

CONGRESOS Y CURSOS

Editores Científicos:

HERNÁN GONZALO ORDEN

MARTA ROJO ARCE



R-EVOLUCIONANDO EL TRANSPORTE

Burgos
CIT 2021
R-Evolucionando el Transporte



Con la colaboración de:



UNIVERSIDAD
DE BURGOS



Foro de Ingeniería del Transporte

Editores Científicos:

HERNÁN GONZALO ORDEN

MARTA ROJO ARCE

R-EVOLUCIONANDO EL TRANSPORTE



**UNIVERSIDAD
DE BURGOS**

2021

(CONGRESOS Y CURSOS, 76)

XIV CONGRESO DE INGENIERÍA DEL TRANSPORTE CIT 2021

ESCUELA POLITÉCNICA SUPERIOR.
UNIVERSIDAD DE BURGOS, 6, 7 Y 8 JULIO 2021



Foro de Ingeniería del Transporte

Cualquier forma de reproducción, distribución, comunicación pública o transformación de esta obra solo puede ser realizada con la autorización de sus titulares, salvo excepción prevista por la ley. Diríjase a CEDRO (Centro Español de Derechos Reprográficos, www.cedro.org) si necesita fotocopiar o escanear algún fragmento de esta obra.

© LOS AUTORES

© UNIVERSIDAD DE BURGOS

Edita: Servicio de Publicaciones e Imagen Institucional
UNIVERSIDAD DE BURGOS
Edificio de Administración y Servicios
C/ Don Juan de Austria, 1
09001 BURGOS - ESPAÑA

ISBN: 978-84-18465-12-3 (e-book)

DOI: <https://doi.org/10.36443/9788418465123>

ÍNDICE / INDEX

PRESENTACIÓN / PRESENTATION	23 / 24
COMITÉ ORGANIZADOR / ORGANIZER COMMITTEE	25
COMITÉ CIENTÍFICO / SCIENTIFIC COMMITTEE	25
ÁREAS TEMÁTICAS / CONFERENCE TOPICS	26
AEROPUERTOS / AIRPORTS	27
A DATA-DRIVEN APPROACH FOR DYNAMIC AND ADAPTIVE AIRCRAFT TRAJECTORY PREDICTION Rodríguez-Sanz, Álvaro; Cordero García, José Manuel; García Ovies-Carro, Icíar; Iglesias, Enrique.....	29
EVALUATING AIRPORT AND AIRLINE SERVICE QUALITY: A STRUCTURAL EQUATION MODELING APPROACH Muñoz, Claudia; Laniado, Henry.....	61
BICICLETAS Y PEATONES / BICYCLES AND PEDESTRIANS	69
AFECCIÓN DE LA PRESENCIA DE CICLISTAS EN CARRETERAS CONVENCIONALES ESTRECHAS. ADAPTACIÓN DE UN MODELO DE MICROSIMULACIÓN Moll Montaner, Sara; López Maldonado, Griselda; García García, Alfredo	71
ANÁLISIS DE LA DEMANDA Y DISEÑO DE ESTRATEGIAS DE PROMOCIÓN DEL USO DE LA BICICLETA EN SEVILLA García Sánchez, Alejandra; Romero Pérez, Luis Miguel.....	91
ANALYSIS OF REAL EXPERIENCES USING DIFFERENT SIZED BIKE SHARING SCHEMES IN IRISH CITIES Jiménez, Pilar; Nogal, María	107
METODOLOGÍA BASADA EN GIS PARA LA PLANIFICACIÓN DE UNA RED URBANA DE CARRILES BICI Plasencia-Lozano, Pedro; Pantiga-Facal, Estela; Méndez-Manjón, Irene	127
CONDITIONING FACTORS FOR BIKE SHARING SUCCESSFUL EVOLUTION. THE CASE OF BICIMAD Julio, Raky; Monzon Andrés	141
ESTUDIO DE LA PERCEPCIÓN DEL RIESGO DE CICLISTAS EN CARRETERAS CON REALIDAD VIRTUAL Pérez Zuriaga, Ana María; Camacho Torregrosa, Francisco Javier; García García, Alfredo; Marín-Morales, Javier; Guixeres, Jaime; Alcañiz, Mariano	155
A PREDICTION OF BIKE FLOW IN BIKE RENTING SYSTEMS WITH THE TENSOR MODEL AND DEEP LEARNING Seitbekova, Yerkezhan; Assilbekov, Bakytzhan; Kuljabekov, Alibek; Beisembetov, Iskander.....	175
MODELLING INDIVIDUAL PERCEPTION OF BARRIERS TO BIKE USE Caicedo Mafla, María Angélica; Mayorga, Miguel; Estrada Romeu, Miquel	185

PREDICTING THE WILLINGNESS TO CARRY LIGHTWEIGHT GOODS BY BIKE AND KICK-SCOOTER: A DESCRIPTIVE ANALYSIS Silveira Santos, Túlio; Vassallo, José Manuel; Moreira Torres, Ewerton Chaves	205
A STATED PREFERENCE SURVEY FOR EVALUATING PEDESTRIANS' EXPECTATIONS ON WALKWAYS Grazia Bellizzi, Maria; Forciniti Carmen	225
BIG DATA EN EL TRANSPORTE / BIG DATA ON TRANSPORT.....	239
A PYTHON PACKAGE FOR PERFORMING PENALIZED MAXIMUM LIKELIHOOD ESTIMATION OF CONDITIONAL LOGIT MODELS USING KERNEL LOGISTIC REGRESSION Martín-Baos, José Ángel; García-Ródenas, Ricardo; Rodríguez-Benitez, Luis	241
EVALUATION OF TRANSPORT EVENTS WITH THE USE OF BIG DATA,ARTIFICIAL INTELLIGENCE AND AUGMENTED REALITY TECHNIQUES Pérez Diez, Fernando; Cabrerizo Sinca, Julià; Roche Vallès, David; Campos Cacheda, José Magín	255
URBAN POPULATION DYNAMICS DURING THE COVID-19 PANDEMIC BASED ON MOBILE PHONE DATA Romanillos Arroyo, Gustavo; García Palomares, Juan Carlos; Moya-Gómez, Borja; Gutiérrez Puebla, Javier; Torres, Javier; López, Mario; Cantu Ros, Oliva G; Herranz, Ricardo	279
UNDERSTANDING THE USER CHARACTERISTICS FOR SUBSTITUTING TRIPS BY TELEWORKING AND ONLINE SHOPPING López Soler, Juan Ramón; Christidis, Panayotis; Vassallo Magro, José Manuel.....	295
ECONOMÍA DEL TRANSPORTE / ECONOMY OF TRANSPORT.....	309
EX-POST EVALUATION OF GOVERNMENT LOANS PROVIDED TO SHADOW TOLL MOTORWAYS IN SPAIN Garrido Maza, Laura; Vassallo, José Manuel.....	311
METODOLOGÍA DE PRIORIZACIÓN DE INVERSIONES EN LOS PROCESOS DE PLANIFICACIÓN DE TRANSPORTE Pino Hernández, Eva María; Durán Corchado, Esther; Barbero Ruiz, Cristina; Hernández Martín, María Ángeles	329
THE EMERGENT LONG TAIL BUSINESS MODEL IN THE AIRLINE INDUSTRY. THE CASE OF VOLOTEA Mateu Céspedes, José María; García Torregrosa, Alba María	347
TOLL HIGHWAYS IN FINANCIAL DISTRESS: THE WINDING ROAD TO TERMINATE THE CONTRACTS Baeza Muñoz, María de los Ángeles; Garrido Maza, Laura; Vassallo Magro, José Manuel; García Moral, Andrés	359
ANÁLISIS DE LA PREDISPOSICIÓN A COMPARTIR VEHÍCULO POR LOS ESTUDIANTES UNIVERSITARIOS González, Rosa Marina; Pérez Díaz, Irene; Nieto González, Imanol L	369

INICIATIVAS POLÍTICAS PÚBLICAS DEL TRANSPORTE DE CARGA URBANO SEGÚN EL SECTOR PARA LA CIUDAD DE BARRANQUILLA – COLOMBIA Meléndez Uribe, Ramiro; Suero Pérez, Diego Fernando; Correa Ordóñez, Fabian Jose; Polo Charris, Edna Margarita; Quintero Polo, Silvia Patricia.....	395
THE STRATEGIC VARIANCE ANALYSIS OF LAN AND TAM AIRLINES MERGER IN THE EARLY 2010'S Da Silva Alves, Luiz Augusto; Rocha, Carlos Henrique	405
¿LOS SOBREVIVIENTES MAXIMIZAN SU UTILIDAD LUEGO DE UN DESASTRE? Fernandez Pernet, Stephanie; Amaya, Johanna; Arellana, Julián; Cantillo, Victor	427
FERROCARRILES / RAILWAYS	451
LA RED DE VÍA MÉTRICA EN GALICIA Rodríguez Bugarín, Miguel; Novales Ordax, Margarita; Orro Arcay, Alfonso	453
TOWARDS THE NUMERICAL GROUND-BORNE VIBRATIONS PREDICTIVE MODELS AS A DESIGN TOOL FOR RAILWAY LINES: A STARTING POINT García Moreno, Andrés; Ruiz Aguilar, Juan Jesús; Moscoso López, José Antonio	477
USING DATA ANALYTICS & MACHINE LEARNING TO DESIGN BUSINESS INTERRUPTION INSURANCE PRODUCTS FOR RAIL FREIGHT OPERATORS Cardona, John F.; Castaneda, Juliana; Martins, Leandro do C.; Gandouz, Mariem; Juan, Angel A.; Franco, Guillermo	487
MONITORIZACIÓN Y ANÁLISIS DEL COMPORTAMIENTO DE APARATOS DE VÍA FRENTE A EVENTOS CLIMÁTICOS EXTREMOS Martínez Fernández, Pablo; Villalba Sanchís, Ignacio; Salvador Zuriaga, Pablo; Insa Franco, Ricardo; Viñas Olmo, Víctor Manuel; Pineda-Jaramillo, Juan.....	505
ENDURECIMIENTO CON EXPLOSIVOS DE CRUZAMIENTOS DE VÍA: PROCESO RIOMETAL DE MAXAM Carrillo de Albornoz Portes, Javier; Fernández de Miguel, Ignacio; Gudín Böller, Andrés.....	517
NUEVOS DESARROLLOS PARA METROS LIGEROS Raúl Parra Hermida, Martín Pacheco, Pablo; Oromí Frago, Pablo.....	529
ESTUDIO EXPERIMENTAL DE LA PISADA DE PASAJEROS AL MOMENTO DE BAJAR AL ANDÉN DESDE UN TREN URBANO Seriani, Sebastian; Erenchun, Cristobal; Palma, Felipe	543
METHODOLOGY FOR THE DEVELOPMENT OF RAILWAY OPERATING PLANS Quintero González, Sergio; Martín Cabo, Sergio	563
REFLEXIONES FRENTE A LA LIBERALIZACIÓN DEL TRANSPORTE DE VIAJEROS EN LAS LÍNEAS DE ALTA VELOCIDAD EN ESPAÑA. CORREDOR MADRID-LEVANTE Font Torres, Juan B.; Insa Franco, Ricardo	577
FORMACIÓN E INNOVACIÓN EN EL TRANSPORTE / TRAINING AND INNOVATION IN TRANSPORT	587
ANÁLISIS DE LAS ENSEÑANZAS EN VEHÍCULOS Y TRANSPORTES EN LAS TITULACIONES DE INGENIERÍA INDUSTRIAL Y AFINES Jiménez Alonso, Felipe.....	589

EL USO DE CLASSCRAFT PARA MEJORAR EL CONOCIMIENTO Y EL INTERÉS DE LOS ESTUDIANTES DE PRIMARIA EN LA MOVILIDAD SOSTENIBLE Sipone, Silvia; Abella García, Víctor; Rojo Arce, Marta	605
ENSEÑANZA DE LA MOVILIDAD SOSTENIBLE A TRAVÉS DE LA LITERATURA INFANTIL. UN PROYECTO DE APRENDIZAJE Y SERVICIO Miguel Borge, Marta; Aguilar López, Ana María	633
LA INGENIERÍA DEL TRANSPORTE EN LA UNIVERSIDAD ESPAÑOLA: ESTRUCTURACIÓN DE LAS ENSEÑANZAS Y DESCRIPCIÓN DE CONTENIDOS EN TITULACIONES VINCULADAS A LA INGENIERÍA CIVIL Díaz y Pérez de la Lastra, José María	645
INFRAESTRUCTURAS / INFRASTRUCTURES.....	673
BITUMINOUS BASE COURSES FOR FLEXIBLE PAVEMENTS WITH STEEL SLAGS Skaf Revenga, Marta; Bartolomé González, Javier; Gonzalo Orden, Hernán; Linares Unamunzaga, Alaitz; Ortega López, Vanesa; Manso Villalaín, Juan Manuel.....	675
MEJORA DEL DISEÑO DE GLORIETAS EN SERVICIO CON MEDIDAS DE BAJO COSTE Rubio Martín, Juan Luis; Jurado Piña, Rafael; Pardillo Mayora, José M ^a	685
PROYECTO EMULCELL: NUEVAS EMULSIONES BITUMINOSAS FABRICADAS CON NANOCELULOSAS. RESULTADOS PRELIMINARES Rodríguez Pasandín, Ana María; Pérez Pérez, Ignacio; Prego Martínez, Francisco Javier; Míguens Blanco, Alberto	699
REVISION OF THE SPANISH QUALITY CONTROL PROCEDURE FOR ROFILLS AND RANDOM FILLINGS Teijón-López-Zuazo, Evelio; Vega-Zamanillo, Ángel; Calzada-Pérez, Miguel Ángel.....	709
STUDY ON THE CONSERVATION OF BITUMINOUS MIXES IN HIGH MOUNTAIN ROADS AND COASTAL ZONES Vega-Zamanillo, Ángel; Juli-Gándara, Luis; Calzada-Pérez, Miguel Ángel; Teijón-López Zuazo, Evelio	719
TÉCNICAS DE APRENDIZAJE AUTOMÁTICO PARA LA PREDICCIÓN DE INTERVENCIONES DE MANTENIMIENTO EN INFRAESTRUCTURAS LINEALES DE CARRETERA Morales Sánchez, Francisco José; Reyes Gutiérrez, Antonio; Caceres Sánchez, Noelia; Romero Pérez, Luis Miguel; García Benítez, Francisco	731
LA INFRAESTRUCTURA DEL TRANSPORTE ROMANO COMO PATRIMONIO CULTURAL Romera Aguayo, Jesús María; Pérez-Acebo, Heriberto; Revilla-Cuesta, Víctor; Manso, Juan Manuel	749
COOL PAVEMENTS FOR CLIMATE CHANGE ADAPTATION Ávila Freire, Cristina; Simón Grau, José; López Ayerra, Julio	757
ANALYSIS OF ROCK MASS CLASSIFICATIONS FOR SAFER INFRASTRUCTURES Fernández Gutiérrez, Jesús David; Sánchez Rodríguez, Sergio; Pérez Acebo, Heriberto; Gonzalo Orden, Hernán.....	775

ITS, OPERACIÓN Y GESTIÓN / ITS, OPERATION AND MANAGEMENT 799**AN EMPIRICAL ANALYSIS OF UBER FARES: EVIDENCE FROM MADRID**

Rangel, Thais; Gonzalez, Juan Nicolas; Gomez, Juan; Romero, Fernando; Vasallo, Jose Manuel.....801

**EXPERIENCIAS DE SISTEMAS COOPERATIVOS COMO CATALIZADORES PARA
ALTOS NIVELES DE AUTOMATIZACIÓN EN LA CONDUCCIÓN**Naranjo Hernández, José Eugenio; Jiménez Alonso, Felipe; Valle Barrio, Alfredo; Cruz Ruiz,
Alberto; González Pérez, Jorge; Gómez Torres, Aitor821**TINNGO: TRANSPORT INNOVATIVE GENDER OBSERVATORY. SPANISH HUB. TAXI
CASE STUDY.**

Calvo Monteagudo, Mireia; Colleoni, Margherita833

**PLATOONING OF CONNECTED AUTOMATED VEHICLES ON FREEWAYS: A BIRD'S
EYE VIEW**

Martínez-Díaz, Margarita; Al-Haddad, Christelle; Soriguera, Francesc; Antoniou, Constantinos.....847

**CROSS-CASE ANALYSIS OF BUS OPERATION IN DIFFERENT CONTEXT: OVIEDO
(SPAIN) AND TANGIER (MOROCCO)**

Cortez, Adriana; Monzón, Andrés; Al Akioui, Abid873

LOGÍSTICA, OPERACIONES Y TRANSPORTE DE MERCANCÍAS /**LOGISTICS, OPERATIONS AND TRANSPORTATION OF GOODS 893****ANÁLISIS COMPARATIVO DE LOS PUERTOS MÁS IMPORTANTES DE ESPAÑA
USANDO BOOTSTRAPPED DEA**Gil Ropero, Antonio; Gil García, Ana Gema; Cerbán Jiménez, María del Mar; Turias Domínguez,
Ignacio J.....895**ECOFLOTA: BUSINESS INTELLIGENCE SYSTEM FOR THE TRANSITION TOWARDS
SUSTAINABLE MOBILITY FLEETS**

Güerri, Sergio; Moya Polo, Javier; Rodríguez Álvaro, José Ángel; Calvo Monteagudo, Mireia919

EFFECTOS DE LA CONDUCCIÓN EFICIENTE EN LA DISTRIBUCIÓN DE MERCANCÍAS

Coloma, Juan Francisco; García, Marta; Fernández, Gonzalo; Monzón, Andrés937

**PREDICTING ON-TIME DELIVERIES IN TRUCKING: A MODEL BASED ON THE WORKING
CONDITIONS OF DRIVERS**

Berrones-Sanz, Luis David961

**EFFICIENCY OF SCALE OF LOGISTICS IN THE PRODUCTION OF THE WORLD'S
COUNTRIES (2007-2018)**

Pesquera, Miguel Angel.....973

**EUROPEAN MODULAR SYSTEMS PERFORMANCES COMPARISON IN FREIGHT
TRANSPORT OPERATIONS**

Larrodé Pellicer, Emilio; Muerza Marín, Victoria.....997

**MICRO DISTRIBUTION IN URBAN LOGISTICS. THE PILOT CASE OF THE OLD DISTRICT
OF BARCELONA**

Gasparín Casajust, Paco; Dani, Eglantina; Saurí Marchan, Sergí.....1007

OPERATIONAL EFFICIENCY OF LAST MILE DELIVERY THROUGH DATA ANALYTICS

Boggio-Marzet, Alessandra; Monzón de Cáceres, Andrés1025

LOGÍSTICA URBANA FERROVIARIA Y E-COMMERCE: ANÁLISIS DE COSTES EXTERNOS DEL MODELO M4G (METRO FOR GOODS)	
Villa Martínez, Rafael; Monzón de Cáceres, Andrés	1043
ANALYSIS OF THE TECHNICAL AND OPERATIONAL CAPACITY OF A COMBINED SEMI-TRAILER RAIL TRANSPORT SERVICE BETWEEN THE PORT OF ALGECIRAS AND ZARAGOZA.	
Escobar de la Iglesia, Jaime; Larrodé Pellicer, Emilio	1075
AN AGILE AND REACTIVE BIASED-RANDOMIZED HEURISTIC FOR AN AGRI-FOOD RICH VEHICLE ROUTING PROBLEM	
Tordecilla, Rafael D.; Copado-Méndez, Pedro J.; Panadero, Javier; Martins, Leandro do C.; Juan, Angel A.....	1085
PROMOTING SUSTAINABLE AND INTELLIGENT FREIGHT TRANSPORTATION SYSTEMS IN THE BARCELONA METROPOLITAN AREA	
Calvet, Laura; Copado, Pedro ; Juan, Angel A.; Alvarez-Palau, Eduard J. ; Viu, Marta; Castillo, Cristian.....	1097
A PARALLEL PROGRAMMING APPROACH TO THE SOLUTION OF THE LOCATION-INVENTORY AND MULTI ECHELON ROUTING PROBLEM IN THE HUMANITARIAN SUPPLY CHAIN	
Angarita Monroy, Andrés Guillermo; Lamos Díaz, Henry	1115
FUZZY OPERATIONAL DECISION-MAKING PROCESS IN URBAN FREIGHT TRANSPORT	
Gómez-Marín, Cristian Giovanni; Cogollo-Flórez, Juan Miguel; Serna-Urán, Conrado Augusto.....	1139
MODELIZACIÓN Y SIMULACIÓN / MODELLING AND SIMULATION.....	1147
A FINITE ELEMENT APPROACH FOR THE TRAFFIC ASSIGNMENT PROBLEM	
Cortínez, Víctor H.; Dominguez, Patricia N.....	1149
SIMULACIÓN Y ANÁLISIS DE TRÁFICO DENTRO DEL ESTUDIO INFORMATIVO DE LA AUTOVÍA ORBITAL B-40 EN BARCELONA	
Rojo, Marta; Linares, Alaitz; Salas, Miguel Ángel; Bergado, Nuria; Ortega, Carlos; Gonzalo Orden, Hernán	1169
MODELO DE MOVILIDAD DE EMT: PLANIFICACIÓN A PARTIR DE FUENTES BIG DATA	
Valdés Serrano, Cristina; Pérez del Olmo, Ana	1187
MODELOS DE EMISIONES DE PARTÍCULAS Y NOX DE AUTOBUSES EN RECORRIDOS URBANOS	
Gomes Bastos, Edinalva; Cueto-Felgueroso González-Pardo, María; Mira, José Manuel; Fonseca, Natalia Elizabeth; Arenas-Ramírez, Blanca; Aparicio-Izquierdo, Francisco	1199
NEW UNCONVENTIONAL SOURCES OF INFORMATION FOR TRANSPORT ANALYSIS. THE CASE OF A MODEL FOR PUBLIC TRANSPORT SERVICES IN MAJORCA	
Martínez-Alvaro, Oscar; Hernández Santana, Iván	1213
OBTENCIÓN DE MATRICES ORIGEN DESTINO PARA MODELOS MESOSCÓPICOS A PARTIR DE DATOS GPS	
Sagües García, Carlos; Calatrava Nicolás, María; Riveros González, Laura Milena.....	1223

OPTIMIZACIÓN DE LA REGULACIÓN SEMAFÓRICA EN LA ZONA DEL 22@ DE BARCELONA	
Rodero Blánquez, Francisco; Arrom Coll, Pere; Puignau Arrigain, Sara.....	1239
CARACTERIZACIÓN DE LA MOVILIDAD DE CORREDORES EN MARATONES	
Llopis Castelló, David; García García, Alfredo.....	1259
SIMULACIÓN DE POLÍTICAS DE GESTIÓN DINÁMICAS DE APARCAMIENTO MEDIANTE UN MODELO DE MICROSIMULACIÓN DE TRÁFICO	
Rodríguez Gutiérrez, Andrés; Cordera Piñera, Rubén; Alonso Oreña, Borja; Benavente Ponce, Juan.....	1283
THE GRAVITY MODEL AS A TOOL FOR DECISION MAKING. SOME HIGHLIGHTS FOR INDIAN ROADS	
Martínez Alvaro, Oscar; García, Jose Manuel; Kumar, Narender	1303
ESTIMACIÓN DE DENSIDAD DE PASAJEROS EN EL SISTEMA DE METRO DE MADRID PARA TOMA DE DECISIONES OPERATIVAS BASADA EN MODELIZACIÓN	
Gallart Gil, Irene; Carmena Vives, Gonzalo; Rodríguez Pastor, Eduardo; Galindo Pinto, Ignacio	1315
DEL DATO COLABORATIVO A MÚLTIPLES RUTAS ENTRE PARES ORIGEN-DESTINO: HERRAMIENTAS PARA OBTENER RUTAS MEDIANTE LA LIMPIEZA, FILTRADO, TRATAMIENTO Y ENRIQUECIMIENTO DE REDES DE OPEN STREET MAPS (OSM).	
Santiago-Iglesias, Enrique; Barros Sulca, Diana Carolina; Moya-Gómez, Borja; Gutiérrez Puebla, Javier; García Palomares, Juan Carlos; Martínez Álvaro, Oscar	1331
UN ALGORITMO PARA PLANIFICAR RUTAS MÁS RÁPIDAS CON ARCOS DEPENDIENTES DEL TIEMPO EN REDES URBANAS	
Ortega, Francisco A.; Marseglia, Guido; Mesa, Juan A.; Piedra-de-la-Cuadra, Ramón.....	1349
ANALYSIS OF THE VEHICLE-BICYCLES INTERACTION ON TWO-LANE RURAL ROADS USING A DRIVING SIMULATOR BASED ON FIELD DATA	
Dols, Juan F.; Molina, Jaime; Moll, Sara; López, Griselda; Camacho-Torregrosa, F. Javier; García, Alfredo	1363
ASSESSING SIM RACING SOFTWARE FOR LOW-COST DRIVING SIMULATOR TO ROAD GEOMETRIC RESEARCH	
Higuera de Frutos, Santiago; Castro Malpica, María.....	1377
PREDICTION OF CONTAINER FILLING FOR THE SELECTIVE WASTE COLLECTION IN ALGECIRAS (SPAIN)	
Rodríguez López, Juana Carmen; Moscoso Lopez, Jose Antonio; Ruíz Aguilar, Juan Jesus; Rodríguez García, Inmaculada; Alcántara Pérez, Jose Manuel; Turias Domínguez, Ignacio J.....	1393
COMPARISON OF MARITIME TRANSPORT INFLUENCE OF SO2 LEVELS IN ALGECIRAS AND ALCORNOCALES PARK (SPAIN)	
Rodríguez García, María Inmaculada; Moscoso López, José Antonio ; Ruiz Aguilar, Juan Jesús; González Enrique, Javier; Rodríguez López, Juana Carmen; Turias Domínguez, Ignacio José	1409
UNCERTAINTY ANALYSIS METHODS TO SELECT THE OPTIMAL ALTERNATIVE IN THE DESIGN OF PARKING FACILITIES	
Muñoz-Medina, Belén; Ordóñez, Javier; Romana, Manuel G.; Alcaraz, Vicente; Lara-Galera, Antonio	1427

MOVILIDAD / MOBILITY.....	1441
ACCESIBILIDAD A CENTROS HISTÓRICOS, EL CASO DE MAJADAHONDA	
Cuello León, María; Espinosa Hernández, Carlota; Sánchez de Toro, José Antonio; Sastre González, Julián	1443
WALKING, DRIVING AND WELLBEING DURING THE COVID-19 PANDEMIC LOCKDOWN IN SPAIN	
Ruiz Sánchez, Tomás; Arroyo López, Rosa; Mars Aicart, María del Lidón	1451
ANALYSIS OF UNIVERSAL ACCESSIBILITY AT PUBLIC TRANSPORT STOPS IN THE CITY OF CÁCERES	
Jiménez Espada, Montaña; González Escobar, Rafael	1471
¿A QUIÉN AFECTA MADRID CENTRAL? ANÁLISIS DE LOS CAMBIOS EN EL TRÁFICO TRAS UN AÑO DESDE SU IMPLANTACIÓN.	
Cuevas-Wizner, Rodrigo; Ortega, Emilio; Martín, Belén	1483
CITIES AT HUMAN SPEED: A FAVORABLE WAY TO REDUCE THE PACE OF MODERN LIFE. PULL AND PUSH MEASURES FOR CHANGE.	
López García de Leániz, Cristina	1499
COSTS AND BENEFITS OF GENDER POLICIES IN TRANSPORTATION. STATE OF THE ART OF QUANTITATIVE APPROACHES	
Martínez Alvaro, Oscar; Barea López, Pedro.....	1519
THE DIGNITY PROJECT- TOWARD A SYSTEM OF INCLUSIVE DIGITAL MOBILITY IN THE BARCELONA METROPOLITAN AREA	
Roca Bosch, Elisabet; Wybraniec, Bartosz; Lazzarini, Boris; Villares Junyent, Míriam; Garola Crespo, Àlvar.....	1535
EL RECIENTE CAMBIO DE PARADIGMA DE LA MOVILIDAD EN EL ÁMBITO EUROPEO	
Saldaña Alegre, Pedro; Martínez Boada, Javier	1545
DISPOSICIÓN DE LOS VIAJEROS A ADOPTAR SOLUCIONES MAAS EN ÁREAS METROPOLITANAS EUROPEAS	
Lopez-Carreiro, Iria; Monzón, Andrés	1571
IMPACTO EN LA ACEPTABILIDAD Y REPARTO MODAL DE LAS MEDIDAS PARA MEJORAR LA CALIDAD DEL AIRE EN MADRID CENTRAL	
Vassallo Magro, José Manuel; Tarrío Ortiz, Javier; Gómez Sánchez, Juan; Soria Lara, Julio Alberto.....	1591
ATTITUDES TOWARDS THE ENVIRONMENT RELATED TO TRAVEL AND PERSONAL MOBILITY	
Arroyo López, Rosa; Ruiz Sánchez, Tomás; Mars Aicart, M ^a del Lidón.....	1629
INTERMODALIDAD EN LAS ESTACIONES DEL FUTURO	
Fernández Morote, Graciela; García Jiménez, Eva; Folgueira Chavarría, Cesar A.; Alonso Aparicio, Teresa; Pérez Laínez, Raquel; Mesa Arévalo, Aurora.....	1643
LOS PLANES DE ACCIÓN PARA LA MOVILIDAD DE GRANDES EVENTOS DEPORTIVOS	
Pérez Senderos, Rodrigo; Mateos Manzanque, Sonia	1663

EXPLORING THE SPATIO-TEMPORAL DYNAMICS OF MOPED-STYLE SCOOTER SHARING SERVICES IN URBAN AREAS.	
Arias Molinares, Daniela; Gutiérrez Puebla, Javier; García Palomares, Juan Carlos; Romanillos Arroyo, Gustavo; Talavera García, Ruben	1673
THE URBAN FREIGHT DISTRIBUTION IN MEDIUM SIZE CITIES: DESCRIPTIVE DATA TAKEN FROM PAMPLONA (SPAIN) AND ANGERS (FRANCE)	
Serrano-Hernandez, Adrian; Gougeon, Thomas; Cadarso, Luis; Juan, Angel. A.; Faulin, Javier	1701
OPTIMIZACIÓN DE DATOS GEOLOCALIZADOS DE TELEFONÍA MÓVIL EN ESTUDIOS DE DEMANDA DE VIAJEROS	
Bejarano Aparicio, Carlos; Heredia Santana, Ángeles; de Frutos Pérez, Beatriz	1713
TWITTER Y MOVILIDAD ESPACIO-TEMPORAL: VISUALIZACIÓN 3D DE FLUJOS DE MOVILIDAD	
Osorio Arjona, Joaquín	1725
EVOLUTION OF MOBILITY DURING THE COVID-19 CRISIS IN THE REGION OF MADRID	
Al Akioui Sanz, Abid; Monzón de Cáceres, Andrés; Álvarez del Valle, Lucas	1739
MOBILITY TO THE UNIVERSITY CAMPUSES OF THE COMMUNITY OF MADRID: DIAGNOSIS AND BASES FOR A SUSTAINABILITY STRATEGY	
Balsero Martínez, Luisa Fernanda; Lamarty Belica, Karim; Monzón de Cáceres, Andrés	1763
OPPORTUNITIES FOR SUSTAINABLE AND INTELLIGENT MOBILITY IN THE RESPONSIVE CITY	
Angarita Lozano, Diana Liseth; Díaz Márquez, Sonia Esperanza; Morales Puentes, María Eugenia ...	1781
IMPACT OF COVID-19 ON URBAN TRANSPORTATION HABITS IN THE CITY OF GIJÓN	
Pantiga Facal, Estela; Plasencia Lozano, Pedro; Méndez Manjón, Irene	1801
LA REGULACIÓN MUNICIPAL COMPARADA SOBRE EL USO DE LOS VEHÍCULOS DE MOVILIDAD PERSONAL (VMP): ANÁLISIS SOBRE EL DESARROLLO NORMATIVO DE GIJÓN, VALLADOLID, VIGO, HOSPITALET DE LLOBREGAT Y VITORIA	
Hernández Diez, Enrique; Méndez Manjón, Irene ; Plasencia Lozano, Pedro	1817
MEDICIÓN DE PM_{2,5} SEGÚN LAS CONDICIONES DEL TRÁFICO EN EL CENTRO DE MADRID MEDIANTE UN DISPOSITIVO MÓVIL	
Lamas Casado, Diego ; Martín Ramos, Belén; Calderón Guerrero, Carlos; Ortega Pérez, Emilio	1851
CAMPAÑA DE ENCUESTAS PARA LOS PLANES DE MOVILIDAD UNIVERSITARIA SOSTENIBLE (PMUNIVS) DE LA COMUNIDAD DE MADRID. ESTRATEGIAS DE SEGUIMIENTO PARA ANIMAR A LA PARTICIPACIÓN EN TIEMPOS DE LA PANDEMIA DE LA COVID-19	
Moya-Gómez, Borja; Balsero Martínez, Luisa Fernanda; Monzón, Andrés	1865
THE POTENTIAL IMPACT OF USING TRAVEL APPS AS A TOOL TO REDUCE CAR USE IN CITIES. A LITERATURE REVIEW.	
Casquero Soler, Daniel; Martínez Álvaro, Óscar; García García, Marta	1887

ESTUDIO PARA LA IMPLEMENTACIÓN DE UNA APLICACIÓN MÓVIL PARA VIAJES COMPARTIDOS DE LA COMUNIDAD ACADÉMICA ENTRE SU VIVIENDA Y EL CAMPUS UNIVERSITARIO. FACULTAD DE INGENIERÍA, UNIVERSIDAD NACIONAL DE COLOMBIA - SEDE BOGOTÁ
 Castro García, William; Bedoya Paniagua, Daniel Alejandro; Barón Collazos, Andrea Marcela; Pirazán Sáenz, Daniel Alexander; Pino Monroy, Derly Alejandra; Ospina Rojas, Sara Sofía; Gómez Saavedra, Ana María 1905

THE CHALLENGE OF SUSTAINABLE UNIVERSITY MOBILITY: COMPARING THE ACCESSIBILITY AND QUALITY OF PUBLIC SPACE OF 14 CAMPUSES IN MADRID
 Falcone Guerra, Mariana; Manso Barrio, Antonio; Monzón, Andrés 1957

NUEVOS VEHÍCULOS Y FORMAS DE MOVILIDAD / NEW VEHICLES AND MEANS OF MOBILITY1971

FACTORES CLAVE EN LA ADOPCIÓN DE LAS MOTOS DE USO COMPARTIDO EN NÚCLEOS URBANOS DE ESPAÑA
 Aguilera García, Álvaro; Gómez, Juan; Sobrino, Natalia 1973

AUTONOMOUS VEHICLE CONTROL IN CARLA CHALLENGE
 del Egido Sierra, Javier; Díaz Díaz, Alejandro; Bergasa Pascual, Luis M.; Barea Navarro, R.; López Guillén, M.E 1991

¿CUÁLES SON LOS FACTORES QUE EXPLICAN LA ADOPCIÓN Y FRECUENCIA DE USO DE LOS SERVICIOS DE RIDE-HAILING? APLICACIÓN AL CASO DE MADRID
 Gómez Sánchez, Juan; Aguilera García, Álvaro; Dias, Felipe F.; Bhat, Chandra R.; Vassallo Magro, José Manuel 1999

NEW URBAN MOBILITY OPTIONS: ALTERNATIVE FUTURES AND THEIR IMPACT IN TRANSPORT PLANNING TECHNIQUES
 Burrieza Galán, Javier; Rodríguez Vázquez, Rita; Cantú Ros, Oliva G.; Aifadopoulou, Georgia; Salanova Grau, Josep; Konstantinidou, Maria; Frederix, Rodric; Pápics, Péter..... 2049

OPTIMIZATION OF THE POWERTRAIN OF ELECTRIC VEHICLES FOR A GIVEN ROUTE
 Luque Rodríguez, Pablo; Álvarez Mántaras, Daniel; Roces García, Jorge; Castejón Herrer, Luis; Malón Litago, Hugo 2081

OPTIMIZACIÓN DE UNA MANIOBRA DE ADELANTAMIENTO APLICADA A VEHÍCULOS AUTÓNOMOS.
 Alonso Villarmarzo, Marta; Martínez García, Carlos; Jiménez Alonso, Felipe; Álvarez Mántaras, Daniel 2093

REGULACIÓN VTCS Y TAXIS EN LA UE
 Martín Armas, Henar; Romero Adame, Cinta; Sastre González. Julián; Márquez Pigner, Manuel..... 2109

UN NUEVO PARADIGMA DE LA MOVILIDAD: EL AUTOBÚS ELÉCTRICO
 Villalba Sanchis, Ignacio; Insa Franco, Ricardo ; Salvador Zuriaga, Pablo; Martínez Fernández, Pablo 2117

VEHÍCULOS AUTÓNOMOS, FORMA URBANA Y NUEVOS ENFOQUES DE PLANIFICACIÓN BACKCASTING: UNA REVISIÓN DE LAS INVESTIGACIONES RECIENTES
 Nogués, Soledad; González González, Esther; Cordera, Rubén; Moura, José Luis 2129

EL VEHÍCULO AUTÓNOMO Y EL MEDIO AMBIENTE: UNA REVISIÓN DE LA LITERATURA CIENTÍFICA	
Silva, Óscar; Cordera, Rubén; González González, Esther; Nogués, Soledad	2159
A GIS-BASED EVALUATION OF THE E-MOPED SHARING SYSTEMS IN SPAIN	
Méndez-Manjón, Irene; Plasencia-Lozano, Pedro; Pantiga-Facal, Estela	2193
EL SARS-COV-2 Y SU IMPACTO EN LA OBTENCIÓN DE DATOS SOBRE MOVILIDAD. LA EXPERIENCIA DEL PROYECTO TRAVELWELL+	
Eguidazu Casamitjana, Sergio; López Esalas, Yenis M.; Arroyo López, Rosa; Mars Aicart, Lidón.....	2205
BIENESTAR, TRANSPORTE Y MOVILIDAD SOSTENIBLE	
López Esalas, Yenis M.; Martín Rollon, Beatriz; Arroyo López, Rosa; Mars Aicart, Lidón	2215
LA REGULACIÓN DE LOS PATINETES ELÉCTRICOS COMPARTIDOS EN LAS CIUDADES ESPAÑOLAS	
Baeza Muñoz, María de los Ángeles; Pérez Doval, José María; González Sarmiento, Juan Nicolás; Vassallo Magro, José Manuel.....	2229
COLLABORATIVE MOBILITY: COMMON FEATURES IN A NEW GENERATION OF MOBILITY BUSINESS MODELS	
Papí Ferrando, José Francisco; Gonzalo Orden, Hernán; Zaragoza Ramírez, Aniceto.....	2243
FROM URBAN CONGESTION PRICING TO TRADABLE MOBILITY CREDITS: A REVIEW	
Li, Siyu; Robusté, Francesc	2263
PLANIFICACIÓN DEL TRANSPORTE / PLANNING OF TRANSPORT	2281
ANÁLISIS DE EQUIDAD EN LA OFERTA DE TRANSPORTE PÚBLICO MEDIANTE UN MODELO LUTI (LAND-USE AND TRANSPORT INTERACTION). APLICACIÓN AL ÁREA METROPOLITANA DE BUCARAMANGA EN COLOMBIA.	
Manrique Bautista, Jhair Andrés; Cordera Piñera, Rubén; Alonso Oreña, Borja; Moreno Gonzalez, Emilio Germán.....	2283
A NOVEL APPROACH TO THE TAIL ASSIGNMENT PROBLEM IN AIRLINE PLANNING	
Fuentes, Manuel; Cadarso, Luis; Vaze, Vikrant; Barnhart, Cynthia.....	2309
PUBLIC TRANSPORTATION MULTIMODALITY IN THE CITY OF LISBON	
Lemonde, Carlos; Arsenio, Elisabete; Henriques, Rui	2321
CRITERIA FOR OPTIMIZING A ROAD NETWORK	
Regalado López, Francisco Javier; Campos Cacheda, José Magín; Saurí Marchán, Sergi	2335
DISEÑO DE UN ENFOQUE COLABORATIVO PARA LA EVALUACIÓN DE POLÍTICAS DE TRANSPORTE DESTINADAS A MEJORAR LA CALIDAD DEL AIRE EN EL CENTRO DE LAS CIUDADES	
Tarriño Ortiz, Javier; Soria Lara, Julio Alberto; Vassallo Magro, José Manuel.....	2353
IDENTIFYING MOBILITY PATTERNS AND BARRIERS FROM AGEING POPULATION TO ACCESS TO RETAIL ACTIVITY	
Ariza-Álvarez, Amor; Martínez Montes, David; Arranz-López, Aldo; Arce-Ruiz; Rosa M.; Soria-Lara, Julio A.....	2377

SPATIAL ANALYSIS OF PUBLIC TRANSPORTATION INFRASTRUCTURE IN SANTIAGO, CHILE Medina-Tapia, Marcos; Robusté, Francesc; Estrada, Miquel.....	2393
THINKING THE UNTHINKABLE: THE DESIGN OF DISRUPTIVE VISIONS FOR LAND USE AND TRANSPORT INTEGRATION Soria-Lara, Julio A.; Cascajo, Rocío; Ariza-Álvarez, Amor; Arce-Ruiz, Rosa M.; Aguilera-Benavente, Francisco; López García de Leaniz, Cristina.....	2411
QUANTIFICATION OF TRANSPORT OFFER LINKED TO A EUROPEAN HYPERLOOP NETWORK Fernández Gago, José Ángel; Collado Pérez-Seoane, Federico	2427
LOCALIZACIÓN BAJO DOS PERSPECTIVAS ENFRENTADAS: ¿CERCANÍA O REPARTO JUSTO? Hernández Díaz, Alfredo G.; López-Sánchez, Ana D.; Sánchez-Oro, Jesús; Duarte, Abraham; Martínez-Gavara, Anna	2451
CUANDO EL MÁS CERCAÑO NO ES EL PREFERIBLE Hernández Díaz, Alfredo G.; López-Sánchez, Ana D.; Sánchez-Oro, Jesús; Duarte, Abraham	2461
PREMIOS A JÓVENES INVESTIGADORES - FINALISTAS / YOUNG RESEARCHERS AWARDS - FINALISTS.....	2469
ANALYSIS OF PUBLIC-PRIVATE PARTNERSHIP MODELS IN HIGH-SPEED RAILWAY TRANSPORT IN PORTUGAL González-Medrano, Mario; García Martín, Tomás	2471
FROM INNOVATION TO THE LAW: A COMPARATIVE ANALYSIS OF NEW TECHNOLOGIES IN AUTONOMOUS MOBILITY LEGISLATION. García Crespo, Héctor	2491
IDENTIFICACIÓN DE RESPONSABILIDAD DE LOS CONDUCTORES. APLICACIÓN AL MÉTODO DE EXPOSICIÓN CUASI-INDUCIDA Sanjurjo de No, Almudena; Arenas Ramírez, Blanca; Aparicio Izquierdo, Francisco.....	2505
DOES SIZE REALLY MATTER? DUAL DISTRIBUTION CHANNEL WITH VANS AND AUTONOMOUS DELIVERY DEVICES Lemardelé, Clément; Estrada Romeu, Miquel	2519
CASE OF STUDY OF A MIXED CARSHARING SYSTEM DESIGN Jiménez Meroño, Enrique; Soriguera Martí, Francesc	2529
SOFTWARE TOOL FOR ANALYSIS AND VISUALIZATION OF GPS TRACKS IN URBAN ENVIRONMENTS Cogollos Adrián, Héctor; Porras Alfonso, Santiago; Baruque Zanón, Bruno	2551
ESTUDIO DE LA CAPACIDAD EN ESTACIONES FERROVIARIAS: METODOLOGÍA PARA EL CÁLCULO TEÓRICO Aguado López, Juan Manuel; Zamorano Martin, Clara; Achutegui Hernandez, Javier	2561
DIGITAL SOCIETY AS A DETERMINING FACTOR IN MOBILITY, URBAN DYNAMICS AND CURRENT CITIES STRUCTURE Castillo Luna, Victor Manuel	2581

SIGNAL PROCESSING AND MACHINE LEARNING FOR AIR TRAFFIC DELAY PREDICTION	
Tenorio, Víctor M.; Marques, Antonio G.; Cadarso, Luis	2603
THE IMPACT OF COVID-19 ON INTERMODAL FREIGHT TRANSPORT: AN EXANTE AND EX-POST ANALYSIS	
Rahnama, Shaghayegh; Larrodé Pellicer, Emilio; Muerza Marín, Victoria	2615
CAN RAIL INFRASTRUCTURE DETERMINE PERCEIVED QUALITY OF SERVICE OF SUBURBAN TRAINS? INSIGHTS FROM CERCANÍAS MADRID	
Romero, Carlos; Zamorano, Clara; Monzón, Andrés	2627
RELACIÓN ENTRE TIEMPOS DE OPERACIÓN DE AUTOBUSES URBANOS Y TIEMPOS DE RECORRIDO DE TRÁFICO GENERAL	
Montero Lamas, Yaiza M ^a ; Novales Ordax, Margarita; Orro Arcay, Alfonso	2639
QUANTIFYING THE SAFETY IMPACT OF CONNECTED AND AUTONOMOUS VEHICLES IN MOTORWAYS: A SIMULATION-BASED STUDY	
Miqdady, Tasneem; de Oña, Rocío; de Oña, Juan	2653
REINFORCEMENT LEARNING FOR TRAFFIC SIGNAL CONTROL: COMPARISON WITH COMMERCIAL SYSTEMS	
Cabrejas Egea, Alvaro; Zhang, Raymond; Walton, Neil	2673
PUERTOS / PORTS	2693
CONTAINER SHIP SIZE: WHICH DIMENSIONS CAN BE EXPECTED?	
Garrido Salsas, Javier; Saurí, Sergi ; Marrero, África; Gül, Ümit; Rúa, Carles.....	2695
DEVELOPMENT OF A MULTICRITERIA SCHEME FOR THE LOCATION AND SELECTION OF SUSTAINABLE URBAN DRAINAGE SYSTEMS IN PORTS	
Menéndez Suárez-Inclán, Antonio; Álvarez-Rabanal, Felipe P. ; Sañudo-Fontaneda, Luis A.; Allende-Prieto, Cristina; Rocés-García, Jorge	2719
PROPUESTA DE UN NUEVO MODELO DE GOBERNANZA PORTUARIA DEL SISTEMA PORTUARIO ESPAÑOL BASADO EN LA EFICIENCIA Y LA COMPETITIVIDAD	
Camarero Orive, Alberto; Parra Santiago, José Ignacio; Pery Paredes, Pascual	2738
SEGURIDAD EN EL TRANSPORTE / SAFETY IN TRANSPORT	2759
INTELLIGENT EMERGENCY MANAGEMENT SYSTEM FOR RAILWAY TRANSPORT	
Balboa Marras, Adriana; Abreu Menéndez, Orlando V.; González-Villa, Javier; Alvear Portilla, Daniel.....	2761
SAFETY AND ROAD INFRASTRUCTURE: A SPATIAL ANALYSIS IN SUBURBS OF BOGOTÁ	
Forigua, Julio; Lyons, Liliana.....	2777
AGENT-BASED SIMULATION MODEL OF BUS EVACUATION EVENTS	
Alcalá Fazio, Enrique; Bartolomé Peña, Carlos.....	2787
AD HOC MINIMUM SEPARATION: A CHALLENGE FOR AIR TRAFFIC CONTROL (ATC)	
Serrano-Mira, Lidia ; Pérez Sanz, Luis; Pérez-Castán, Javier A	2803

SEGURIDAD EN PASOS A NIVEL Y FACTOR HUMANO: LA EXPERIENCIA DEL PROYECTO EUROPEO SAFER-LC.

Liberal Liberal, Jose Manuel; Lorenzo Carrascosa, Laura 2815

SOSTENIBILIDAD / SUSTAINABILITY2833

CONNECTIONS BETWEEN MOBILITY AND URBAN FABRICS IN THE CITY OF BURGOS (SPAIN)

Serrano-López, Roberto; Linares-Unamunzaga, Alaitz 2835

GREENHOUSE GAS EMISSION IN URBAN PASSENGER TRANSPORT

Rubén Tarcaya, Héctor; Arenas, Angélica Noemí 2845

IMPACTO SOBRE EL CAMBIO CLIMÁTICO QUE GENERA LA MOVILIDAD EN LA UPM: CÁLCULO DE LA HUELLA DE CARBONO

Sobrino Vázquez, Natalia; Arce Ruiz, Rosa María 2853

IMPLEMENTATION OF ASSET MANAGEMENT SYSTEMS AS A GUARANTEE OF SUSTAINABILITY WITHIN THE FRAMEWORK OF THE SOCIAL, BUSINESS AND FINANCIAL OBJECTIVES OF TRANSPORT COMPANIES. CASE OF APPLICATION TO RAILWAY ADMINISTRATORS AND OPERATORS

Maté Sanz, David 2873

UNDERSTANDING TRANSPORTATION PREREQUISITES TO BE INTEGRATED WITH URBAN DEVELOPMENT IN DEVELOPING COUNTRIES: IRAN AS A CASE

Hamed Abdi, Mohammad; Lamíquiz Daudén, Francisco José 2891

SUPERVISED MACHINE LEARNING ALGORITHMS FOR MEASURING AND PROMOTING SUSTAINABLE TRANSPORTATION AND GREEN LOGISTICS

Castañeda, Juliana; Cardona, John F.; Martins, Leandro do C.; Juan, Angel A 2903

¿CUÁL ES EL IMPACTO DE LAS POLÍTICAS DE TRANSPORTE EN LA PROPIEDAD DE AUTOMÓVILES? EVIDENCIA EMPÍRICA DE LA CIUDAD DE MADRID

González Sarmiento, Juan Nicolás; Pérez Doval, José María; Gómez Sánchez, Juan; Vassallo Magro, José Manuel 2923

SYSTEMATIC DESIGN OF WIRELESS CHARGING TRANSPORTATION NETWORK

Correa, Diego; Jakub, Gil; Moyano, Christian 2947

NUEVAS FORMAS DE SEMAFORIZACIÓN EN LAS CIUDADES

Martín Rollón, Beatriz; Ruiz Sánchez, Tomás; Arroyo López, Rosa 2961

TRÁFICO Y SEGURIDAD VIAL / TRAFFIC AND ROAD SAFETY2971

ANÁLISIS EXPLORATORIO DE LA MOVILIDAD DE LOS VEHICULOS TIPO TURISMO REGISTRADOS EN LAS ITV EN ESPAÑA

Narváez-Villa, Paúl; Arenas Ramírez, Blanca; Mira, José Manuel 2973

EVALUATION OF THE EFFICIENCY OF TRAFFIC LIGHTS TURNING RED IN CASE OF EXCEEDING SPEED LIMIT WITH PREVIOUS PANELS INDICATING THE SPEED

Pérez-Acebo, Heriberto; Otxoa-Muñoz, Xabier; Marquina-Llaguno, Mikel; Gonzalo-Orden, Hernán 2987

ESTUDIO DE ACCIDENTES DE CICLISTAS EN ESPAÑA

Arenas Ramírez, Blanca; Sanjurjo de No, Almudena; Aparicio Izquierdo, Francisco 3001

IMPACT ON URBAN MOBILITY OF PREVENTIVE MEASURES AGAINST COVID-19 DURING THE STATE OF ALARM. THE PARTICULAR CASE OF A MEDIUM-SIZED CITY Linares Unamunzaga, Alaitz; Gonzalo Orden, Hernán; Serrano López, Roberto; Rojo Arce, Marta.....	3017
MITIGACIÓN DEL IMPACTO DE LA IMPLEMENTACIÓN DEL ‘PLATOONING’ DE CAMIONES EN LAS VISIBILIDADES DISPONIBLES EN AUTOPISTAS Pastor-Serrano, Daniel; García, Alfredo	3031
WHY IS NECESSARY TO REDUCE THE SPEED IN URBAN AREAS TO 30 KM/H? Gonzalo Orden, Hernán; Rojo Arce, Marta; Linares Unamunzaga, Alaitz; Aponte Sanjémez, María Nadia; Pérez Acebo, Heriberto	3045
ROAD SAFETY OF ELDER PEDESTRIANS IN THE URBAN CONTEXT: AN APPROACH BASED ON INFRASTRUCTURE AND SOCIOECONOMIC VARIABLES Gálvez-Pérez, Daniel; Guirao, Begoña; Ortuño, Armando.....	3055
COMPARISON OF MULTIVARIATE REGRESSION MODELS AND ARTIFICIAL NEURAL NETWORKS FOR PREDICTION HIGHWAY TRAFFIC ACCIDENTS IN SPAIN: A CASE STUDY Alqatawna, Ali; Rivas Álvarez, Ana María; Sánchez-Cambronero García-Moreno, Santos.....	3071
URBAN ROAD ACCIDENTS AND RIDEHAILING SERVICES: A STUDY OF DEPENDENCE IN MADRID Flor García, María; Ortuño Padilla, Armando; Guirao Abad, Begoña; Casares Blanco, Jairo	3083
ESTUDIO DE LA SEVERIDAD DE ACCIDENTES DE TRÁFICO DE AUTOCARES Y AUTOBUSES EN ARGENTINA Y ESPAÑA CON ÁRBOLES DE CLASIFICACIÓN Toalombo Vargas, Víctor Miguel; del Valle Arenas Ramírez, Blanca; Pillajo Quijia, Giovanni Pablo	3093
THE ROLE OF DRIVERS’ SCHEMES ON TRAFFIC SIGNS COMPREHENSION. Hernando Mazón, Ana; Lucas Alba, Antonio; Ferruz Gracia, Ana M ^a ; Orejudo Hernández, Santos.....	3103
HOW TO INCORPORATE AUTOMATED VEHICLES ON ROAD SAFETY AUDITS Camacho Torregrosa, Francisco Javier; García, Alfredo; Llopis Castelló, David	3113
CLASIFICACIÓN Y CARACTERIZACIÓN DE ELEMENTOS DEL RECORRIDO PEATONAL EN UN ENTORNO URBANO MEDIANTE DATOS LIDAR Varela-García, Francisco-Alberto; Fernández Rivera, Francisco; Esmoris Pena, Alberto Manuel; Fernández Arango, David; López Vilariño, David; Cabaleiro Domínguez, José Carlos.....	3135
DIFFERENCES IN ROAD-TRAFFIC CRASH RATES DURING CONSTRUCTION AND NON-CONSTRUCTION TIMES ON ARTERIAL STREETS: A COMPARATIVE STATISTICAL ANALYSIS Mangones M, Sonia C.; García M, Jaime Alejandro; Holguín M, David Orlando; Orejuela L, Danny Alexander.....	3151
INFLUENCIA DEL GASTO EN CONSTRUCCIÓN Y MANTENIMIENTO DE CARRETERAS EN LA SEGURIDAD VIAL EN EL CONTEXTO EUROPEO Navarro-Moreno, José ; Calvo-Poyo, Francisco ; Garach, Laura ; de Oña, Juan.....	3169
LOCALIZACIONES DE RIESGO MÍNIMO PARA VEHÍCULOS AUTOMATIZADOS Y CONECTADOS García, Alfredo; Camacho Torregrosa, Francisco Javier; Llopis Castelló, David	3181

ANALYSIS OF TRAFFIC VELOCITY UNDER DIFFERENT WEATHER AND TEMPORARY CONDITIONS Cogollos Adrián, Héctor; Porras Alfonso, Santiago; Baruque Zanón, Bruno	3197
WORKING HOURS AND TRAFFIC ACCIDENT INJURIES: CASE STUDY IN BARCELONA Aiash, Ahmad; Robusté, Francesc.....	3207
TRANSPORTE PÚBLICO / PUBLIC TRANSPORT	3215
ANÁLISIS ESTRUCTURAL DE REDES DE TRANSPORTE PÚBLICO USANDO TEORÍA DE REDES. CASO DE GUADALAJARA MÉXICO. Barraza, Orlando; Estrada, Miquel.....	3217
MEJORA DE LA CARACTERIZACIÓN DE LOS SERVICIOS DE UN SISTEMA DE TRANSPORTE PÚBLICO COMBINANDO DATOS DE LOS SUBSISTEMAS DE LOCALIZACIÓN, BILLETAJE Y PLANIFICACIÓN Benavente Ponce, Juan; Alonso Oreña, Borja; Moura Berodia, José Luis; Rodríguez Gutiérrez, Andrés	3231
ANÁLISIS DE LA INFLUENCIA DE LA RESERVA DE PLATAFORMA EN LAS OPERACIONES DE UN SISTEMA DE AUTOBÚS Vázquez Varela, Miguel Ángel; Orro Arcay, Alfonso; Novales Ordax, Margarita; Pérez-López, José B.; Rodríguez Bugarín, Miguel	3275
THE UNDELAYABLE LEGAL REFORM OF PUBLIC PROCUREMENT RULES IN THE MANAGEMENT MODELS FOR THE URBAN TRANSPORT PUBLIC SERVICE IN THE AUTONOMOUS COMMUNITY OF CASTILLA Y LEÓN Cantera, José Manuel	3289
CHARGING OPERATIONS IN BATTERY ELECTRIC BUS SYSTEMS AT THE DEPOT Campos Cacheda, José Magín; Mención Camps, Josep; Estrada Romeu, Miquel	3297
ANÁLISIS DE LA VARIACIÓN DE LA DEMORA EN PARADA EN CONDICIONES METEOROLÓGICAS ADVERSAS Novales Ordax, Margarita; Orro Arcay, Alfonso; Perez-Lopez, Jose-Benito; Feal García, Jorge; Rodríguez Bugarín, Miguel	3309
ANALYSIS OF AN AUTONOMOUS DRIVING MODULAR BUS SYSTEM Romea, Guillem; Estrada Romeu, Miquel.....	3325
MULTIMODAL SHORTEST HYPERPATHS CONSIDERING CROWDING IN TRANSIT VEHICLES López, David; Lozano, Angélica.....	3335
EL AUTOBÚS AUTÓNOMO: ANÁLISIS DE PERCEPCIÓN A TRAVÉS DE VARIABLES LATENTES Pereira Rodríguez, Andrés; López-Lambas, María Eugenia; Cidón Martínez, Pablo	3355
VARIACIÓN ESPACIAL Y TEMPORAL DE LA SATISFACCIÓN DE LOS USUARIOS EN SISTEMAS DE TRANSPORTE PÚBLICO POR CARRETERA Echaniz, Eneko; Cordera, Rubén; Rodríguez, Andrés; Nogués, Soledad; dell'Olio, Luigi.....	3373

TOOLS FOR THE MONITORING, USER CHARACTERIZATION, AND THEIR APPLICATIONS TO THE PUBLIC INTEGRATED TRANSPORT SYSTEM DUE TO THE COVID 19 DISEASE EFFECTS: A CASE STUDY IN BOGOTÁ, TRANSMILENIO COMPANY	
Ramírez-Buitrago, Felipe Andrés; Correal-Huertas, Nicolás Adolfo; Ramírez-Leuro, Laura Daniela; Sandoval-Pederos, Daniel Andrés; Rubio-Caballero, Luis Alberto	3393
IMPROVING BRT ROUTE DESIGN THROUGH CODE: THE CASE OF BOGOTÁ'S BRT SYSTEM, TRANSMILENIO	
Ramírez-Buitrago, Felipe Andrés; Correal-Huertas, Nicolás Adolfo; Chala Penagos, Manuel Camilo; Hoyos Ruiz, Miguel Darío; Ochoa Díaz, Andrés Felipe ;Rivera Pérez, Andrés Leonardo.....	3417
METRO SYSTEMS IN LATIN AMERICA, COMPARISON OF PLANNING AND DEVELOPMENT MODELS VERSUS OTHER REGIONS IN THE WORLD	
Bastidas-Zelaya, Efraín.....	3433
GENERAL GUIDELINES FOR THE DESIGN OF BRT ROUTES IN THE PUBLIC TRANSPORT INTEGRATED SYSTEM OF BOGOTÁ	
Moreno Triviño, John; Castro García, William	3445
ADAPTACIÓN DE SERVICIOS DE MOVILIDAD AL NUEVO ESCENARIO DE LA COVID-19: LA EXPERIENCIA DEL GRUPO ALSA CON EL PROGRAMA "ALSA MOVILIDAD SEGURA "	
Cillero Hernández, Alberto; Bouzada Outeda, Paula.....	3465
VEHÍCULOS, MATERIAL MÓVIL, AUTOMOCIÓN Y EQUIPOS /	
VEHICLES, AUTOMOTIVE AND EQUIPMENT	3479
APLICACIÓN DE LAS REGIONES DE ESTABILIDAD ($R-\beta$) AL DISEÑO DE VEHÍCULOS	
Alonso Villarmarzo, Marta; Álvarez Mántaras, Daniel; Luque Rodríguez, Pablo	3481
CONSIDERACIONES FUNCIONALES DE LAS CVTS INERCIALES	
Morales Sánchez, Francisco José; García Benítez, Francisco	3495
INFLUENCE OF TIRE DYNAMICS ON A BRAKING PROCESS WITH ABS	
Pérez Fernández, Javier; Alcázar Vargas, Manuel G. ; Velasco García, Juan M.; Cabrera Carrillo, Juan A.; Castillo Aguilar, Juan J	3515
NUMERICAL SIMULATION OF A SEMITRAILER'S LATERAL PROTECTION SYSTEM AGAINST CAR FRONTAL CRASH	
Valladares Hernando, David; Fernández Lacruz, David; Castejón Herrero, Luis; Malón Litago, Hugo; Luque, Pablo; Álvarez Mántaras, Daniel	3521
THERMAL COMFORT IN CONVENTIONAL VEHICLES (ICE) AND ELECTRIC (EV) - EVALUATION METHODS	
Mirones Gómez, Bernardo José.....	3535
AUTORES / AUTHORS	3547

ROAD SAFETY OF ELDER PEDESTRIANS IN THE URBAN CONTEXT: AN APPROACH BASED ON INFRASTRUCTURE AND SOCIOECONOMIC VARIABLES

Daniel Gálvez-Pérez

PhD Candidate, Universidad Politécnica de Madrid, España

Begoña Guirao

Associate Professor, Universidad Politécnica de Madrid, España

Armando Ortuño

Associate Professor, Universidad de Alicante, España

ABSTRACT

The world generalized phenomenon of population ageing, caused by an increase in life expectancy, has led to a more elderly being actively part of mobility and road traffic. In developed countries, like Spain, fatalities and severe injuries among elderly pedestrians in the urban context are a matter of concern since, in the last decades, the fatal accident risk for elderly pedestrians is rising. Although there is an extensive literature on the decline of driving and pedestrian skills in the elderly, few research has been devoted to the impact of the street type and socioeconomic factors per urban district on this type of collisions.

The road safety analysis of pedestrians' collisions is complex due to the diversity of the features, the dispersion of the data and the lack of infrastructure information associated to the accident location at official databases. The main target of this paper is the identification of the basic socioeconomic and infrastructure factors that contribute to elder pedestrian accident at urban level, taking the administrative units (districts) as territorial accident location. Madrid is the capital of one of the most rapidly ageing nations in the world, and was selected as case study because it also has a high proportion of elderly residents (19%). The Spanish General Directorate of Traffic (DGT) provided the database (2006-2018) on accident statistics and the crashes involving an elderly in Madrid were filtered to elaborate and ad-hoc data base. The study methodology was based on a negative binomial model to test the accident occurrence at district level. Results revealed the clear influence of the district population variables (density and total inhabitants) together with the activity centres associated to the elderly mobility, followed by the road length and the ageing rate per district.

1. INTRODUCTION

According to UE statistics (Eurostat, 2015), the 24% of the population in Europe will be aged over 65 years in 2030 and in 2050 this figure will reach the 28%. This fact will be translated, in terms of mobility, into more elderly being actively part of road traffic.

Road safety figures have started to provide evidence of the consequences: at the moment one road traffic fatality out of five is aged 65 or over (European Commission, 2015); but by 2050 (if the risk rates of older people and younger age groups decline at the same pace) it is expected that one road traffic fatality out of three will be an older person (European Commission, 2015).

Elder Pedestrians and cyclists, which concentrate in urban areas, are the weakest users. Statistics reflects that elderly make up 39% of all pedestrian fatalities and 40% of all pedal cyclist fatalities compared to 18 and 19% of all car driver and passenger fatalities (European Commission, 2015). If we check statistics provided by OECD countries, the real fact is that persons 65 years and over 65 years represent 13 to 20% of the population, but they make up more than 50% of pedestrian fatalities (ITF, 2012). Consequently, there is a scientific need to understand the factors that affects the elder pedestrian accidents and prevent them implementing countermeasures on our streets.

Although there is an extensive literature on the decline of driving and pedestrian skills in the elderly, few research has been devoted to the impact of the street type and socioeconomic factors per urban district on this type of collisions. Using a negative binomial model applied to Madrid case study, the main target of this paper is the identification of the basic socioeconomic and infrastructure factors that contribute to elder pedestrian accident at urban district level. The paper is divided into the following sections: Section 1 contains a brief introduction; Section 2, the state of the art on elderly pedestrians; Section 3 gives a detailed description of the case study, model structure and main results; Finally, Section 4 shows the conclusions and future research lines.

2. ROAD SAFETY OF ELDER USERS

An extensive literature (Dunbar et al, 2004; Oxley et al. 2004; Palamara and Broughton, 2013) has been devoted to study the specific physical and mental limitations of the elderly as road users. These physical and mental limitations use to be exacerbated by age-related illnesses and certain chronic medication. Having more than on illness (comorbidity) is also more usual among the elderly population and is also linked to a higher accident's risk. Due to their physical and mental state, also this age group registers greater fatality rates (Henary et al, 2006). Until now, the higher road collision risk of the elderly has been linked to the reduction in physical and mental faculties with advancing age, which can lead to an inappropriate and unexpected behaviour in elderly pedestrians and drivers compares to the rest of road users (except children).

Elderly drivers have been paid more scientific interest than elderly pedestrians (Charlton et al, 2017; Charlton et al; 2006), although figures reflect that fatal accidents involving elderly drivers are still very few compared to elderly pedestrian fatalities (Langford et al., 2006).

We know that physical and mental limitations of elderly pedestrian are usually related to a lower walking speeds, reduced ability to make head and neck movements, less muscle agility, a poorer vision, poorer hearing, and longer reaction time. The idea of adapting street infrastructure for an ageing society is starting to grow among policymakers and local authorities and institutions like the World Health Organization is promoting the approach of creating “age-friendly” cities (WHO, 2007).

According to this idea of adapting street infrastructure to an ageing society, there is a need to study how the location features of the accident is affecting to the crash occurrence. The location of the accident can be linked to infrastructure features (street crossings, parking lots, signalling, sidewalks width, etc.) and also to socioeconomic factors of the urban district (population density, land use features, ageing rates, etc).

But in most literature studies dealing with elderly users, the analysis of infrastructure and socioeconomic variables is reduced to subjective perceptions declared by the elderly by surveys (Bernhoft and Carstensen, G. 2008, Oxley et al, 2004) and rarely backed by pedestrian collision data and the analysis of the accident location in the city.

In relation to road infrastructure as variable (sidewalks, parking lots and carriageway) some recent studies (Galanis et al, 2017; Corazza et al, 2018; Demasi et al, 2019) have analysed pedestrian road safety in relation to urban road type and traffic flows, but only a few of them have special consideration for elderly pedestrians (Corazza et al, 2018).

The works developed by Galanis et al (2017) are more focused on pedestrian behaviour (legal or illegal walking behaviour) in relation to infrastructure type and traffic flows. Pedestrian walking on the sidewalk for the entire length of the tested street segment was considered a legal behaviour and otherwise was illegally considered.

In a Greek city of 130.000 inhabitants, the legal or illegal walking behaviour in six different types of streets was recorded by video cameras and photos. Results showed that the highest rate of legal behaviour was presented in main arterials (91.8%) and the lowest one in local streets (53.7%). Low motorized traffic flow levels in combination with maintenance and mobility problems in pedestrian infrastructure push pedestrians to walk outside the sidewalk, underestimating road safety issues.

Corazza et al (2018) focused on the pavement state of the sidewalks and its influence on elderly pedestrian accidents. Distressed or too narrow sidewalks may induce pedestrians to walk outside the sidewalks and on the carriageways, providing very unsafe situations, especially for the elderly. Authors classified the pavement state of the sidewalks in a district of Rome (Italy) and studied the relationship with a higher recurrence of accidents involving pedestrians with special attention to elderly pedestrian accidents.

Finally, Demasi et al (2019) focused on all vulnerable users (pedestrians, cyclists and motorcyclists) and designed a methodology to estimate the level of road safety of each section of a street and the hazard index of the overall branch.

Apart from considering traffic flows and speed limitations, authors identified 9 categories of elements of the street infrastructure to evaluate: pavement, geometry (narrow sidewalk, narrow lane width), lighting, intersections, cross-section (missing pedestrian crossing, pedestrian crossing without ramps), private access (lack of visibility, lack of ramps), road signs (traffic lights, roadside signs), urban furniture (safety barriers, urban furniture causes lack of visibility at intersections, urban furniture occupies shoulder or lane) and stopping (illegal parking).

Although the approach of Demasi et al. (2019) is the most interesting and would be linked and applied to elderly pedestrian accidents, it needs a database fed with a very detailed road inventory. Official accident databases use to give poor infrastructure data associated to the location of the accident and sometimes local authorities cannot supply a good inventory of their streets. The quality of the accident database always conditions the research methodology of road safety studies. This database is designed by the national authorities in each country and is compiled from a collection of road traffic accident information. In comparison to other national data bases, the Spanish one is sufficiently consolidated (Casado-Sanz et al, 2019). The pedestrian accident data used in this paper was extracted from the Spanish Accident Statistics database, and includes the accidents on Madrid city streets involving single vehicle and a pedestrian, during a period of 11 years (2006-2018). Three of the weakest points of the Spanish accident database are:

- The absence of traffic exposure data (traffic flow) associated to the accident location.
- The absence of the street road layout (lane width, sidewalk width) and traffic signalling information associated to the accident location.
- The absence GPS coordinates associated to the accident location (as in the US), using instead the kilometric point on the road in interurban roads or the closest street number in urban scenarios, leading to further data processing problems.

The two first points push researchers to collect these variables from other official databases or develop a systematic procedure of ad-hoc measurement. These ad-hoc works are very laborious, but is the only way to obtain a holistic approach for road safety assessments. The third issue is especially important in urban scenarios because working with GPS coordinates eases the process of assignment of other variables (traffic flows, road layout, sidewalk geometry, etc.) to the accident location point. In this preliminary study, a great effort has been devoted to the GPD coordinates procurement process, while basic infrastructure and socioeconomic variables have been obtained directly from official databases.

3. MADRID DATA BASE AND METHODOLOGY

3.1. Madrid case study

Spain is one of the countries in the world (together with Sweden, Finland, Germany, Italy, Greece and Japan) with the largest number of elderly people. In 2019, Spanish people over the age of 65 were approximately 19.3%, and almost 6% were over the age of 80 (INE, 2019); and this amount could reach 40% in 2060 (United Nations, 2019).

Madrid city has been selected as case study in this research because it is the capital of one of the countries in the world that presents the most positive evolution of the ageing of the population. Furthermore, the city has a high overall elderly proportion of 19%. It is a large city with almost 3.5 million of inhabitants and it is divided into 21 districts. This administrative division will be used in the statistical analysis of this research, as information is available and officially provided at this detail level.

The available data for this study consists of a subset of the Spanish Accident Statistics Database during the period 2006-2018, where collisions involving 1 vehicle and 1 elderly pedestrian took place in Madrid city, as it is explained in the next section. The main issue with the database was to geolocate the events, because their location is recorded using the name of the street and not with GPS coordinates.

3.2. Database

In this section it is explained how the database for the statistical operations was constructed. It consists of two separated operation: dependent (number of crashes per district) and independent variables gathering. This last group is comprised of different nature features about each district. It was intended to use only direct data (i.e., already available) as independent variables in this research.

The first step of the data collecting process was to obtain a clean elderly road safety database containing the location and basic characteristics (e.g., date, time, and type) of the accident to perform further processes of filtration. A simplified National Spanish database of accidents for the period 2006-2018 was the starting point.

Accidents with the profile of “vehicle-pedestrian collisions” were kept, summing up a total of 20,236 accidents. Later, a subset of accidents with a configuration of “1 person and 1 vehicle involved” of 18,118 (89 % of total collisions) records were found suitable to be studied for homogeneity purposes. Finally, the database was filtered to obtain events where the involved pedestrian was 65 years or older. This process provided information about 4,663 elderly pedestrian collisions. A preliminary analysis of this database manifests the fragility of the elderly, as this group represents only 25.7% of total collisions but 50.9% and 34.2% of total fatalities and serious injuries, respectively.

One of the most important operations to perform in the proposed study was to geolocate the accidents based on the name of the street and the number or the name of two streets for street crossings. This procedure became more challenging because of the lack or misspelling of this information in some records. The geolocation of the data required the creation of a database containing every possible location of Madrid city. This was accomplished using GIS operations and different databases, mainly the Madrid Council Open Data Portal and Spain National Geographic Institute (IGN). This information was joined to the accidents database using string-searching algorithms and it was possible to geolocate 97 % of the accidents. Later, the district code was added to each observation and this dataset was grouped by district to obtain the dependent variable to study in this analysis: the number of crashes per district. Figure 1 shows the location of the accidents per city district and victim severity.

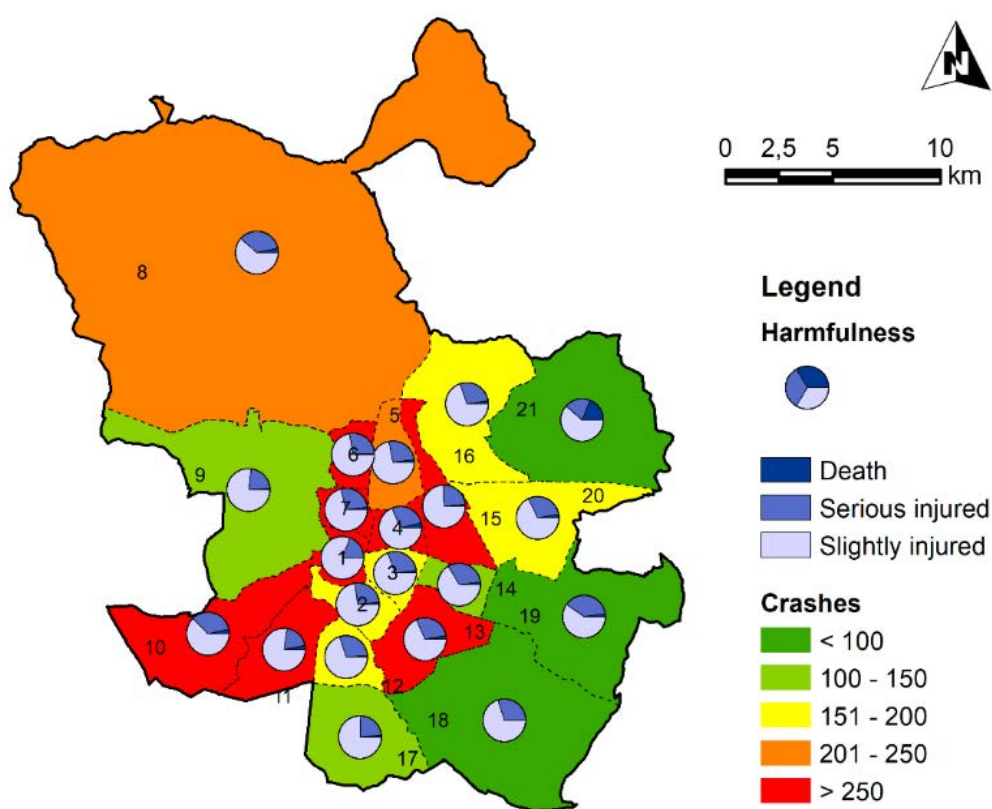


Figure 1: Number of collisions between vehicles and elderly pedestrians and harmfulness in Madrid Districts.

To measure the impact of socio-economic and infrastructure features on elderly road safety in this macroscopic analysis, different variables (see Table 1 and Figure 2) regarding Madrid districts were gathered and processed from various data sources.

Socio-economic variables are inhabitants, population density, ageing rate, average annual income per household and Activity Centres (Point of Interest, POIs). Inhabitants is an indicator of the exposure, in the absence of pedestrian flow data. Population density reflects how crowded a certain district is. Ageing rate captures the population structure.

Average annual income per household states the socioeconomic status of a district. Inhabitants information was available via the Spanish Statistics National Institute (INE) for the period 2006-2014. These data were grouped per year and census section and five-year age group, and via Madrid Council Open Data Portal for the period 2014-2018. These data were grouped per year, district, and age of inhabitants.

It was possible to postprocess both files to construct a single homogenous dataset containing the number of inhabitants living in each district and year, separating them in five-year age groups. Population density was calculated regarding the surface of each district and the information about inhabitants.

Furthermore, ageing rate was obtained as the ratio between inhabitants over the age of 65 and total inhabitants of each district. In the following analysis only last year data will be used for simplicity reasons, because ageing rate has increased slightly in Madrid city. Finally, average annual income per household was obtained for each district directly from the Madrid Council Statistical Portal for the year 2015.

Activity centres were included in this study through the location of Points of Interest (POIs) existing in each district. The number of POIs indicates the possible locations where pedestrians can access to. Hence, it can be associated with a higher pedestrian flow.

This information was obtained directly from the Madrid Council Data Base, when it was possible, and from the Madrid Council Open Data Portal in the form of point-shapefiles that were located on a map and intersected with Madrid districts' geometry. The number of locals per type -restaurants, stores, senior centres, and hospital centres- was calculated in each district. In this study, it was used the total number of these points as a unique variable named POIs.

Infrastructure data group different features about the existing road network. At this point of the research, only direct data will be used. This way, infrastructure variables that require a complex process to be obtained, such as sidewalk widths, are planned to be used in further research. Total length of roads was obtained for each district from the Madrid Council Database.

In consequence, road density considering the surface of each district was computed. Street crossing location was found ad-hoc using the geometry of the street axis and GIS techniques. In addition, signalised street crossing locations is available at Madrid Council Open Data Portal. Hence, it was calculated the proportion of signalised intersections of each district.

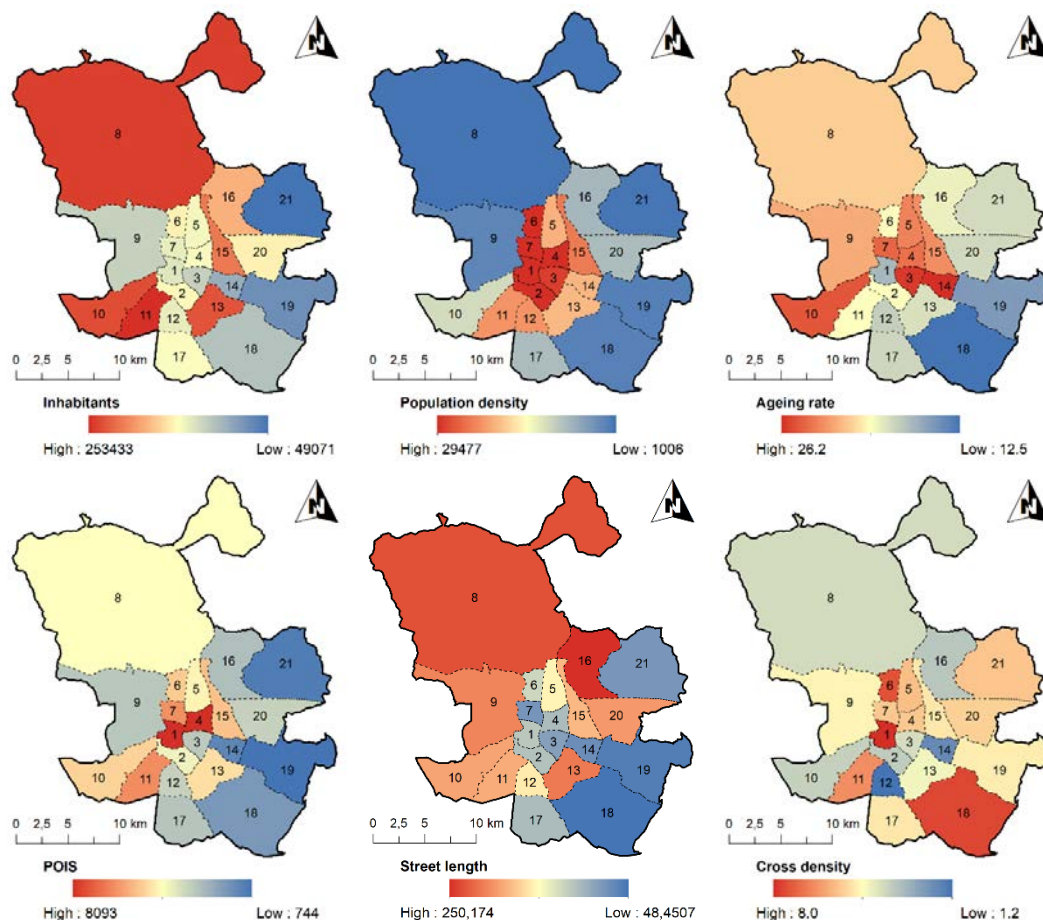


Figure 2: Spatial representation of independent variables.

Group	Variable	Unit	Mean	St. Dev.	Min	Max
Socio-economic	Inhabitants	#	155,834.40	56,436.15	49,071	253,433
	Population Density	#/km2	14,007.85	9,700.58	1,006.00	29,477.78
	Ageing rate	%	20.13	3.78	12.53	26.16
	Average annual income per household	€	39,209.01	11,146.21	24,688.07	60,947.89
Infrastructure	POIS	#	2,844.29	1,637.71	744	8,093
	Road length	km	140.21	62.58	48.45	250.17
	Road density	km/km2	11.67	7.17	0.94	22.74
	Street crossing density	#/km	4.92	1.61	1.18	8.03
	Signalised street crossing	%	18.99	9.69	5.02	43.95

Table 1: Statistical summary of the independent variables.

At this point, the information reunited in this section was ready to construct a statistical model to assess the importance of the independent variables on the number of vehicle-elderly pedestrian collisions per district in Madrid city. These operations are explained in the following sections.

3.3. The Negative Binomial Regression

This study uses a Negative Binomial (NB) Regression, which is widely spread throughout road safety crashes frequency estimation in general and in macroscopic studies (Ziakopoulos and Yannis, 2020). The output of this regression can only have null or positive numbers.

This model is derived from a Poisson-gamma distribution (Hilbe, 2011) and it can handle over dispersed data, on the contrary of the Poisson regression in which the mean and variance of the data are considered to be equal. As overdispersion was present on the crash frequency per district data, a NB was suitable to construct a statistical model. The density function of the NB is as follows (equation 1):

$$P(Y = y_i) = (\Gamma(y_i + \alpha^{-1})) / (\Gamma(\alpha^{-1})y_i!) \cdot (\alpha\mu_i) / (1 + \alpha\mu_i)^{y_i} \cdot (1) / (1 + \alpha\mu_i)^{\alpha^{-1}} \quad (1)$$

Where $P(Y=y_i)$ is the probability of Y being y_i , μ_i is the expected number of events, α is the dispersion parameter and y_i is the number of occurrences at i . The expected number of vehicle-pedestrian collisions is given by the following equation (2):

$$\mu_i = \exp(\beta_0 + \sum_{j=1}^n \beta_j' x_{ij}) \quad (2)$$

Where μ_i is the expected number of events, β_0 is the estimated intercept if it is considered, β_j are the estimated parameters and x_{ij} are the independent or explanatory variables at i .

3.4. Model Assessment

After collecting the proposed variables for every district, the next step is to formulate a Negative Binomial Regression that returns the best goodness of fit in the operation of calculating the total number of crashes in each district. This process involves constructing and comparing every possible combination of the 10 selected variables. Thus, an exhaustive procedure was performed to test every subset of the candidate variables and approximately 1,000 models were constructed and assessed based on their Akaike Information Criterion (AIC). The AIC (equation 3) is an estimator of the goodness of fit based on the likelihood and the number of parameters of the model. This criterion does not report an overall score on the goodness of fit, but a rating to compare a set of models that are employed on the same data. The final model is the one with the lowest AIC value.

$$AIC = 2k - 2\ln(L) \quad (3)$$

Where L is the maximum of the likelihood function and k is the number of parameters of the model.

3.5. Results

In this section it is presented the model that was found to have the lowest AIC value among all the possible ones. This final model is based on inhabitants, population density, ageing rate, road length and number of POIs. All the variables have a positive effect on the total number of collisions between vehicles and pedestrians over the age of 65. The most significative variable is the population density, followed by inhabitants, POIS, ageing rate, and road length. Every variable has a p value smaller than 5%, which means that the null hypothesis of the estimate being null is rejected.

A greater number of inhabitants in a district is found to have direct effect on the number of crashes in that district. This can be explained if it is assumed that a pedestrian that suffers a collision is an inhabitant of that very same district (i.e., pedestrian flow increases with population) or if it is presumed that it is more likely that a person walking in one district is an inhabitant of that district. This way, the variable “inhabitants” could also be understood as an indicator of pedestrians’ traffic. Also, population density is an indicator of how crowded a district is, and even a sign of how tall the buildings are. This way, population density provides an indicator of how many conflicts could happen in an equal area. Ageing rate parameter is found to be positive. It can be understood by the same argumentation about inhabitants and presuming that the elderly usually transits in their own district.

From the infrastructure perspective, as road length increases so does the number of crashes. This is explained because road length is a measure of exposure and as it improves the probability of a crash occurring increases, too.

Finally, from the land use point of view, the number of Points of Interest also has a positive effect on the number of crashes. This fact can be explained because it can be expected that there would be a higher pedestrians and vehicle traffic where there are more of these special locations. In consequence, exposure would be higher in those districts where the number of POIs is elevated. Also, it is important to note that those points act as attractive nodes to people.

Variable	Estimate	Std. Error	z value	p-value	
Intercept	3.103	1.878e-01	16.524	< 2e-16	***
Inhabitants	4.195e-06	8.722e-07	4.810	1.51e-06	***
Population density	2.768e-05	4.775e-06	5.797	6.74e-09	***
Ageing rate	2.354e-02	8.763e-03	2.686	0.00724	**
Road length	2.149e-03	8.456e-04	2.542	0.01103	*
POIs	9.958e-05	2.375e-05	4.192	2.76e-05	***
Significance Codes	0 ‘***’	0.001 ‘**’	0.01 ‘*’		
Log-likelihood	-98.859				
AIC	211.718				
BIC	219.030				

Table 2: Summary statistics of the final negative binomial model.

4. CONCLUSIONS

In this study, a negative binomial regression model was constructed to evaluate the number of collisions between one vehicle and one elderly pedestrian at a district level in Madrid city, considering socio-economic and infrastructure variables to assess their importance. It can be considered a first approach on the subject by the authors. Because of that, mainly direct data has been used to study the phenomenon. A database containing features about Madrid districts was constructed to be the independent variables in this study.

Crashes that were found to be suitable for this study were geolocated using self-designed algorithms to be placed in a GIS software in order to obtain the number of crash occurrences in each city district, that is the dependent variable in this research. Later, these two objects were joined to form the final dataset to construct the regression model. An exhaustive model search was performed to find the model with the lowest AIC, that was the indicator to assess the goodness of fit.

Variables from all groups have been found to be significant. The final regression model is composed by inhabitants, population density, ageing rate, road length and the number of Points of Interest (POIs), being population density the most significant in the model. The small sample size used in this study (21) is due to the lack of direct information about the proposed variables at a smaller spatial level, such as neighbourhoods. This issue can be solved as it is described in the next paragraph.

Further research is considered to be necessary in various respects due to some reasons:

- There is a remarkable heterogeneity inside the districts in some variables. In consequence, the study of the neighbourhoods or using a homogeneous grid is thought to be the next step to follow. Furthermore, some of the candidate variables have not been found to be significant, but in a further analysis at another scale they will be tested again. Also, sample size will be increased if another spatial unit is used. Finally, one of the most time-consuming tasks carried out was to geolocate the accidents. The data obtained in this respect is understood to be valuable and it will be used in further analysis at a smaller spatial level. Because of these main reasons, a similar study on a smaller spatial unit will be carried out, although it will be necessary to measure some already used variables in a different manner.
- New variables that require to be obtained ad-hoc will be employed in further analysis. For instance, it is the case of not available infrastructure data regarding sidewalks width.
- A change in the methodology is also a way to go. In this sense, a significant number of approaches to study the phenomenon could be used. For instance, a multinomial logistic regression to study the severity level or a study based on street segments.

These proposals imply collecting a bigger amount of data and executing more processes than the option of changing the spatial unit to be studied. Therefore, this option will be implemented after the first one.

The ultimate objective of this research is to develop a set of countermeasures to mitigate road safety issues in view of the present population ageing process. Developing criteria and strategies about how cities should be designed is an important subject to reduce elderly pedestrian road accidents. Further research will explore in more detail possible contributory factors that are not found in this paper.

ACKNOWLEDGEMENTS

Daniel Gálvez-Pérez is developing his doctoral thesis while he enjoys a grant from to the Universidad Politécnica de Madrid through the “Programa Propio de I+D+I 2020: Ayudas para Contratos Predoctorales”.

REFERENCES

BERNHOF, I. M., & CARSTENSEN, G. (2008). Preferences and behaviour of pedestrians and cyclists by age and gender. *Transportation Research Part F: Traffic Psychology and Behaviour*, 11(2), 83–95.

CASADO-SANZ, N.; GUIRAO, B.; GÁLVEZ-PÉREZ, D. (2019). Population ageing and rural road accidents: Analysis of accident severity in traffic crashes with older pedestrians on Spanish crosstown roads. *Research in Transportation Business & Management*, 30, 100377.

CHARLTON, J. L., OXLEY, J., FILDES, B., OXLEY, P., NEWSTEAD, S., KOPPEL, S., & O'HARE, M. (2006). Characteristics of older drivers who adopt self-regulatory driving behaviours. *Transportation Research Part F: Traffic Psychology and Behaviour*, 9(5), 363–373.

CHARLTON, J., OXLEY, J., KOPPEL, S., ABURUMMAN, M., HUA, P., & WILLIAMS, T. (2017). Older drivers: A review of the literature, programs and practices. Monash University.

CORAZZA, M.V.; DI MASCIO, P.; MORETTI, L. (2018). Management of sidewalk maintenance to improve walking comfort for senior citizens. *WIT Trans. Built Environ.* 2018, 176, 195–206.

DEMASI, F., LOPRENCIPE, G. AND MORETTI, L. (2018). Road Safety analysis of Urban Roads: Case Study of an Italian Municipality. *Safety*, 4(4), 58.

DUNBAR, G., C.A. HOLLAND, E.A. MAYLOR. (2004). Older pedestrians: A critical review of the literature. Road Safety Research Report No. 37. Department of Transport, London.

GABRIEL, Z., & BOWLING, A. (2004). Quality of life from the perspectives of older people. *Ageing & Society*, 24(05), 675–691.

GALANIS, A., BOTZORIS, G., AND ELIOU, N. (2017). Pedestrian road safety in relation to urban road type and traffic flow. *Transportation Research Procedia*, 24, 220–227.

HENARY, B.Y., IVARSSON J., CRANDALL, JR. (2006). The influence of age on the morbidity and mortality of pedestrian victims. *Traffic Injury Prevention*, 7(2), 182–190.

HILBE, J. M. (2011). Negative binomial regression. Cambridge University Press.

EUROPEAN COMMISSION. (2015). ElderSafe. Risks and countermeasures for road traffic of elderly in Europe. Final report. N° MOVE/C4/2014-244. Brussels: European Commission–Directorate-General for mobility and transport (DG-MOVE).

EUROSTAT. (2015). Population projections: Main scenario - Population on 1st January by sex and single year age.

INSTITUTO NACIONAL DE ESTADÍSTICA (INE). (2019). Indicadores de Estructura de la Población. Proporción de personas mayores de cierta edad por provincia. Available online at: <https://www.ine.es/jaxiT3/Tabla.htm?t=1488> (accessed 15 March 2021)

INTERNATIONAL TRANSPORT FORUM (ITF). (2012). Pedestrian Safety, Urban Space and Health. Organisation for Economic Co-operation and Development.

LANGFORD J, METHORST R, HAKAMIES-BLOMQUIST L. (2006). Older drivers do not have a high crash risk—A replication of low mileage bias. *Accident Analysis & Prevention*, 38(3), 574-578.

OXLEY, J, CORBEN, B., FILDES B., O’HARE, M., ROTHENGATTER, T. (2004). Older vulnerable road users- measures to reduce crash and injury risk. Monash University Accident Research Centre Reports, 218, p-162.

PALAMARA, P., & BROUGHTON, M. (2013). An investigation of pedestrian crashes at traffic intersections in the Perth Central Business. Report No. RR 13-002. Curtin-Monash Accident Research Centre.

UNITED NATIONS. (2019). Department of Economic and Social Affairs. World Population Ageing 2019. United Nations; New York, NY, USA, pp. 1–2

WORLD HEALTH ORGANIZATION. (2007). Global age-friendly cities: A guide. World Health Organization.

ZIAKOPOULOS, A., & YANNIS, G. (2020). A review of spatial approaches in road safety. *Accident Analysis & Prevention*, 135, 105323.