Research Institutions and Researchers: WIT / Michael Pedini and Gary O Brien
Please place *one* "x" below in the appropriate area on the research continuum where you feel this project fits

Basic/Fundamental ⟶ Applied/Pre Commercial

				X		

Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	**A – FTURE NETWORKS AND COMMUNICATIONS**

Key words: *(max 4) Transport Apps, Sustainable routing, Forestry and Biomass.*

1. **Rationale for Undertaking the Research**

This section should outline the rationale for carrying out the research and identify the need / problem to be addressed

Ireland forest cover equates to 10% of total land mass, with plan projections of 17% by 2030 . 57% is state owned and operated by Coillte and 43% managed by the private owners. Ireland's forests are mainly comprised of 80% conifers and 20% broadleaves. In 2010, 2.88 million m^3 (Mm^3) of round wood was harvested; 2.7 million of this was utilized for processing, while 199,000 m^3 was used in the firewood sector. 2.217 Mm^3 came from Coillte forests and 0.463 Mm^3 came from private forests . In 2010, 34% of the total roundwood harvest in the Republic of Ireland was used for the production of biomass energy. The overall demand for roundwood in Ireland is expected to increase from 4.46 Mm^3 in 2011 to 6.038 Mm^3 in 2020 and 7.38 Mm^3 by 2028 which equates to an estimated net realisable volume of 85.06 Mm^3. The majority of this increase is to come from the private sector while Coillte forest estate will remain consistent with production around 3 Mm^3.
These forecasted increase in volumes will lead to increased volumes of timber haulage in order for the timber to be extracted for use to the end market, be it the sawmills, the panel board mills, direct export or the increasing wood energy sector which has a planned demand of 3.084 Mm^3 for 2020. Given 2010's harvested volumes of 2.88 Mm^3 equates to approximately 160 000 truck movements of logs only annually on Irish roads. By 2028, if the timber volume doubles then so too will the truck movements, up to approximately 320 000 loads per annum. This excludes the movement of trucks due to the sawmilling residue by-products such as sawdust, bark and chip which would represent perhaps another 50% of the log truck movement given the planned demand of 3.084 Mm^3 from the wood energy sector.

In general, road transportation is the main method for distributing unprocessed logs and chips from the forest to the processing plant, and this will remain as the most important mode of transport in Ireland (Devlin et al. 2008). In the woody biomass scenario, forest truck companies are paid based on the dry weight of the biomass, and it is recognised that secondary transport can be responsible for 20% to 40% of the supply chain costs. This highlights the challenge of placing enough material on trucks under legal and weight restrictions.

Local councils are concerned about this planned increase in timber traffic and what effect it will have on the condition of roads and the cost of repair and how it will also affect the safety of other road users such as at school drop off and pick up times where heavily laden timber trucks could pose a real safety issue and traffic problem within the local access roads that lead to the forest compartments being harvested. Therefore, developing an agreed routes map that could be followed by hauliers could alleviate this problem as routes could be varied at specific times of the day (like school opening and closing times) and forest compartment entry and exit points could be interchanged to avoid excessive truck movement and damage than usage over a smaller number of access routes.

2. Research Approach

Specify the research methodologies employed, emphasising novel techniques and also outline any modifications from the original approved project proposal

The MARTT project was tasked with developing a digital map that will route timber trucks from forest compartment to the destination mill (or biomass plant) in a safer, sustainable and more fuel efficient manner. There will be an increase in the timber traffic on public roads in accordance with the forecasted increase in timber supply. Therefore, a more sustainable, safer and cost effective approach in the form of a GIS based agreed routes map is needed to manage the transport of this increased woodflow. This map will be used by timber hauliers as part of the timber extraction planning process. The routes will be agreed between local authorities and district forest managers and private forest owners, identifying the strongest and safest routes so as to avoid increased congestion around small towns and villages, reduce excess wear and tear on vulnerable roads and avoid excessive weight across roads. The development of the road database and GIS map will develop a road cost matrix to determine whether timber access routes are either fail or based on 4 main criteria – agreed routes, consultation routes, severely restricted routes and excluded routes. In addition, this map will be used to identify important routes that need maintenance and upgrading work. A mobile app RouteTagger will also be developed to help build a database of road conditions, primarily for the lower class timber access routes for use by all state and private planned harvesting sites. There are 5 main WPs within this MARTT project. The first 4 were carried out the by MSc student (Gary O Brien) in WIT and WP5 primarily by the research fellow RF (Ger Devlin) based in UCD. The project is also being co-ordinated by the RF and direct supervision to the MSc also coupled with supervision from supervisor in WIT (Michael Pedini).

Task/ Workpackage 1 (PPR 1&2)	**Start Date: 11/01/2015**	**Completion Date:** 30/04/2015
Task Title:	Scoping Exercise of existing use of such agreed routes for timber transport - Local Council, NRA, DTTAS Consultations, UK TTF.	

Task/ Workpackage 2 (PPR1&2)	**Start Date: 01/05/2015**	**Completion Date:** 31/10/2015
Task Title:	**GIS data review of road vector data from UII, NRA and councils.**	

Task/ Workpackage 3 (PPR 1&2 and completed in PPR3)	**Start Date: 01/11/2015**	**Completion Date:** 30/04/2016
Task Title:	**Develop matrix of road classification conditions with ArcGIS**	

Task/ Workpackage 4 (PPR3)	**Start Date: 01/05/2016**	**Completion Date:** 31/12/2016

Task Title:	**Map of Agreed Routes for Timber Transport (MARTT)**

Task/ Workpackage 5 (PPR3)	**Start Date: 01/11/2015**	**Completion Date:** 31/12/2016
Task Title:		

3. Research Achievements/Results

Outline main results achieved

WP1 -

Milestone Number	M1
Milestone Title	Develop links with relevant stakeholders to kick-start the review process
Status	Completed

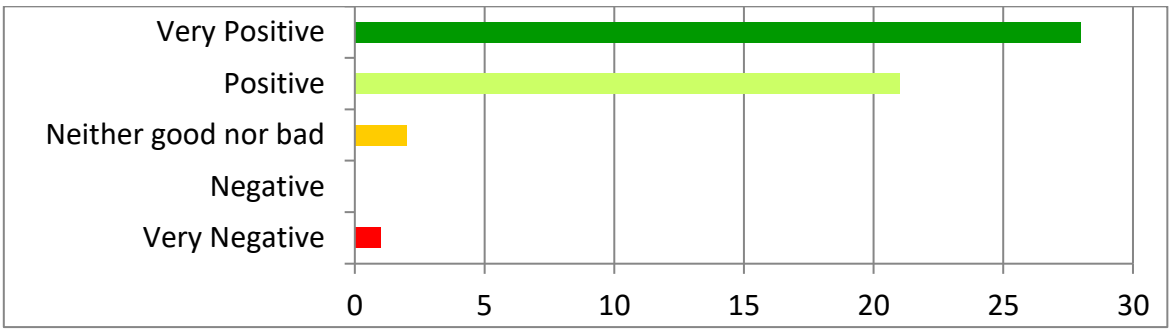
For WP1 there were meetings with relevant stakeholders on the outputs of this research programme and how it can be implemented into existing local council and government infrastructures. Stakeholder representatives include

- Trevor McHugh (IFSAM – private forest owners)
- John Lyons (Coillte and FITG)
- John McCarthy – (DTTAS)
- Shay O Connor (Leitrim CC)
- Barry Kehoe (Westmeath CC)
- Gerry McMorrow (McMorrow Haulage – Leitrim)

A survey was also developed and sent out to relevant stakeholders. It was important that some of these issues were formalised and then formulated into a survey that could be given to stakeholders to answer.

In this way data can be attained and analysed and results reached that will aid in the decision making process and ensure that the issues of stakeholders are addressed during the development of the GIS routing map. A link to the actual survey can be viewed here https://www.surveymonkey.com/r/3L9PJ5B

A summary of one of some of main questions on the survey includes – How would you rate the move to develop Agreed Routes for timber trucks in Ireland?



WP2 -

Milestone Number	M2
Milestone Title	Classifying the road types – starting with the aforementioned councils and the NRA on quality of GIS data.
Status	Completed

The main body of work consisted of reviewing GIS data to see what gaps exist relevant to the requirement of road metadata. The MSc student Gary O'Brien (based at WIT) was the main contributor to this task.

Previous work on agreed routes mapping have all been done with paper maps. The MARTT project attempted to incorporate digital data to make the process more mobile and more manageable with easier integration into existing systems such as the GPS tracking on timber trucks.

Other work around GIS data access and GIS software, plus meetings with the local government management agency (LGMA) and the work they have done on the pavement management system (http://www.maproadpms.ie/) regarding classifying the roads – Paul Fox is the contact here and they have systems in place to allow any development around Mobile Applications that will fit with existing infrastructure.

Peter Murphy in Coillte is their GIS person who is looking at both the internal forest roads network and urban network to see how it can connect with the in-cab satellite navigation systems for timber hauliers. This work has good synergies with the work on this project and the group has met him already for initial discussions.

We gained access to Coillte's harvesting plans in a GIS format which allows integration into our own GIS data. This data gives a breakdown of what forest compartments will be either clearfelled or thinned on a yearly basis to 2020. We have used this data to show realistic timber extraction scenarios for the Agreed Routes Map and how timber flow can be modelled.

WP3 -

Milestone Number	M3
Milestone Title	To develop a road scoring matrix to review GIS road data
Status	Completed

It was decided to pick a small area in Cork to focus the analysis as to use all of Cork would be too problematic at the start. A new shapefile was created and a square polygon was digitised which covered a 216 square kilometer area. This polygon was then used along with the Clip tool in the Extract toolbox in order to extract data from the Clearfell, Thinning, Bridges and PSCI and Road Width datasets that was contained within the polygon area. This created new feature classes for the clipped area for each of the datasets.

The clipped area was selected based on the fact that it contained Glennon Brothers sawmill near Fermoy. The sawmill shapefile was created by finding the coordinates of Glennon Brothers sawmill on Google Maps then inputting these coordinates into an Excel table. Using the 'Display

XY data' function in ArcMap a point shapefile was created from the Excel table with the position of the sawmill.

Table 1: Classification matrix showing the criteria that were used to classify routes in the model. (LP=Local Primary; LS=Local Secondary; LT=Local Tertiary; NP=National Primary; NS=National Secondary; R=Regional)

	Excluded	Restricted	Consultation	Unrestricted
Road class	-	-	LS, LT	NP, NS, R, LP
Road width	< 2.5m	2.5 - 4m	4 - 5m	≥ 5m
PSCI Rating	1 & 2	3 & 4	5 & 6	≥ 7
Bridge Overpass (Condition)	5	3 - 4	0 - 2	

In order to ascertain how the different parameters affect the results of the model it is necessary to isolate different parameters and run them separately to the overall model. The criteria that are described above were for Scenario 1 (SC1) (Table 3.5). In total three different scenarios were used during analysis with different parameters included or excluded depending on the scenario (Table 14).

- Scenario 1 (SC1) includes all parameters as seen in Table 1.
- Scenario 2 (SC2) excluded road width from the analysis (Table 2).
- Scenario 3 (SC3) excluded PSCI Rating from the analysis (Table 2).

The model was run for each scenario and the attribute tables of each shapefile converted into excel format in order to analyse the data. The lengths for each route type for each scenario were summed up in order to quantitatively compare scenarios.

Table 2: The parameters that were used for each scenario.

	Scenario 1	Scenario 2	Scenario 3
Road Class	✓	✓	✓
Road Width	✓	X	✓
PSCI Rating	✓	✓	X
Bridge Overpass	✓	✓	✓

WP4 -

Milestone Number	M4
Milestone Title	Develop GIS interactive map with colour coded routes to show agreed routes versus non agreed routes.
Status	Completed

The results show that for SC1, 27.5% (102.13km) of the roads in the selected area were assigned as Unrestricted, 22.4% (83.35km) as Consultation, 46.3% (171.95km) as Restricted and 3.7% (13.84km) as Excluded (Table 3 and Fig. 4). Restricted roads make up approximately 46% of the overall route types for the selected area in SC1. It may not be practically feasible to have this amount of road restricted without having an effect on the overall mobility of timber in the country.

For SC2 where road width has been removed as a parameter from the model, 67.8% (251.59km) of the roads were assigned as Unrestricted, 20.9% (77.5km) assigned as Consultation, 7.6% (28.33km) assigned as Restricted and 3.7% (13.84km) assigned as Excluded (Table 3 and Fig. 4). When we compare the results of SC2 with those from SC1, we can see significant differences in the amount of road assigned to each route type. The total length of unrestricted road increased substantially from 102.13 km in SC1 to 251.59 km in SC2, an increase of approximately 146%. The length of consultation roads decreased slightly from 83.35 km to 77.5 km, a decrease of approximately 7%. The length of restricted roads decreased substantially from 171.95 km to 28.33 km, a decrease of 83.5%. The length of excluded road remained the same at 13.84km. From these results it is possible to say that as the parameters are set currently, width has a substantial effect with regard to assigning a unrestricted or restricted to a segment of road. However, width has only a minor effect for consultation roads while it plays no part in assigning an excluded status to a road.

For SC3 where PSCI rating was removed as a parameter from the model, 29.8% (110.63km) of the roads were assigned as Unrestricted, 21.9% (81.44km) assigned as Consultation, 48.3% (179.19km) assigned as Restricted and none of the roads were assigned as Excluded (Table 15 and Fig. 36). When comparing the results of SC3 with that of SC1, the effect of removing PSCI ratings from the model only had a minor effect on total length of all route types except for excluded roads. The total length of unrestricted roads increased by 8.3% from 102.31km in SC1 to 110.63km in SC3. The total length of consultation roads decreased by 2.3% from 83.35km to 81.44km. The total length of restricted roads increased by 4.2% from 171.95km to. For SC3 there were no excluded roads at all. This tells us that while PSCI rating has only minor role in determining the total length of unrestricted, consultation and restricted roads, PSCI rating is the sole determining factor in assigning a length of road an excluded status. Therefore, as the parameter that was set for width assigned a road as excluded if the width was less than 2.5m, it's clear that there are no roads less than 2.5m wide for the selected area. When the attribute data was examined the smallest width of any road in the area was 3m wide.

Table 3: Length (km) of route types assigned to roads for Scenarios 1, 2 and 3. (Highlighted box indicates the route type with most amount of road classified for each scenario.)

	Scenario 1	Scenario 2	Scenario 3
Unrestricted	102.13	251.59	110.63
Consultation	83.35	77.50	81.44
Restricted	171.95	28.33	179.19
Excluded	13.84	13.84	

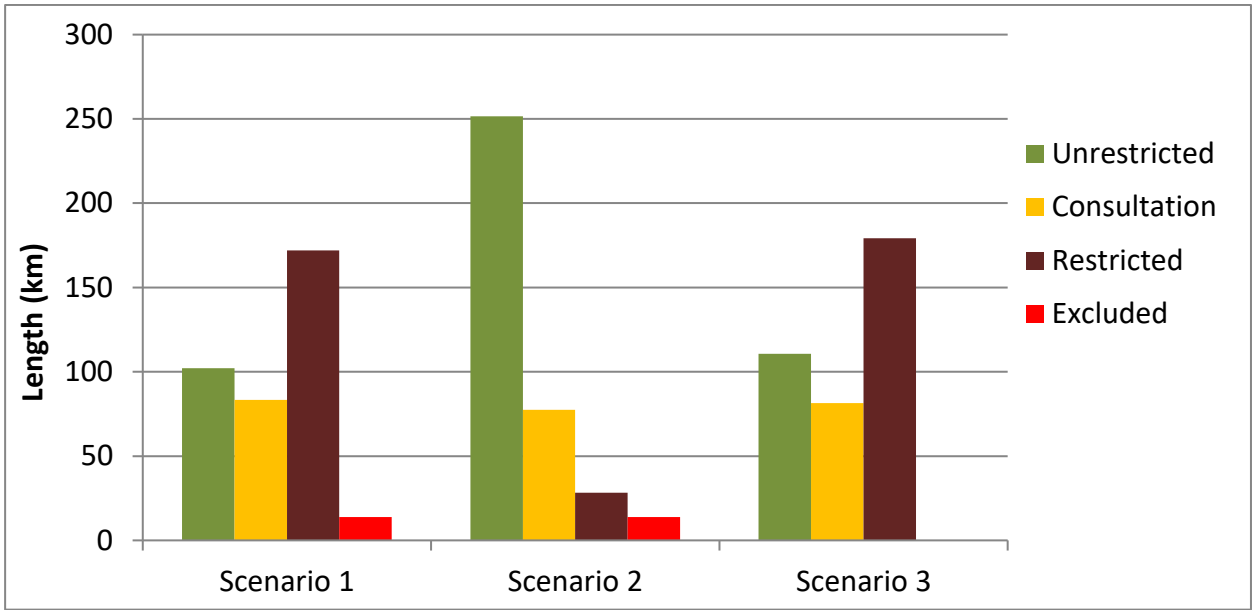


Figure 4: Length of route types assigned to roads for Scenarios 1, 2 and 3.

WP5 -

Milestone Number	M5
Milestone Title	Mobile App Development – Route Tagger
Status	Completed

In Ireland, truck transport by road dominates and will remain as the main transportation mode of timber and biomass. Cost efficiency and flexibility of forest transport can be typically improved by optimizing routes as well as incorporating an agreed routes strategy for truck movements. Given the planned doubling of mobilized timber in Ireland to some 6.96 Mm3 by 2028 this will also lead to a doubling of truck movements to approximately 200,000 truck movements per annum. This research has expanded the concept of developing agreed routes for timber and biomass transport from traditional paper map exercises to a GIS based model called MARTT. The model incorporates digital map data where a matrix of scenarios that include road class, road width, road bridges and a road condition index known as PSCI (pavement service condition index) are used to determine how routes can be categorised into Excluded, Restricted, Consultation or Unrestricted. The GIS model is then expanded and developed into a mobile app – Route Tagger that will allow truck operators the ability to plan and adhere to the agreed routes in a more mobile manner to adhere to the new agreed routes strategy that will lead to increased sustainable mobilization of timber and biomass for both traditional sawmilling and bioenergy markets.

The transportation app was built with ArcGIS Online - ESRI's new cloud based mapping system which defines their products as "mapping without limits" Perhaps one of the best features of the software is its functionality to build a multiplatform or single platform to run on any device including iOS, Android, Windows, OS X and Linux. The Appstudio for ArcGIS allows maps created within ArcGIS be converted into mobile apps which can effectively be published. From there the Web AppBuilder allows the app to incorporate more functionality in the form of widgets. Figure 5 shows a screenshot of the App interface where the widgets are displayed on the bottom of the screen and include route guidance, layer zoom, agreed routes etc. These widgets can be used by the truck driver in a mobile manner to determine which route should be driven in accordance with the agreed routes strategy. Using the GPS function on the smart phone, the App will direct the driver on their route once a start and destination has been inserted – similar to google maps except the agreed routes map has been built also for consideration when calculating routes. The future plan for this app is to look and integrate it into the forest and biomass sector and monitor the implementation and progress in line with potential on-going development.

Figure 6 – Screenshot of mobile app RouteTagger.

4. Impact of the Research

A summary of the impact of the research should be provided through the project outputs and outcomes however please provide a synopsis of the benefits / improvements the research has made to the area under investigation. Outline the benefits of the research to end users, e.g. industry, consumers, regulatory authorities, and scientific community etc

Transporting woody raw materials from the forest stand to the customer is the largest part of production costs for many suppliers around the world. The problem of timber transport is not discussed so often and it differs dramatically from general road transport. Payloads can be considerably affected through differing log species and the associated variation in moisture content of these logs. Loading and unloading times can also affect efficiency together with the in-forest driving which can increase fuel consumption versus general haulage by as much as 50%. Transportation costs generally vary with particular travel circumstances including hauling distance, truck configurations, road conditions, transported goods, loading and unloading, truck utilisation and national road regulations (weight restrictions and speed limits). Travel distance is the dominant variable determining transportation costs and reported to have a direct correlation with fuel consumption of the truck. The longer the distance, the higher the fuel consumption and subsequently the higher the carbon emissions.

The development of this GIS map of agreed routes (MARTT) in conjunction with the transportation mobile app RouteTagger will allow the integration of new technology to enable people on the ground of the forest and biomass sector in Ireland the ability to control and

manage more effectively and reduce the environmental impact of the transport and biomass operations within the supply chain to improve the sustainability overall.

- **How they may be relevant to End Users (Industry, Policy, Farming, Practitioners)**

The use of such an app – RouteTagger has high commercial exploitation opportunities available to it. Given the planned increased demand in wood mobilisation, extracting wood and biomass in a sustainable manner is extremely important to maximise the offset of CO2 emissions from the forest and biomass sector. However, taking it to the next commercialisation stage requires more funding for it to happen.

- **How it has added to the research base (skills, leveraging of funding, infrastructure capabilities etc.)**

Developing spatial type mobile applications is a highly desired skillset that has been achieved here and will / could play a critical part in the future / final development of the app going forward. There has been no leverage funding.

4(a) Summary of Research Outcomes

(i) Collaborative and Industry links developed during this research

Links have been developed with -

- Department of Transport, Tourism and Sport (DTTAS)
- Forest Industry Transport Group (FITG)
- Irish Forestry and Forests Products Association (IFFPA)
- Local Government Management Agency (LGMA)
- Veon Ltd
- Coillte
- Leitrim and Cork County Councils.

(ii) Outcomes where new products, technologies and processes were developed and/or adopted

N/A

(iii) Outcomes with economic potential

N/A

(iv) Outcomes with national/ policy/social/environmental potential

The use of a fully developed GIS map would play a critical part in the sustainable movement of timber for traditional sawmilling markets but also for biomass / bioenergy markets. Given all contracted timber hauliers for Coillte are GPS tracked and monitored in a central dispatch, the ability to integrate agreed routes mapping for timber movement could be quite seamless.

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.

Devlin, G., O Brien, G., Pedini, M. and Nieuwenhuis, M. (2016). Development of a Transportation App "RouteTagger" to Demonstrate the Sustainable Mobilization of Biomass for Bioenergy Markets in Ireland through GIS Agreed Route Mapping (MARTT). In Review. Energies - Special Issue - Woody Biomass for Bioenergy Production.

(ii) Popular non-scientific publications and abstracts including those presented at conferences

N/A

(iii) National Report

Michael Joyce (Edited by Ger Devlin). 2015. Managing Timber Transport - Good Practice Guide. National report Launched by the then Minister of State at the Department of Agriculture, Food

and the Marine Tom Hayes TD and Minister of State at the Department of Transport, Tourism and Sport (DTTAS) Alan Kelly TD.

(iv) Workshops/seminars at which results were presented

MARTT - Developing a GIS based agreed routes map for sustainable timber transport in Ireland.
14th IrBea National Bioenergy Conference 2015 - Poster Presentation.

(v) Intellectual Property applications/licences/patents

N/A

(vi) Other

N/A

5. Scientists trained by Project

Total Number of PhD theses: 0____

Please include authors, institutions and titles of theses and submission dates. If not submitted please give the anticipated submission date

Total Number of Masters theses: 1____

Please include authors, institutions and titles of theses and submission dates. If not submitted please give the anticipated submission date
Gary O Brien. 2016. Map of Agreed Routes for Timber Transport.
This thesis is submitted to Waterford Institute of Technology in fulfillment of the requirements for the Masters of Science (MSc). December 2016.
Head of School: Orla O'Donovan
Principal Supervisors: Dr. Ger Devlin and Michael Pedini
External Examiner: Professor Shane Ward

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (person years)
UCD	1	.02
WIT	1	.02
Total	**2**	**.04**

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates/Contract Researchers	1	1
PhD students		
Masters students	1	1
Temporary researchers		
Other		
Total	**2**	**2**

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
N/A	

9. Project Expenditure

Total expenditure of the project: € 155,053.91

Total Award by DAFM: € 155,054.31

Other sources of funding including benefit in kind and/or cash contribution(specify): € 0

Breakdown of Total Expenditure

Category	Name UCD	Name WIT	Total
Contract staff	78,554.44		78,554.44
Temporary staff			
Post doctorates			
Post graduates		42,577.03	42,577.03
Consumables	20	475.36	495.36
Travel and subsistence	871.57	1,097.82	1,969.39
Sub total	79,446.01	44,150.21	123,596.22
Durable equipment		558.63	558.63
Other			-
Overheads	19,861.50	11,037.55	30,899.05
Total	**99,307.51**	**55,746.40**	**155,053.91**

10. Leveraging

Summarise any additional resources'/funding leveraged by this award from other sources i.e. Additional Staff, National/EU funding secured, EI Commercialisation Fund

N/A

11. Future Strategies

Outline development plans for the results of the research.

The biggest issue with developing a road class matrix using digital road data in a GIS is the availability of quality digital data. While the matrix works in principal and methodology, its use is hindered by the lack of viable data where the matrix can be applied. Lack of data in this instance includes underlying metadata (data about data). This includes the 4 main criteria that were used to define the matrix such as PSCI data, width, road class and bridge data.

This creates a knock on effect when developing the GIS map – the map is only as effective as the model used to create the agreed routes. While the sample areas chosen reflected the greatest level of digital data available to develop any model and carry out any analysis, applying it nationwide is currently limited. Until such time as this data becomes more readily available then the best solution might be to re-model the matrix classification tool to consider only data that has National coverage. The most likely dataset to offer this is the PSCI data as its being increased on a yearly basis by local councils as its used as a basis by the Department of Transport, Tourism and Sport (DTTAS) as a means of determining road budget expenditure.

Ultimately a "commercialisation stage" is needed to bring it to the next level and something like this might involve linking in with mapping company's like Google Maps to see if their interactive mapping and underlying road data could play a part in completing MARTT.