RGC Ref. No.:
UGC/FDS14/E06/17
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines:
1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

Design of Flexible Vehicle Management Systems for Mass Customised and Sustainable Paratransit Services

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

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Dr. MO, Yiu-wing/ Associate Professor	Department of Supply Chain and Information Management/ The Hang Seng University of Hong Kong
Co-Investigator(s)	Dr. MAK, Ho-yin/ Associate Professor	Saïd Business School/ University of Oxford
Co-Investigator	Dr. WANG, Yue/ Associate Professor	Department of Supply Chain and Information Management/ The Hang Seng University of Hong Kong

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	1/1/2018	NA	NA
Project Completion Date	12/31/2019	6/30/2020	5/6/2019
Duration *(in month)*	24 months	30 months	Same as above
Deadline for Submission of Completion Report	12/31/2020	6/30/2021	Same as above

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. *Analyse new service requirements and the process flows of different paratransit services.*
2. *Design a flexible vehicle management system for an integrated transportation model.*
3. *Formulate a decision model for vehicle routing to meet multiple classes of demand.*
4. *Conduct a proof-of-concept system with the collaborating organisation.*
5. *Evaluate operations performance under various scenarios through simulation experiments.*

5.2 Revised objectives

Date of approval from the RGC: NA

Reasons for the change: NA

5.3 Realisation of the objectives
(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

All the proposed objectives have been achieved through literature review, market study, project meeting with practitioners, survey, computer programming, etc. The results have been published in journal papers and presented in international conference.

The objectives 1-3 focus on the conceptual model of systems design and mathematical programming model for a practical decision problem. We collect management inputs for the design of vehicle management system, which can handle various types of paratransit services. Those inputs have been used to derive a generic decision model of scheduling vehicles for the mixed mode of dial-a-ride service and schedule route service. Preliminary experiments are then conducted to evaluate the systems characteristics.

Objectives 4-5 aim to realize the proposed approach as a proof-of-concept with the collaborating organization. Based on the dataset collected from the organization, we evaluate the characteristics and benefits of managing various types of paratransit through a system approach. The results have been published in an international journal.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. Analyse new service requirements and the process flows of different paratransit services.	✓	100%
2. Design a flexible vehicle management system for an integrated transportation model.	✓	100%
3. Formulate a decision model for vehicle routing to meet multiple classes of demand.	✓	100%
4. Conduct a proof-of-concept system with the collaborating organisation.	✓	100%
5. Evaluate operations performance under various scenarios through simulation experiments.	✓	100%

6. Research Outcome

6.1 Major findings and research outcome
(Maximum 1 page; please make reference to Part C where necessary)
In this research project, the major findings and research outcome are summarized into two areas: i) Design of flexible vehicle management system for paratransit services; ii) Proof of concept for the accessible transportation community.

i) Design of flexible vehicle management system for paratransit services: Dealing with an increase in the variety and volume of transportation demands by people with travel difficulties in the ageing population, transportation organisations need to provide flexible and sustainable paratransit services to meet these increasing demands. Through the collaboration with an organization, we investigate the design of flexible vehicle scheduling systems for community organizations to serve more people and achieve higher operational efficiency. The proposed system is evaluated and designed based on user

requirements for different types of paratransit services. Further, we identify an integrated service option and process flow for dial-a-ride passengers to ride on a vehicle with schedule route passengers. This decision model is formulated as a two-stage decision model and evaluated by numerical simulations with a case study. It is found that the proposed system would enable the organisation to serve more people with fewer vehicles but without an increase in the travelling time. These results demonstrate the importance of a flexible vehicle scheduling system for accessible transportation organisations to sustain their service operations. The result has been published in an international journal paper, entitled "Mass Customizing Paratransit Services with a Ridesharing Option" accepted for the publication in IEEE Transactions on Engineering Management (Mo et al., 2020(a)).

ii) Proof of concept for the accessible transportation community: Through the research study with a non-profit accessible transportation organization, we identify the importance of integrating several information technology systems such as geographic information system (GIS), vehicle scheduling system, enterprise resource planning (ERP) system, simulation system, etc, for the design of flexible vehicle management system. The framework of three module layers of a vehicle routing system is proposed and evaluated based on the dataset collected from the collaborated organization. The application of how to integrate those technologies for the mixed model of schedule route and dial-a-ride services are reported in the published paper, entitled "Design of Flexible Vehicle Scheduling Systems for Sustainable Paratransit Services" in the journal of Sustainability (Mo et al., 2020(b)).

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

With the proof of concept with the collaborating organization, the PI realizes the possibility of managing various services via a system approach once the commonality is well defined, even for a complex transportation problem with demand uncertainty. The developed methodology and techniques in this research project would be leveraged for future research as well as parts of teaching materials. The future research would be focused on the crowdsourcing platform which not only manages the uncertainty on demand side, but also on supply side. Successful case studies can be found in business applications, but not yet in the community transportation services.

7. Layman's Summary

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

Given the current ageing population and limited social welfare expenditure, scholars are renewing their interests in how community organisations can operate to sustainably serve various needs of people with travel inconvenience in society. This research aims to design flexible vehicle management systems that enhance the management of various paratransit services through better system design and optimisation of vehicle resources.

The study scope of paratransit services includes schedule route, dial-a-ride, feeder and pooled dial-a-ride. Users who require those services have different expectations for travelling times, prices, service frequency as well as pick-up and drop-off locations. This variety of service requirements poses numerous new challenges for community organisations to sustain paratransit services. Hence, it is essential to innovate options for a holistic approach to coordinating various types of service in a common sharing platform, which meet people's diverse needs in a more efficient way. The outcomes of this research would support the policy review and operational improvements for community organisations.

Part C: Research Output

8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the 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) *(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 RGC *(Yes or No)*	Accessible from the Institutional Repository *(Yes or No)*
Year of Publication	Year of Acceptance *(For paper accepted but not yet published)*	Under Review	Under Preparation *(optional)*						
2018				Daniel Y. Mo*, Yue Wang, Y.C.E. Lee, Mitchell M. Tseng	"Mass Customizing Paratransit Services with a Ridesharing Option", *IEEE Transactions on Engineering Management*, 67(1), 234 – 245.	2018	Yes (Annex I)	Yes	Yes
2020				Mo, D.Y.; Lam, H.Y.; Xu, W.; Ho, G.T.S.	Design of Flexible Vehicle Scheduling Systems for Sustainable Paratransit Services. *Sustainability*, 12(14): 5594. https://doi.org/10.3390/su12145594	2021	Yes (Annex II)	Yes	Yes

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered

(Please attach a copy of each conference abstract)

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 RGC *(Yes or No)*	Accessible from the Institutional Repository *(Yes or No)*
12/ 2018/ SG	Consolidating Orders in a Crowdsourcing Delivery Network	2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)	2018	Yes (Annex III)	Yes	Yes

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning

(Please elaborate)

The research experience and knowledge transfer have been achieved through supervision of group of students on a senior year project as well as updating the teaching materials in module of information technology in supply chain. A group of students have been involved to deal with vehicle routing problem by using machine learning method and optimization software. In addition, the management of various types of transportation services has been developed as part of undergraduate teaching materials.

11. 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
NA	NA	NA	NA

12. **Other Impact**

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

Apart from the journal publication, this research project also achieved the technology transfer. During the collaboration with the accessible transportation community, the PI's research team shared the benefits of resource saving by using optimization approach and machine learning method. The functionality design and parameter setting have been shared to the accessible transportation community which considered the adoption and evaluation of the proposed methods. Last but not least, the project students have been trained to share the possibility of using those advanced methods during their job seeking process.

13. **Statistics on Research Outputs**

	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	2	1	0	0	Type	No.
					NA	NA

14. **Public Access Of Completion Report**
(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	**Reasons**
NA	NA