RGC Ref.: N_HKU707/15 NSFC Ref.: 71561167001
(please insert ref. above)

The Research Grants Council of Hong Kong
NSFC/RGC Joint Research Scheme
Joint Completion Report

(Please attach a copy of the completion report submitted to the NSFC by the Mainland researcher)

Part A: The Project and Investigator(s)

1. Project Title

Advancing Transportation Systems Analysis by Integrating Safety Evaluation

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Mainland Team
Name of Principal Investigator *(with title)*	Professor S.C. Wong	Professor Helai Huang
Post	Chair Professor	Professor, Dean
Unit / Department / Institution	Department of Civil Engineering, The University of Hong Kong	School of Traffic and Transportation Engineering, Central South University
Contact Information	Telephone: (852) 28591964 E-mail: hhecwsc@hku.hk	Telephone: (0731) 82656631 E-mail: huanghelai@csu.edu.cn
Co-investigator(s) *(with title and institution)*		Professor Mohamed Abdel-Aty, University of Central Florida Dr. Xin Pei, Tsinghua University Dr. Liang Zheng, Central South University

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval *(must be quoted*)
Project Start date	01/01/2016		
Project Completion date	31/12/2019		
Duration *(in month)*	48		
Deadline for Submission of Completion Report	30/09/2020		

Part B: The Completion Report

5. Project Objectives

5.1 Objectives as per original application

1. To establish quantitative safety assessment methods for decision support in transportation planning, policymaking, and management and engineering by integrating safety evaluation into TSI, trip behavior modeling, and supply-demand equilibrium theory.
2. To develop a transportation network-level safety performance function (i.e., meso CPM) using Bayesian spatiotemporal and hierarchical modeling techniques in

which a variety of factors related to the regional road network, road entities, traffic flow, and human-vehicle systems are accounted for.

3. Based on decision-making optimization theory, to upgrade TSA methodology to integrate the objectives of both transportation efficiency and traffic safety to establish inherently safe and efficient transportation networks.

5.2 Revised Objectives

Date of approval from the RGC: _____

Reasons for the change: _____

_____

1.
2.
3. ....

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

a. Spatial correlation is a factor that cannot be neglected when modeling crash frequencies at road entities [J2, J4, J11, J12, J14, J15, J27, J31, J33, J37, J38, J41, C3]. Artificial neural networks [J1] and distributed lag non-linear models [J39] have been demonstrated as effective tools to model the non-linear relationship between crash frequencies and contributing factors. Given the widespread heterogeneity in traffic safety data [J7, J8, J9, J17, J34, J42, J45], segmenting crashes into relatively homogeneous clusters as a preliminary step when investigating injury severities can help uncover some important influencing factors hidden in the whole-data model [J35].

b. Macro-level CPMs are commonly used to investigate the social, economic, and road network attributes of regions, which assist local authorities in conducting rapid investigations when monitoring regional safety performance [J3, J4, J20, J12, J18, J24, J27, J31, J33, J38, J41, C3, C7]. However, safety is a microscopic concern, as traffic crashes are typically caused by micro-level factors associated with the specific road segments, intersections, or driver-vehicle units involved

[J5, J7, J8, J17, J20, J21, J22, J29, J30, J32, J34, J35, J36, J42, J44, C1, C4, C5, C6, C11]. Although micro-level CPMs can illustrate the effects of the detailed attributes of road entities on crash occurrences [J1, J9, J10, J13, J14, J15, J16, J19, J23, J26, J28, J43, C2, C8, C9], they normally neglect the macro-level factors related to urban development [J6].

c. Bayesian hierarchical modeling has been suggested as a reliable tool to develop meso-level CPMs [J2, J25] because of its capability to integrate all factors potentially responsible for traffic crashes at both the macro- and micro-levels, and to account for network spatial correlation between intersections and their connected road segments. The empirical analysis confirmed that our proposed Bayesian hierarchical joint model outperformed the conventional negative binomial model in terms of goodness-of-fit and predictive performance [J2].

d. Travelers with different safety perceptions make route choice decisions differently. In addition to travel time, the safety performance of routes has been proved to play a significant role in travelers' route choice behaviors [J40]. The incorporation of safety perception into route choice modeling thus helps to achieve more robust and realistic estimations [J40].

Potential for further development of the research and the proposed course of action
(maximum half a page)

Based on this research project, we have updated transportation system analysis theory by an integrated consideration of both transportation efficiency and road safety in transportation planning, policymaking, and transportation management. These achievements set the foundation for the development of a further proposal for a large research grant, such as a Collaborative Research Grant, with the ultimate aim of establishing an inherently sustainable transportation system by integrating the three pillars of sustainability (economic, environmental, and social dimensions) comprehensively. Specifically, given the growing levels of traffic congestion, higher parking costs in metropolitan areas, and serious pollution problems caused by greenhouse gas emission and traffic noise associated with motorization, people are increasingly encouraged to walk and cycle more as viable and sustainable modes of transportation. Despite the well-documented benefits of walking and cycling, pedestrians and cyclists have long been recognized as vulnerable road users and face substantially higher risks of fatality and injury than motorists. Therefore, a hierarchical, prospective, and quantitative approach will be developed to comprehensively evaluate the economic, environmental, and physical benefits of the promotion of walking and cycling, as well as the burdens of traffic injuries to those who walk and cycle more. The outcomes of this research are expected to renew the analytical methodology for sustainable transportation system analysis, fostering a more livable community.

7. The Layman's Summary

(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

Traditional transportation system analysis (TSA) focuses primarily on evaluating and optimizing transportation efficiency. As decisions concerning transportation planning, engineering, and travel-demand management can significantly affect traffic safety, safety should be incorporated into the TSA process. With the ultimate aim of establishing inherently safe transportation networks, we proposed a proactive, system-wide, and quantitative approach to preventing crashes. The approach has three pillars: (1) establishing quantitative safety assessment methods that integrate safety evaluation into transportation system identification, trip behavior modeling, and supply-demand equilibrium theory; (2) developing a network-level safety performance function using advanced statistical techniques accounting for a variety of factors related to the regional road network, road entities, traffic flow, and human-vehicle interactions; and (3) upgrading TSA methodology with the integrated optimization of both transportation efficiency and traffic safety. For methodological demonstration and evaluation, case studies were conducted on the transportation networks of three regions, Hong Kong, Hillsborough County, Florida, U.S., and Hunan province, China. Our research holds promise for the development of an innovative TSA methodology that integrates both transportation efficiency and road safety in transportation planning, policymaking, and transportation management and engineering, which will lead to revolutionary TSA methods.

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s) ***(bold** the authors belonging to the project teams and denote the corresponding author with an asterisk*)*	Title and Journal/ Book *(with the volume, pages and other necessary publishing details specified)*	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institution repository *(Yes or No)*
Year of publication	Year of Acceptance *(For paper accepted but not yet published)*	Under Review	Under Preparation *(optional)*						

2016				[J1] Q. Zeng, **H. Huang***, **X. Pei** and **S.C. Wong**	Modeling nonlinear relationship between crash frequency by severity and contributing factors by neural networks. Analytic Methods in Accident Research, 10, 12-25.	Yes, 2018	Yes	Yes	Yes
2016				[J2] J. Wang and **H. Huang***	Road network safety evaluation using Bayesian hierarchical joint model. Accident Analysis and Prevention, 90, 152-158.	Yes, 2018	Yes	Yes	Yes
2016				[J3] **H. Huang**, Q. Yin, D.C. Schwebei, L. Li and G. Hu*	Examining road traffic mortality status in China: a simulation study. Plos One, 11(4), e0153251.	Yes, 2018	Yes	Yes	Yes
2016				[J4] N. Dong, **H. Huang***, J. Lee, M. Gao and **M. Abdel-Aty**	Macroscopic hotspots identification: a Bayesian spatio-temporal interaction approach. Accident Analysis and Prevention, 92, 256-264.	Yes, 2018	Yes	Yes	Yes
2016				[J5] S. Xu and **H. Huang***	Traffic crash liability determination: danger and dodge model. Accident Analysis and Prevention, 95, 317-325	Yes, 2018	Yes	Yes	Yes
2016				[J6] **H. Huang**, B. Song, P. Xu, Q. Zeng*, J. Lee and **M. Abdel-Aty**	Macro and micro models for zonal crash prediction with application in hot zones identification. Journal of Transport Geography 54, 248-256.	Yes, 2018	Yes	Yes	Yes

2016				[J7] F. Chang, M. Li, P. Xu, H. Zhou, M.M. Haque and **H. Huang***	Injury severity of motorcycle riders involved in traffic crashes in Hunan, China: a mixed ordered logit approach. International Journal of Environmental Research and Public Health, 13(7), 714.	Yes, 2018	Yes	Yes	Yes
2016				[J8] Q. Zeng, H. Wen and **H. Huang***	The interactive effect on injury severity of driver-vehicle units in two-vehicle crashes. Journal of Safety Research, 59, 105-111.	Yes, 2018	Yes	Yes	Yes
2016				[J9] X. Xu, S. Xie*, **S.C. Wong**, P. Xu, **H. Huang** and **X. Pei**	Severity of pedestrian injuries due to traffic crashes at signalized intersections in Hong Kong: a Bayesian spatial logit model. Journal of Advanced Transportation, 50, 2015-2028.	Yes, 2018	Yes	Yes	Yes
2017				[J10] J. Wang, **H. Huang*** and Q. Zeng	The effect of zonal factors in estimating crash risks by transportation modes: motor vehicle, bicycle and pedestrian. Accident Analysis nd Prevention, 98, 223-231.	Yes, 2018	Yes	Yes	Yes
2017				[J11] P. Xu, **H. Huang***, N. Dong and **S.C. Wong**	Revisiting crash spatial heterogeneity: a Bayesian spatially varying coefficients approach. Accident Analysis and Prevention, 98, 330-337.	Yes, 2018	Yes	Yes	Yes

2017				[J12] Q. Guo, P. Xu, **X. Pei***, **S.C. Wong** and D. Yao	The effect of road network patterns on pedestrian safety: a zone-based Bayesian spatial modeling approach. Accident Analysis and Prevention, 99, 114-124.	Yes, 2018	Yes	Yes	Yes
2017				[J13] Q. Zeng*, H. Wen, **H. Huang**, **X. Pei** and **S.C. Wong**	A multivariate random-parameters Tobit model for analyzing highway crash rates by injury severity. Accident Analysis and Prevention, 99, 184-191.	Yes, 2018	Yes	Yes	Yes
2017				[J14] Q. Zeng*, H. Wen, **H. Huang** and **M. Abdel-Aty**	A Bayesian spatial random parameters Tobit model for analysing crash rates on roadway segments. Accident Analysis and Prevention, 100, 37-43.	Yes, 2018	Yes	Yes	Yes
2017				[J15] **H. Huang**, H. Zhou, J. Wang*, F. Chang and M. Ma	A multivariate spatial model of crash frequency by transportation modes for urban intersections. Analytical Methods in Accident Research, 14, 10-21.	Yes, 2018	Yes	Yes	Yes
2017				[J16] X. Xu*, **S.C. Wong**, F. Zhu, **X. Pei**, **H. Huang** and Y. Liu	A Heckman selection model for the safety analysis of signalized intersections. PLoS One, 12, e0181544.	Yes, 2018	Yes	Yes	Yes

2017				[J17] F. Meng, P. Xu, **S.C. Wong***, **H. Huang** and Y.C. Li	Occupant-level injury severity analyses for taxis in Hong Kong: a Bayesian space-time logistic model. Accident Analysis and Prevention, 108, 297-307.	Yes, 2018	Yes	Yes	Yes
2017				[J18] F. Meng, W. Wong, **S.C. Wong***, **X. Pei**, Y.C. Li and **H. Huang**	Gas dynamic analogous exposure approach to interaction intensity in multiple-vehicle crash analysis: case study of crashes involving taxis. Analytic Methods in Accident Research, 16, 90-103.	Yes, 2018	Yes	Yes	Yes
2018				[J19] Q. Zeng, H. Wen, **H. Huang***, **X. Pei** and **S.C. Wong**	Incorporating temporal correlation into a multivariate random parameters Tobit model for modeling crash rate by injury severity. Transportmetrica A, 14, 177-191.	Yes, 2018	Yes	Yes	Yes
2018				[J20] **H. Huang**, Y. Peng, J. Wang*, Q. Luo and X. Li	Interactive risk analysis on crash injury severity at a mountainous freeway with tunnel groups in China. Accident Analysis and Prevention, 111, 56-62.	Yes, 2018	Yes	Yes	Yes

2018				[J21] W. Yan, W. Xiang, **S.C. Wong***, X. Yan, Y.C. Li and W. Hao	Effects of hands-free cellular phone conversational cognitive tasks on driving stability based on driving simulation experiment. Transportation Research Part F, 58, 264-281.	No	Yes	Yes	Yes
2018				[J22] C. Sun, **X. Pei***, J. Hao, Y. Wang, Z. Zhang and **S.C. Wong**	Role of road network features in the evaluation of incident impacts on urban traffic mobility. Transportation Research Part B, 117, 101-116.	No	Yes	Yes	Yes
2018				[J23] S. Xie, N. Dong, **S.C. Wong**, **H. Huang** and P. Xu*	Bayesian approach to model pedestrian crashes at signalized intersections with measurement errors in exposure. Accident Analysis and Prevention, 121, 285-294.	No	Yes	Yes	Yes
2018				[J24] Y. Gu, M. Li, **L. Zheng** and **H. Huang***	Backwash-spread effects of transportation corridors on the development of city groups. Journal of Urban Planning and Development, 144(3), 04018028.	No	Yes	Yes	Yes
2018				[J25] C. Han, **H. Huang**, J. Lee and J. Wang*	Investigating varying effect of road-level factors on crash frequency across regions: a Bayesian hierarchical random parameter modeling approach. Analytical Methods in Accident Research, 20, 81-91.	No	Yes	Yes	Yes

2018				[J26] J. Wang, A. Pervez, Z. Wang, C. Han, L. Hu and **H. Huang***	Crash analysis of Chinese freeway tunnel groups using a five-zone analytic approach. Tunnelling and Underground Space Technology, 82, 358-365.	No	Yes	Yes	Yes
2018				[J27] X. Zhai, **H. Huang***, M. Gao, N. Dong and N.N. Sze	Boundary crash data assignment in zonal safety analysis: an iterative approach based on data augmentation and Bayesian spatial model. Accident Analysis and Prevention, 121, 231-237.	No	Yes	Yes	Yes
2019				[J28] P. Xu, S. Xie, N. Dong, **S.C. Wong*** and **H. Huang**	Rethinking safety in numbers: are junctions with more crossing pedestrians really safer? Injury Prevention, 25, 20-25.	No	Yes	Yes	Yes
2019				[J29] F. Meng*, **S.C. Wong**, W. Yan, Y.C. Li and L. Yang	Temporal patterns of driving fatigue and driving performance among male taxi drivers in Hong Kong: a driving simulator approach. Accident Analysis and Prevention, 125, 7-13.	No	Yes	Yes	Yes
2019				[J30] P. Xu, N. Dong, **S.C. Wong*** and **H. Huang**	Cyclists injured in traffic crashes in Hong Kong: a call for action. PLOS ONE, 14, e0220785.	No	Yes	Yes	Yes

2019				[J31] Q. Zeng, Q. Guo, **S.C. Wong**, H. Wen, **H. Huang** and **X. Pei***	Jointly modeling area-level crash rates by severity: a Bayesian multivariate random parameters spatio-temporal Tobit regression. Transportmetrica A, 15, 1867-1884.	No	Yes	Yes	Yes
2019				[J32] F. Chang, P. Xu, H. Zhou, J. Lee and **H. Huang***	Identifying motorcycle high-risk traffic scenarios through interactive analysis of driver behavior and traffic characteristics. Transportation Research Part F, 62, 844-854.	No	Yes	Yes	Yes
2019				[J33] X. Zhai, **H. Huang***, P. Xu and N.N. Sze	The influence of zonal configuration on macro-level crash modeling. Transportmetrica A: Transport Science, 15(2), 417-434.	No	Yes	Yes	Yes
2019				[J34] X. Zhai, **H. Huang**, N.N. Sze*, Z. Song and K.K. Hon	Diagnostic analysis of the effects of weather condition on pedestrian crash severity. Accident Analysis and Prevention, 122, 318-324.	No	Yes	Yes	Yes
2019				[J35] F. Chang, P. Xu, H. Zhou, A.H.S. Chan and **H. Huang***	Investigating injury severities of motorcycle riders: a two-step method integrating latent class cluster analysis and random parameters logit model. Accident Analysis and Prevention, 131, 316-326.	No	Yes	Yes	Yes

2019				[J36] W. Zhao, M. Quddus, **H. Huang***, J. Lee and Z. Ma	Analyzing drivers' preferences and choices for the content and format of variable message signs (VMS). Transportation Research Part C, 100, 1-14.	No	Yes	Yes	Yes
2019				[J37] H. Zhou, **H. Huang***, P. Xu, F. Chang and **M. Abdel-Aty**	Incorporating spatial effects into temporal dynamic of road traffic fatality risks: a case study on 48 lower states of the United States, 1975-2015. Accident Analysis and Prevention, 132, 105283.	No	Yes	Yes	Yes
2019				[J38] **H. Huang**, F. Chang, H. Zhou* and J. Lee	Modeling unobserved heterogeneity for zonal crash frequencies: a Bayesian multivariate random-parameters model with mixture components for spatially correlated data. Analytical Methods in Accident Research, 24, 100105.	No	Yes	Yes	Yes
2019				[J39] F. Xing, **H. Huang**, Z. Zhan, X. Zhai*, C. Ou, N.N. Sze and K.K. Hon	Hourly associations between weather factors and traffic crashes: non-linear and lag effects. Analytical Methods in Accident Research, 24, 100109.	No	Yes	Yes	Yes

2020				[J40] **H. Huang**, C. Han, G. Xu*, M. Jiang, **S.C. Wong** and M.M. Haque	Incorporating safety reliability into route choice model: heterogeneous crash risk aversions. Analytical Methods on Accident Research, 25, 100112.	No	Yes	Yes	Yes
2020				[J41] Q. Zeng, H. Wen, **S.C. Wong**, **H. Huang**, Q. Guo and **X. Pei***	Spatial joint analysis for zonal daytime and nighttime crash frequencies using a Bayesian bivariate autoregressive model. Journal of Transportation Safety & Security, 12, 566-585.	No	Yes	Yes	Yes
2020				[J42] J. Wang, **H. Huang***, P. Xu, S. Xie and **S.C. Wong**	Random parameter probit models to analyze pedestrian red-light violations and injury severity in pedestrian-motor vehicle crashes at signalized crossings. Journal of Transportation Safety & Security, 12, 818-837.	No	Yes	Yes	Yes
	2019			[J43] A. Pervez, **H. Huang**, J. Lee*, C. Han, J. Wang and X. Zhai	Crash analysis of expressway long tunnels using a seven-zone analytic approach. Journal of Transportation Safety & Security, accepted for publication.	No	Yes	Yes	Yes

	2019			[J44] Z. Yu, H. Zhou*, **H. Huang**, Y. Li and J. Qu	Speed distribution and safety effects of license plate recognition: analysis combining crash and toll record data in Hunan Province, China. Journal of Transportation Safety & Security, accepted for publication.	No	Yes	Yes	Yes
	2020			[J45] H. Zhou, C. Yuan, N. Dong, **S.C. Wong** and P. Xu*	Severity of passenger injuries on public buses: a comparative analysis of collision injuries and non-collision injuries. Journal of Safety Research, in press.				

9. Recognized international conference(s) in which paper(s) related to this research project was/were delivered *(Please attach a copy of each delivered paper. All listed papers must acknowledge RGC's funding support by quoting the specific grant reference.)*

Month/Year /Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institutional repository *(Yes or No)*
December/2016/Hong Kong, China	Behavioral responses to red signal countdown display at signalized intersections based on driving simulator approach	[C1] The 21st International Conference of Hong Kong Society for Transportation Studies	Yes, 2018	Yes	Yes	Yes
December/2016/Hong Kong, China	Incorporating temporal correlation into a multivariate random parameters Tobit model for modeling crash rate by injury severity	[C2] The 21st International Conference of Hong Kong Society for Transportation Studies	Yes, 2018	Yes	Yes	Yes

December/2017/Hong Kong, China	A multivariate random parameters Tobit model for analyzing zonal crash rate by injury severity with spatial correlation	[C3] The 22nd International Conference of Hong Kong Society for Transportation Studies	Yes, 2018	Yes	Yes	Yes
December/2017/Hong Kong, China	Interactive risk analysis on crash injury severity at mountainous freeway with tunnel groups in China	[C4] The 22nd International Conference of Hong Kong Society for Transportation Studies	Yes, 2018	Yes	Yes	Yes
December/2017/Hong Kong, China	Contributory factors to crash severity in Hong Kong by incorporating real-time weather data	[C5] The 22nd International Conference of Hong Kong Society for Transportation Studies	Yes, 2018	Yes	Yes	Yes
December/2017/Hong Kong, China	Identifying high-risk motorcycle-riding behaviors: a multilevel mixed-effects ordered logit model	[C6] The 22nd International Conference of Hong Kong Society for Transportation Studies	Yes, 2018	Yes	Yes	Yes
January/2018/Washington D.C., USA	Gas dynamic analogous exposure approach to interaction intensity in modeling multiple-vehicle crash frequency: a case study of crashes involving taxis	[C7] The 97th Annual Meeting of Transportation Research Board	Yes, 2018	Yes	Yes	Yes
January/2018/Washington D.C., USA	Rethinking safety in numbers: are junctions with more crossing pedestrians really safer?	[C8] The 97th Annual Meeting of Transportation Research Board	Yes, 2018	Yes	Yes	Yes
January/2018/Washington D.C., USA	Bayesian approach to model pedestrian crashes at signalized intersections with measurement errors in exposures	[C9] The 97th Annual Meeting of Transportation Research Board	Yes, 2018	Yes	Yes	Yes

July/2018/Beijing, China	Gas dynamic analogous exposure approach to interaction intensity in multiple-vehicle crash analysis: case study of crashes involving taxis	[C10] The 18th COTA International Conference of Transportation Professionals	No	Yes	Yes	Yes
December/2019/Hong Kong, China	Cyclists injured in traffic crashes in Hong Kong: time to action	[C11] the 24th International Conference of Hong Kong Society for Transportation Studies	No	Yes	Yes	Yes

10. Student(s) trained *(Please attach a copy of the title page of the thesis.)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Pengpeng Xu	PhD	1 September 2016	In progress

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*

1. The paper "Xu, P., **Huang, H.**[*], Dong, N., **Wong, S.C.**, 2017. Revisiting crash spatial heterogeneity: a Bayesian spatially varying coefficients approach. *Accident Analysis & Prevention* 98 330-337" was awarded the Highly Cited Paper by Web of Science in 2020.
2. The paper "Zeng, Q.[*], Wen, H., **Huang, H.**, Abdel-Aty, M., 2017. A Bayesian spatial random parameters Tobit model for analysing crash rates on roadway segments. *Accident Analysis & Prevention* 100 37-43" was awarded the Highly Cited Paper by Web of Science in 2020.
3. The paper "**Huang, H.**, Zhou, H., Wang, J.[*], Chang, F., Ma, M., 2017. A multivariate spatial model of crash frequency by transportation modes for urban intersections. *Analytical Methods in Accident Research* 14 10-21" was awarded the Highly Cited Paper by Web of Science in 2020.
4. The paper "Xu, P., **Huang, H.**[*], Dong, N., **Wong, S.C.**, 2017. Revisiting crash spatial heterogeneity: a Bayesian spatially varying coefficients approach. *Accident Analysis & Prevention* 98 330-337" was awarded the Highly Cited Research Article by the journal in 2020.

Copies of the certificates are attached in Appendix C.

12. Statistics on Research Outputs *(Please ensure the summary statistics below are consistent with the information presented in other parts of this report.)*

	Peer-reviewed journal publications	Conference papers	Scholarly books, monographs and chapters	Patents awarded	Other research outputs (Please specify)
No. of outputs arising directly from this research project [or conference]	45	11			