BEHAVIORAL URBAN INFORMATICS, LOGISTICS, & TRANSPORT LAB (BUILT@NYU)
C2SMART University Transportation Center, New York University

--- 2021 Research Brief ---

This year continues with the upheaval from COVID-19, with the release of vaccines providing some relief toward a semblance of normality, however fragile. Our lab continued to produce research products this year in our area of specialization of "smart MaaS" research – data-driven, automated operations and decision support for a broad class of Mobility-as-a-Service systems. On a bright note, I was promoted to a distinguished Institute Associate Professor position over the summer.

Our lab completed one grant from C2SMART. We started on two new grants with C2SMART, continue our task with NYSDOT to help them produce an RFP for a next-generation statewide mobility program, an EAGER grant with NSF, and collaboration with the Luxembourg team on the FNR grant. We also have some big announcements coming up so hopefully can report on those next year!

- Quantifying and visualizing city truck route network efficiency using a virtual test bed (**C2SMART**, with $300K in-kind cost share from NYC DOT)
- Autonomous Vehicle Good Citizenry Standard (**C2SMART**, as co-PI with lead PI Sarah Kaufman at NYU Rudin Center)
- EAGER/Collaborative Research: Enable elastic capacity for transportation infrastructure through a transmodal modular autonomous vehicle system (**NSF CMMI-2022967**, as a co-PI with lead PI Prof. X. Li from USF) *(ongoing)*
- NYS DOT on-call agreement Task: Statewide Mobility Serivces Program Strategic Procurement Planning (**NYSDOT SR-20-02**) *(ongoing)*
- Urban Transport Network Design with Privacy-Aware Agent Learning (**NSF CAREER CMMI-1652735**) *(ongoing)*
- M-EVRST (Multimodal Electric Vehicle demand ReSponsive Transport) (**FNR**, as a collaborator with PIs Dr. T.Y. Ma/LISER and Prof. F. Viti/U. Luxembourg) *(ongoing)*
- Urban Microtransit Cross-sectional Study for Service Portfolio Design (**C2SMART**, joint with Dr. Zimmerman from Rudin Center in collaboration with Via Transportation with $20K cost-share) *(completed)*
- **NYU VIP** "NYC Clean Fleet" Team with collaboration from NYC Department of Citywide Administrative Services (DCAS) *(completed)*

Research collaborators include Prof. Ozbay at C2SMART, Prof. Zimmerman at NYU Rudin Center, Profs. Menendez and Jabari at NYU Abu Dhabi, Dr. Tai-Yu Ma at LISER, Prof. Xiaopeng Li at University of South Florida, Oliver Gao at Cornell/CTECH, and researchers at the SKEMA Business School (Prof. David Rey) and UNSW (Prof. Travis Waller). Prof. Michel Bierlaire's PhD student, Selin Ataç, is currently in NYC as a Visiting Scholar.

BUILT participated in two summer research programs once again: the Summer Undergraduate Research Program at NYU, and the ARISE program, which supports high school students interested in STEM research.

Research briefs from 2015 – 2020 can be found here.

Research Highlights

With 14 journal articles and 24 other research products, our research agenda this year is divided into two main thrust areas: (1) learning/inference with dynamic network optimization and (2) MaaS systems evaluation. A third thrust area emerged from the second, involving the development of a virtual test bed for evaluating citywide travel impacts of emerging technologies and policies. All our products are open source. Prototypes of our algorithms can be found either online at https://github.com/BUILTNYU or by request. Key findings are presented.

Dynamic transport system learning and network optimization

The research in this thrust deal with designing algorithms for systems in an online setting, where design decisions (e.g. routing, dispatch, positioning) are interdependent with learning efforts. Gyugeun Yoon continues to develop an integrated network design and optimal learning algorithm, significantly expanding on **sequential transit route design with correlated knowledge gradients**. Some of the preliminary work was presented as a poster at the Google Workshop on Urban Mobility Simulation and Optimization.

In a collaboration with Prof. Jabari's group, a **real-time dispatching algorithm for shared automated electric vehicles** was developed with proven performance guarantees. The algorithm is easy to implement and can help overcome one of the more problematic aspects of SAEVs, which is dealing with the charging requirement while serving customers, which can help many mobility providers transition to a more sustainable future. This work will be presented at ISTTT24 in Beijing.

In the research for modular autonomous vehicles (MAVs), Zhexi Fu continued expanding on his work with new algorithms for **routing microtransit vehicles with the added capability of platooning**. The difference from the literature is that this new work considers modular groupings of vehicles, where travel costs can exhibit economies of scale effects (e.g. average costs of travel can go down with larger platoons). This operating technology is critical to the success of running MAVs in practice to fully exploit their potential. The work will be presented at TRB this January.

MaaS evaluation

Qi Liu led the effort to develop a **stable data-sharing game model for oligopolies of public transit operators**. The model shows that having every mobility operator share data with one another, when they are in competition for passengers, may not always be the best solution. The algorithm allows policymakers to identify the circumstances and the partnerships that would make most sense to form to share data with one another. This work will be consequential with the current emergence of MaaS ecosystems and greater calls for "coopetition" between operators. The work will be presented at TRB in January.

In a collaboration with Prof. Waller and Prof. Rey, we developed new **revenue management models for setting optimal pricing schemes for microtransit services**. One of the major challenges of operating such flexible services is low ridership. By adding more personalization of service through optimized fare pricing, we can design services that can attract higher passenger ridership. The work has been accepted for publication in *Transportation Research Part E*.

Microtransit remains a controversial mode as the success in operation can vary significantly, with many examples of high-profile failures due to high costs and low ridership. One of the challenges is the lack of sufficient sample scenario data across multiple deployments to make adequate forecasts for new deployments at the portfolio level. Our C2SMART project this past year involved developing a **simulation-centric approach to "upscale" scenario data**. Related to this approach is the need to extract further data from multiple cities. One such source is Wikipedia, and a **natural language processing algorithm was developed to get classifying information for thousands of cities** around the world, significantly increasing the data availability for classifying city types for segmenting into forecast models. Both the upscale study and the city typology classifier study are led by Srushti Rath and will be presented at TRB in January.

With the spread of COVID-19, we have seen many shared use mobility services altering their operations to account for the need for social distancing. Inevitably this conflicts directly with demand-responsive transit services like paratransit which require high ridership and occupancy to mitigate operating costs. A research question emerged on characterizing the **trade-off between social distancing and low-cost service**, using data from the NYC Paratransit Division of the MTA. The work will be presented at TRB in January.

Virtual test bed for evaluating travel demand impacts of emerging technologies and policies

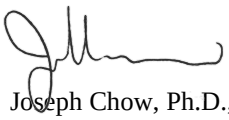
Following the development of MATSim-NYC, we have applied the model to evaluate travel under COVID. In collaboration with Oliver Gao at Cornell/CTECH. We quantified **trade-offs between social distancing measures**

for MTA with impacts on road traffic congestion and greenhouse gas emissions using MATSim-NYC, providing a tool that MTA can use to plan their operations under COVID-19 restrictions. The work was published in *Transportation Research Part A*.

Looking Ahead

The last year has seen my lab's work focus on three major efforts: the integrated learning/optimization for transit, MaaS market evaluation using cooperative game theory, and technology evaluation using a virtual test bed connected to MATSim. With the presence of COVID, we have been adding more efforts to urban deliveries and underserved populations. This work continues with current C2SMART projects, updating MATSim-NYC's synthetic population with a synthetic truck population and identifying a zone design that can support more reliable equity analysis using existing data merged with mobility operator data. In the next year we expect to push more towards equity considerations under different data availability considerations (from limited data requiring scenario data upscaling to ubiquitous synthetic data that allows us to use hybrid machine learning-based discrete choice models).

Sincerely,



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BUILT Lab members active in 2021

PhD student researchers
Susan Jia Xu, Brian Yueshuai He, Ted Pantelidis, Gyugeun Yoon, Qi Liu, Jesse Fu, Bingqing Chloe Liu, Srushti Rath, Haggai Davis, III, Farnoosh Namdarpour, Hai Yang, Xiyuan Ren

MS student researchers
Ziyi Ma (Eisenhower Fellow), Mina Lee, Mengyun Li, Patrick Scalise, Hector Landes

Undergraduate student researchers
Divya Bade (UPenn), Stephanie Tam, Jack Gazard, Junyao Chen, Charles Liu

New Research Products in 2021

Journal publications:

1) **Liu, B.**, **Pantelidis, T.P.**, **Tam, S.**, **Chow, J.Y.J.**, 2022. An electric vehicle charging station access equilibrium model with M/D/c queueing. *International Journal of Sustainable Transportation*, in press.
2) Dong, X., **Chow, J. Y. J.**, Waller, T. S., Rey, D., 2022. A chance-constrained dial-a-ride problem with utility-maximizing demand and multiple pricing structures. *Transportation Research Part E*, in press.
3) **Fu, Z.**, **Chow, J.Y.J.**, 2022. The pickup and delivery problem with dynamic synchronized transfers. *Transportation Research Part E*, 157, 102562.
4) **Ma, Z.**, **Chow, J.Y.J.**, 2021. Transit network frequency setting with multi-agent simulation to capture activity-based mode substitution. *Transportation Research Record*, in press.

5) Wang, D., Tayarani, M., **He, B. Y.**, Gao, J., **Chow, J. Y. J.**, Gao, H. O., Ozbay, K., 2021. Mobility in post-pandemic economic reopening under social distancing guidelines: congestion, emissions, and contact exposure in public transit. *Transportation Research Part A*, SI: COVID-19, 153, 151-170.
6) **Xu, S. J.**, **Chow, J. Y. J.**, 2021. Online route choice modeling for Mobility-as-a-Service networks with non-separable, congestible link capacity effects. *IEEE Transactions of ITS*, in press, doi: 10.1109/TITS.2021.3105230.
7) **Liu, B.**, **Bade, D.**, **Chow, J.Y.J.**, 2021. A bike count forecast model with multimodal network connectivity measures. *Transportation Research Record*, 2675(7), 320-334.
8) **Lee, M.**, **Chow, J.Y.J.**, **Yoon, G.**, **He, B.Y.**, 2021. Forecasting e-scooter substitution of direct and access trips by mode and distance. *Transportation Research Part D* 96, 102892.
9) **Li, M.**, **Chow, J. Y. J.**, 2021. School bus routing problem with mixed ride, heterogeneous fleet, and mixed load. *Transportation Research Record*, 2675(7), 467-479.
10) Dakic, I., Yang, K., Menendez, M., **Chow, J.Y.J.**, 2021. On the design of an optimal flexible bus dispatching system with modular bus units: Using the three-dimensional Macroscopic Fundamental Diagram. *Transportation Research Part B* 148, 38-59.
11) Li, L., **Pantelidis, T. P.**, **Chow, J. Y. J.**, Jabari, S. E., 2021. A real-time dispatching strategy for shared automated electric vehicles with performance guarantees. *Transportation Research Part E*, SI: ISTTT24, 152, 102392.
12) Correa, D., **Chow, J.Y.J.**, Ozbay, K., 2021. Spatial dynamic matching equilibrium models of New York City taxi and Uber markets. *Journal of Transportation Engineering, Part A: Systems* 147(9), 04021048.
13) **Pantelidis, T.**, Li, L., Ma, T.Y., **Chow, J. Y. J.**, Jabari, S. E., 2021. A node-charge, graph-based online carshare rebalancing policy with capacitated electric charging, *Transportation Science*, in press.
14) Wang, D., **He, B.Y.**, Gao, J., **Chow, J.Y.J.**, Ozbay, K., Iyer, S., 2021. Impact of COVID-19 behavioral inertia on reopening strategies for NYC transit, *IJTST*, SI: Transport Systems and Pandemics, 10(2), 197-211.

Conference proceedings:

15) **Fu, Z.**, **Chow, J.Y.J.**, 2022. Modular autonomous vehicle routing with synchronized transfers and vehicle platooning. Proc. 101st Annual Meeting of the TRB, Washington, DC.
16) **Scalise, P.**, **Chow, J.Y.J.**, 2022. Paratransit shared-ride capacity design with infectious disease contact exposure. Proc. 101st Annual Meeting of the TRB, Washington, DC.
17) **Liu, Q.**, **Chow, J.Y.J.**, 2022. Efficient and stable data-sharing in a public transit oligopoly as a coopetitive game. Proc. 101st Annual Meeting of the TRB, Washington, DC.
18) **Rath, S.**, **Liu, B.**, **Yoon, G.**, **Chow, J.Y.J.**, 2022. Microtransit deployment portfolio management using simulation-based scenario data upscaling. Proc. 101st Annual Meeting of the TRB, Washington, DC.
19) **Rath, S.**, **Chow, J.Y.J.**, 2022. Worldwide city transport typology prediction with sentence-BERT based supervised learning via Wikipedia. Proc. 101st Annual Meeting of the TRB, Washington, DC.

Research reports:

20) Urban Microtransit Cross-Sectional Study for Service Portfolio Design, PI: J.Y.J. Chow, Co-PI: K. Ozbay; Sponsor: C2SMART.

Dissertations and Theses completed:

21) **Scalise, P.**, 2021. *Paratransit Operations Design with Disease Contact Exposure*. MS thesis, New York University.

Working papers:

22) **Scalise, P.**, & **Chow, J.Y.J.** (2021). Paratransit shared-ride capacity design with infectious disease contact exposure, https://www.researchgate.net/publication/356597653_Paratransit_shared-ride_capacity_design_with_infectious_disease_contact_exposure.
23) **Yoon, G.**, **Chow, J.Y.J.**, & **Rath, S.** (2021). A simulation sandbox to compare fixed-route, flexible-route transit, and on-demand microtransit system designs. arXiv preprint arXiv:2109.14138.
24) **Liu, Q.**, & **Chow, J.Y.J.** (2021). A congested schedule-based dynamic transit passenger flow estimator using stop count data. *arXiv preprint arXiv:2107.08217*.

Invited Talks:

25) "Modeling capacity effects for route choice in multimodal mobility ecosystems", Google Workshop on Urban Mobility Simulation and Optimization, Nov. 17.
26) "Microtransit deployment portfolio management using simulation-based data upscaling", University of Toronto, Nov. 12.
27) "Microtransit deployment portfolio management using simulation-based data upscaling", Ford Mobility, Oct. 28.
28) "Microtransit deployment portfolio management using simulation-based data upscaling", Via Transportation, Oct. 21.
29) "Overview of MATSim-NYC and Application to COVID", Lawrence Berkeley National Lab, May 5.
30) "Planning towards shared, electric, modular automated mobility", University of South Florida, Apr 2.
31) "COVID modeling lessons learned from NYC: from mode choice behavior to transit contact networks", TRB Workshop: Future of Travel in a Post-COVID-19 Pandemic World, Washington DC, Jan. 21, 2021.

Conference Presentations:

32) "Knowledge gradient-based sequential transit route design", Google Workshop on Urban Mobility Simulation and Optimization, Nov. 17, 2021.
33) "Microtransit deployment portfolio management using simulation-based data upscaling", INFORMS Annual Meeting, Oct. 24, 2021.
34) "An electric vehicle charging station access equilibrium model with M/D/c queueing", INFORMS Annual Meeting, Oct. 24, 2021.
35) "Mobility operator fleet-sharing contract design to risk-pool against network disruptions", INSTR, June 16, 2021.

Prototypes and data:

36) https://zenodo.org/record/5517983#.Yc8voWhKgQ8: code and datasets for urban microtransit cross-sectional study for service portfolio design
37) https://github.com/BUILTNYU/PDPSET: test data for pickup and delivery problem with en-route transfers
38) https://github.com/BUILTNYU/MAV: test data for platoon-enabled modular automated vehicle fleets in Sioux Falls