

本文引用格式 / Please cite this article as:

Luo, Y. D. (2019). From Transportation Infrastructure to Green Infrastructure — Adaptable Future Roads in Autonomous Urbanism. *Landscape Architecture Frontiers*, 7(2), 92-99. <https://doi.org/10.15302/J-LAF-20190209>

从交通基础设施到绿色基础设施 ——无人驾驶城市中的柔性未来道路

FROM TRANSPORTATION INFRASTRUCTURE TO GREEN INFRASTRUCTURE — ADAPTABLE FUTURE ROADS IN AUTONOMOUS URBANISM

1 引言

如今，无人驾驶技术正处于迅速发展阶段，掀起了交通运输业的改革浪潮。在技术层面，Waymo公司无人驾驶汽车的累计路测里程已逾1 609万千米^[1]；特斯拉的全系车型均已搭载SAE L2~L3级^[2]自动驾驶仪^②；由百度公司研发的SAE L4级自动驾驶巴士“阿波龙”已投入量产^[3]。在政策层面，美国已有29个州颁布了与无人驾驶汽车相关的管理条例^[4]；美国国家城市交通官员协会于2017年发布了《无人驾驶城市蓝皮书》，从政策、安全、效率和管理角度探讨了针对无人驾驶汽车的城市设计导则^[5]；2018年，中国多个政府部门联合颁布了《智能网联

<https://doi.org/10.15302/J-LAF-20190209> 收稿时间 RECEIVED DATE / 2019-02-13 中图分类号 / TU984, TP27 文献标识码 / B



罗亚丹

OLIN设计事务所景观设计师；美国景观设计师协会新型交通与新兴技术小组成员；OLIN实验室研究员

LUO Yadan*

Landscape Designer of the OLIN Studio; Member of the New Mobility and Emerging Technologies Subcommittee, American Society of Landscape Architects; Researcher of OLIN Labs

*Corresponding Author

Address: Public Ledger Building, 150 S Independence Mall W suite 1123, Philadelphia, PA 19106, USA
Email: Luoyadan518@gmail.com

摘要

现代道路设计为机动车驾驶者留出了巨大的容错空间，部分区域在午间和夜间等非高峰时段多处于闲置状态，使用率极低。而新兴的无人驾驶技术则可减少容错空间的设置，同时，以该技术为代表的一系列交通技术创新也将重塑城市的形态与空间。当算法控制之下的无人驾驶汽车可以实现精准驾驶时，80%的现有车道空间将可转换为以植被为主的透水空间，由原有交通路网改造而成的巨型绿色基础设施网络也将覆盖城市的每个角落，为修复城市生态系统的连续性提供可能。此外，在高峰时段，云计算系统将为机动车优先分配路权；而在非高峰时段，因机动车路权缩小而释放出的道路空间将为户外餐饮和露天音乐会等活动提供场所。作为景观设计师，作者呼吁更多从业者从生态环境、公共空间和人文关怀等角度展望无人驾驶城市的未来。

关键词

无人驾驶汽车；技术；交通；绿色基础设施；道路柔化

ABSTRACT

Modern road systems consist of a large amount of driving fault-tolerant space for security reasons, leaving much of the area vacant and underutilized in off-peak hours. The emerging autonomous vehicle technology may address this problem while reshaping the urban structure and space through transportation technology innovations. Once the algorithm-controlled vehicles can realize an accurate running, 80 percent of the existing roads can be transformed into vegetated permeable surfaces. As a result, the whole road system will be converted into a pervasive green infrastructure network, which provides an opportunity to enhance the continuity of urban ecosystem. Moreover, the cloud computing technology may help distribute more lanes to vehicles during peak hours and shrink vehicles' right of way during off-peak hours. The saved road space could support activities such as outdoor restaurants and concerts. Finally, the author encourages more landscape architects to contribute to a better future of autonomous urbanism with their visions of eco-environment, public space, and humanity.

KEY WORDS

Autonomous Vehicle; Technology; Transportation; Green Infrastructure; Road Softening

整理 王颖 田乐

EDITED BY WANG Ying Tina TIAN

① 国际自动机工程师学会 (SAE International) 将驾驶自动化划分为无自动化 (L0)、驾驶员辅助 (L1)、部分自动化 (L2)、有条件自动化 (L3)、高度自动化 (L4) 和完全自动化 (L5) 6个等级。

② 更多信息请访问特斯拉公司官网。

① The Society of Automotive Engineers (SAE International) classifies driving automation into six levels: No Automation (L0), Driver Assistance (L1), Partial Automation (L2), Conditional Automation (L3), High Automation (L4), and Full Automation (L5).

② For more information, please visit the official website of Tesla.

1. 以人为导向的乌托邦式 (左) 与以机动车为导向的反乌托邦式 (右) 城市未来

1. A utopian future city with a large amount of pedestrian-oriented neighborhoods (left) and a dystopian future city packed with vehicles (right)

汽车道路测试管理规范 (试行)》，北京、上海等城市相继开放无人驾驶汽车路测。

在不久的将来，以无人驾驶技术为代表的一系列交通技术创新将重塑城市的形态与空间。这种重塑可能是乌托邦式的——更加高效的交通方式将帮助释放大量的城市道路与停车空间，这些空间将转化为以步行为导向的街角公园、线性绿带、漫步道和商店等；也可能是反乌托邦式的——更为廉价和便捷的交通方式将激发大量原本不必要的出行需求，新型交通工具将使现有道路和停车空间更加拥挤，并在技术的加持下占据城市的空中与地下空间，导致步行公共空间和绿色空间被极度挤压 (图1)。如何重新定义城市中人与交通工具的路权归属成为了亟待讨论的议题。

2 现代道路中的容错空间

交通工具的发展侧面反映了人类的进化史。从轮子的发明，到马车、蒸汽汽车，再到汽车、火车、飞机等，人类能够以更快的速度携带更多的物品从一处抵达另一处。但随着速度的提升，这些由人类驾驶的交通工具的安全性也在逐渐降低。对此，人类提出了两种解决方案：一种是以先进的自动化系统代替人类驾驶 (常应用于火车和飞机)，并严格框定其使用场景，以将风险降至最低；另一种是延续人类驾驶模式，同时预留足够的容错空间。

1 Introduction

Autonomous vehicle technology, in a rapid development, is leading to a transportation revolution. From technical perspectives, a range of companies are witnessing breakthroughs. Waymo's driverless system has already racked up 10 million miles of driving experience^[1]; Tesla's full range of vehicles have been equipped with autopilot system of SAE L2 ~ L3^[2] automatic driving^②; and Baidu's auto-driving bus "Apolong" of SAE L4 has commenced mass production^[3]. From policy perspectives, 29 states in the U.S. have enacted regulations on autonomous vehicles^[4]. In 2017, the National Association of City Transportation Officials of the U.S. released the Blueprint for Autonomous Urbanism, which explores urban design guidelines for autonomous vehicles in policy, safety, efficiency, and management^[5]. In 2018, several governmental agencies of China jointly introduced an official regulation on drive test of intelligent connected vehicles; Chinese cities including Beijing and Shanghai have launched drive test programs of autonomous vehicles.

The advances of transportation technologies like autonomous vehicle technology will reshape cities in the near future. For one possibility, due to more efficient transportation modes, traffic and parking spaces in downtowns might be reclaimed towards pedestrian-oriented urban neighborhoods, such as parks, linear green belts, promenades, and stores. For another more pessimistic possibility, however, ever-advancing technologies and vehicles might encourage more unnecessary ride demands and a denser use of traffic and parking spaces, while pedestrian and green spaces or even the sky and undergrounds might be occupied for traffic use (Fig. 1). It is the time to re-examine the right of way between humans and vehicles.

2 The Fault-Tolerant Space of Modern Roads

The transportation development mirrors the episodes of human progress. From the invention of wheels to carriages and steam cars, and to automotive vehicles, trains, and airplanes, humans always pursue a greater and faster transportation. However, manned vehicles are exposing themselves with more and more security problems as transporting speed increases. In response to this, humans have explored two solutions: one is to apply sophisticated automation systems (usually in trains and airplanes) to replace the human drivers in stringent scenarios to minimize risks; the other is to continue humans' driving mode while leaving adequate room for fault tolerance.



目前，第二种模式多应用于汽车驾驶中。为缓解高峰时期交通压力而设计的多车道即包含容错空间，其部分区域在午间和夜间等非高峰时段一直处于空置状态；停车场是另一个典型代表——除去日均两小时的使用时间，私家车大约有22小时都在行驶或停放在他处（图2），不但占用了寸土寸金的城市空间，且难以产生任何价值。就车道而言，3.5m的标准车道可供平均宽度为2m的机动车使用，行驶车辆之间建议保持10~100m不等的安全距离——这些容错空间的设置均是出于对人类反应极限的考虑^[6]。

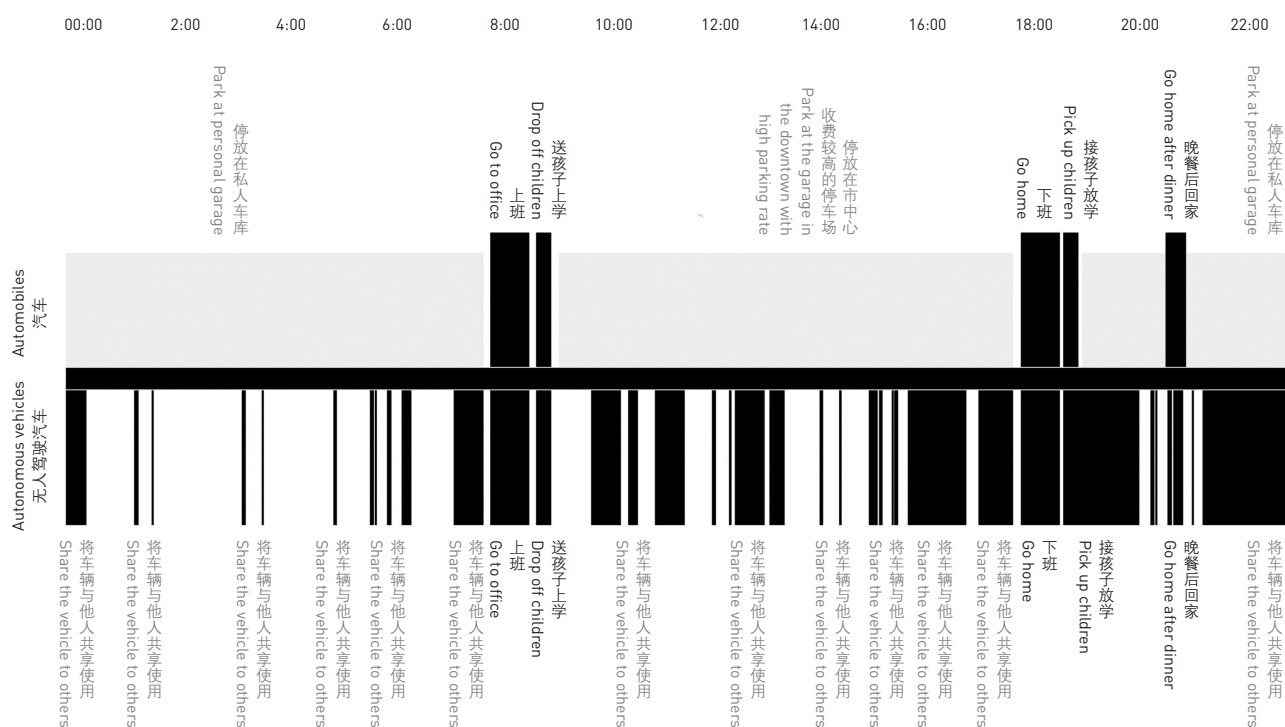
3 无人驾驶汽车开启的城市道路变革

未来，无人驾驶技术将在多个领域掀起巨大变革。首先，云计算技术可统一控制无人驾驶汽车网络，优化配置每条路段的车辆（图2）；空载车辆可自动寻找位于市郊的停车场，而无需占用市中心高地价空间。此外，车载雷达和激光雷达传感器可实时扫描路况信息，并对突发状况进行零延时处理^[7]；在去中心化通信技术的协助下，每辆车均能获取周边车辆的尺寸、目的地和速度等信息，从而轻松实现变道、驶入驶离道路及落客^[8]。再者，由算法控制的无人驾驶汽车可实现精确驾驶，行驶中车辆的间距可以极大缩短（图3）。同时，以电能为代表的清洁能源也将成为未来无人驾驶汽车的主要动力来源。

Now, the latter mode has widely applied in the field of automobile driving. Multi-lane roads and parking lots are two typical fault-tolerant spaces: although helpful for alleviating peak traffic, parts of multi-lane roads may be vacant during off-peak hours; research shows that the average daily vacant hours of a parking lot of private car is 22 hours (Fig. 2), causing a huge waste of urban land resource. The current standard of fault-tolerant space also derives from a consideration on human limits in response to dangers — for a vehicle with an average width of 2 meters, a 3.5-meter-wide lane and a running gap of 10 ~ 100 meters are necessary^[6].

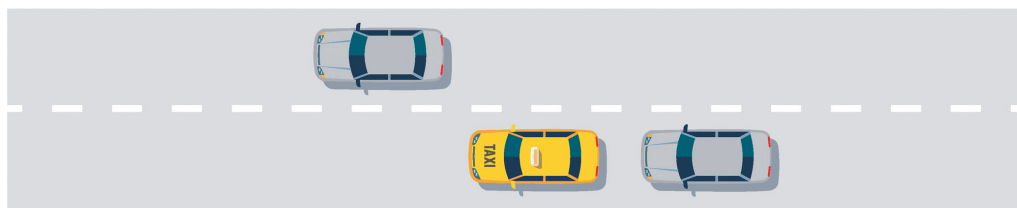
3 Road Revolution of Autonomous Urbanism

In the future, autonomous vehicle technology will make breakthroughs in a range of aspects. First of all, autonomous vehicle networks can be completely operated by cloud computing that would optimize the real traffic volume of each road section (Fig. 2); empty vehicles can park automatically in suburbs instead of occupying downtown spaces. Secondly, autonomous vehicles equipped with radar and LiDAR sensors will detect real-time traffic and react to accidents immediately^[7]; other vehicles' real-time information, including size, destination, and speed, may also be easily obtained with the aid of decentralized communication

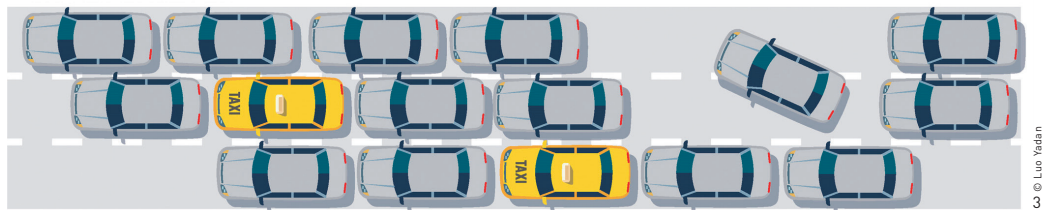


© Luo Yaolan

汽车行驶道路
Road for automobiles



为无人驾驶汽车设计的道路
Road for autonomous vehicles



© Luo Yidan

2. 常规汽车与预期的无人驾驶汽车的日常使用情况
3. 常规汽车行驶间距与无人驾驶汽车行驶间距对比
2. Workday timeline of an automobile in usage and envisioned workday timeline of an autonomous vehicle in usage
3. Spaces between automobiles vs. spaces between autonomous vehicles

3.1 道路柔化计划

为响应上述变革，笔者提出了“道路柔化计划”——基于无人驾驶汽车可精准驾驶这一前提，在现有的3.5m标准车道中，若汽车双轮的着地空间宽度仅需0.5m，那么每条车道所释放出来的3m空间将为修复城市生态系统的连续性提供全新可能。在理想境况下，约80%的现有车道空间均有条件转换为不同层级的植被空间：汽车车轮间1.5m宽的空间可种植生存能力较强的乡土草本植物，两侧各0.75m宽的容错空间可种植乔木类植物（图4，5）；由此形成的交通路网可构建起覆盖城市每个角落的巨型绿色基础设施网络（图6，7），同时连接起碎片化的城市绿地，为不同物种创造连续的栖息地。此外，通过对道路铺面进行植被设计与高程微调，可将特定路段改造为海绵湿地，使经过充分净化的雨水自然下渗，以此来补给甚至取代城市排水系统。当前，遍布城市的不透水沥青路面加剧了城市热岛效应，一方面，由于雨水无法下渗，蒸发过程起到的降温作用受到极大影响；另一方面，该类型路面的低反照率使得地表吸收的太阳热能大大增加^[9]。道路柔化计划无疑能从根本上解决以上问题，其中增种的乔木类植物也能为城市提供大量的林荫空间。

3.2 柔性路权

由于无人驾驶汽车的出现，交通基础设施的定义也将随之拓展。人们只需在出行前提供目的地信息，接下来的整个驾驶过程将交由云计算系统进行控制。在该系统下，每辆无人驾驶汽车均会根据实时交通流量对行驶路线进行调整。由此可以推断，定义路权的将不再是固定不变的道牙、交通标识或信号灯，而是以无人驾驶汽车为代表的可根据道路使用者需求实时调整路权归属的交通基础设施（图8）。

technology, making it possible for lane switching, moving in and out of roads, and dropping off passengers^[8]. Thirdly, as an algorithm-controlled vehicle can accurately drive itself on urban circulation systems, the required running gap can be greatly shortened (Fig. 3). Moreover, clean energy will be the main power source for autonomous vehicles.

3.1 The Road Softening Program

As a response to the transportation revolution, I would propose a Road Softening Program. The program assumes that on the premise of accurate drive of the autonomous vehicles, a standard 3.5-meter-wide lane can be transformed into a combination of two tracks (0.5-meter-wide in total) and three permeable belts (3-meter-wide in total), which may provide an opportunity to enhance the continuity of urban ecosystem. Ideally, 80 percent of an existing lane may be vegetated: the 1.5-meter-wide space between tracks is perfect for local herb plants resistant to busy traffic environment, while the two 0.75-meter-wide fault-tolerant space on each side could offer room for trees' growing (Fig. 4, 5). As a result, the whole urban road system can be converted into a pervasive green infrastructure network in the city (Fig. 6, 7), which connects fragmented urban green spaces and creates continuous habitats for different species. Also, it is possible to convert part roads / streets into sponge bioswales through appropriate planting design and minimum elevation alteration. Rainwater could infiltrate after being purified by the sponge bioswales, which would enhance or even replace the existing urban drainage system. Today, impermeable asphalt pavement dominates urban roads, which results in an increasing urban heat island effect: for one thing, it hinders rainwater infiltration that would impact the heat-reducing function of evaporation; for another, its low albedo increases the solar heat absorbed by the surface^[9]. The solution offered by the Road Softening Program may perfectly respond to these problems, while providing considerable tree shade for the city.

3.2 Right of Way Adaptive to Real-Time Demands

The definition of transportation infrastructure will also expand as autonomous vehicles integrate themselves into the city's transportation infrastructure as the basic adaptable unit. Once the destination is provided by passengers, the driving process will be controlled automatically by cloud computing. The route of each autonomous vehicle can be adjusted instantly according to real-time traffic volume. It is predicted that, in the age of autonomous urbanism, the right of way will be defined by transportation infrastructure that supports instant distribution according to real-time traffic demands, instead of physical road curbs, traffic signs, or traffic lights (Fig. 8).

当前，城市的车道数量多取决于预估的高峰时段车流量。但在非高峰时段，多数道路空间处于闲置状态，机动车拥有大量不必要的路权，而行人的需求却被排除在外。在以无人驾驶汽车为主的未来城市道路交通中，每逢高峰时段，云计算系统可优先将路权分配给机动车（图9）；而在非高峰时段，机动车的路权将不断缩小，具体举措包括减少车道数量、限制车速和关闭部分路段等，由此释放出的空间可为户外餐饮、市集、市民锻炼和露天音乐会等活动提供场所（图10，11）。最终，道路空间将变为可根据机动车与行人需求随时变换形态的弹性空间。

4 无人驾驶汽车专用道设计

将城市中所有路网全部改造为柔性道路无疑是一个漫长的过程，而当下便有一个绝佳的试行机会——无人驾驶汽车专用道。尽管无人驾驶汽车研发人员志在设计可以适应任何路况的无人驾驶汽车，但事实上，天气、路况、网络信号强度等因素都会对无人驾驶汽车的行驶造成影响。因此，针对无人驾驶汽车的交通基础设施更新势在必行。目前，全球已有大量城市开展了相关研究。前文已论述了基于无人驾驶技术进行道路柔化的可能。笔者认为，位于车道与人行道之间的街边停车空间是当前设置无人驾驶汽车专用道的理想试点场所。第一，其无需占用现有城市车道，对整体交通系统影响较小。第二，柔性无人驾驶车道将行人与普通车道隔开，可以起到隔离绿带的作用；同时，这些柔性空间还可以收集来自人行道与车行道的雨水，发挥线性

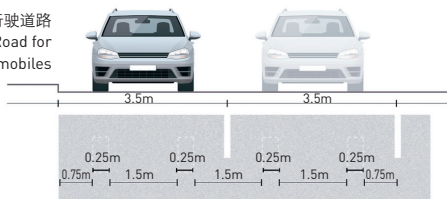
Currently, the number of lanes of urban roads depends mainly on the estimated traffic volume in peak hours. In off-peak hours, however, most roads are less occupied but exclusive to pedestrian use. In the future dominated by autonomous vehicles, cloud computing systems can allocate more rights of way to vehicles during peak hours (Fig. 9) and shrink it during off-peak hours by, for example, reducing lanes, lowering speed limits, and closing some sections of the roads. The saved vacant space can accommodate activities such as outdoor restaurants, markets, citizen sports, and concerts (Fig. 10, 11). Eventually, urban roads will flexibly serve both vehicles and pedestrians according to real-time demands.

4 The Design of Autonomous Vehicle Lanes

Turning the entire urban road system into soft green infrastructure is undoubtedly not easy. However, there is an excellent opportunity for stepping out the first leap of autonomous urbanism — building autonomous vehicle lanes. Although scientists studying in autonomous technology are ambitiously developing vehicles that adapt to any road driving conditions, we cannot deny the fact that the driving of autonomous vehicles is impacted by a number of factors like weather, traffic condition, and signal strength. It makes transportation infrastructure upgrades an imperative. Related

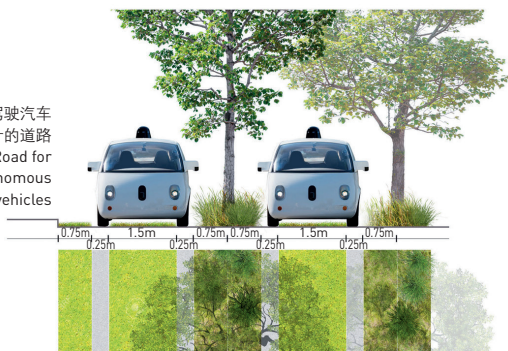
4. 包含容错空间的常规车道与改造后的无人驾驶汽车车道
 5. 改造后的无人驾驶汽车车道——以纽约市街道为例
 6. 常规交通基础设施与柔性道路绿色基础设施示意图
 7. 由交通基础设施转变为绿色基础设施的城市道路网络
4. Sections of a standard road with fault-tolerant space and a transformed road for autonomous vehicles
 5. An example of the road in New York transformed for autonomous vehicles
 6. Renderings of regular transportation infrastructure and green infrastructure
 7. Urban road networks from transportation infrastructure to green infrastructure

汽车行驶道路
Road for automobiles



100%
不透水路面
Impermeable surface

为无人驾驶汽车设计的道路
Road for autonomous vehicles



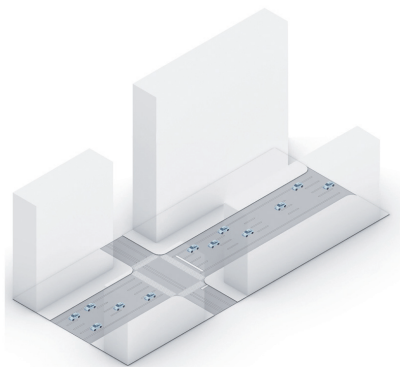
80%
透水路面
Permeable surface

20%
不透水路面
Impermeable surface

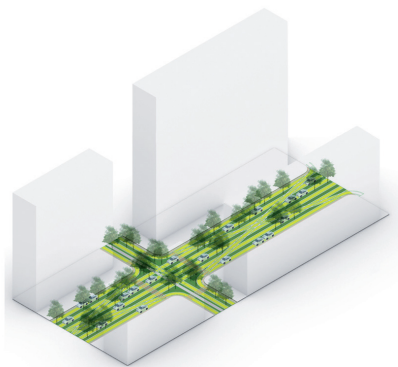
© Luo Yaofan
4



© Luo Yaofan



常规交通基础设施
Regular transportation infrastructure



绿色基础设施
Green infrastructure

© Luo Yadan



供汽车行驶的纽约市道路网络
Road networks for automobiles in New York



供无人驾驶汽车行驶的纽约市道路网络愿景
A vision of road networks for autonomous vehicles in New York

© Luo Yadan
7

research has been seen across the globe, including the Road Softening Program. Here the author believes that the street parking space between vehicle lanes and sidewalks of existing roads would be a perfect site for a trial of the program. First, there is no big alteration needed and little impact on the existing urban road system. Secondly, such a lane will act as both a green barrier that protects pedestrians from vehicles and a linear bioswales that collects rainwater from traffic areas. Thirdly, connected with sidewalks, the lanes can be easily transformed into linear parks in off-peak hours, creating new urban spaces for pedestrians.

The significance of building a soft lane for autonomous vehicles also shines in that it encourages automation engineers to explore how to realize autonomous driving in vegetated urban areas and harmonize the growth of both vehicles and plants. This is an issue that has not been fully studied in the autonomous technology research, which is, however, extremely important for urban development.

Real-time data, usually collected and owned by government agencies or enterprises, is also necessary for autonomous vehicle lane design. Thus, how to access, interpret, and update such data is the key to a soft lane project's success. We may have different strategies to access to various data resource. We can obtain data for free as many smart-city-related start-ups share Application Programming Interfaces (APIs) of data with researchers and partners. For example, the city curb data referred in this article comes from Coord's Open Curbs application^③. For enterprises who do not share APIs, users can manually obtain data through related application interface. For example, the real-time traffic volumes in this study are all sourced from Google Maps. For enterprises who refuse to data sharing (such as Uber), researchers can obtain data through an interpretation of data analyses. For instance, given that Uber recently launched its Express Pool service (a sharing ride in addition to its regular carpooling of UberPool), passengers are asked to arrive the best pick-up / drop-off point by a short-distance walking (within 5 minutes), so as to avoid the detours in the pick-up / drop-off commonly seen in the UberPool mode. The price of Express Pool service is about two thirds that of UberPool^④, which is calculated by Uber's algorithms and big data. Accordingly, we could roughly conclude that the urban walking system can increase the efficiency of the vehicle system by 50 percent.

5 Conclusion

It is the high time to establish systematic regulation to future urban transportation. During my field survey to Mcity of University of Michigan, a connected and automated vehicle test

③ For more information, please visit the official website of Coord.

④ For more information, please visit the official website of Uber.

海绵湿地功能。第三，在非高峰时段，这些与人行道相连的柔性车道可以转化为步行道并延伸为线性公园，为市民创造舒适的步行空间。

建设一条成功的柔性无人驾驶汽车专用道意义重大，这一举措将会促使自动化技术工程师探究如何在植被丰富的环境中实现无人驾驶汽车的精确驾驶，以及机动车与植被的和谐共生。这是一个在无人驾驶技术研发领域不曾被充分考虑，但对城市发展极为重要的议题。

无人驾驶汽车专用道设计亦需要各类城市动态数据的支持，但这些数据大多为政府机构及企业所有。因此，如何收集、解读并实时更新相关数据是项目成功的关键。许多与智慧城市相关的初创企业都可为研究人员或合作伙伴提供应用程序编程接口（API）分析数据。例如，本文所涉及的城市道路道牙信息均来自Coord公司的“开放道牙”应用程序^③。尽管另一些企业不共享API，但用户可通过其应用程序界面获得相关数据。例如，本文所使用的道路实时车流量数据均来自谷歌地图。此外，对于优步公司等拒绝分享数据的企业，我们也可通过逻辑推导来解读其数据分析结果。例如，优步近期推出了快速拼车服务，其要求搭乘者步行一段时间（5分钟内）抵达附近的最佳接/送客点，以避免车辆为精准接/送客人而绕路。据悉，快速拼车服务的价格约为普通拼车服务的三分之二^④，这一定价是优步公司基于内部算法和大数据得出的结果。由此可以推断，城市中的道路步行系统可提高车行系统50%的效率。

5 结语

如今正是为未来城市交通建立系统性规则的关键时期。笔者曾对美国密歇根大学Mcity联网与自动化汽车试验场进行了实地调研——为了给无人驾驶汽车让道，场地内的植被与公共空间被完全抹平。这难免让人担忧未来可能出现以牺牲城市生态为代价提升出行效率的现象，而以车行优先于步行为准则进行城市建设亦可能带来愈发严峻的城市问题。将生态修复与步行空间纳入未来道路系统建设的考量显而易见是明智之举，也是笔者提出道路柔化计划的初衷。

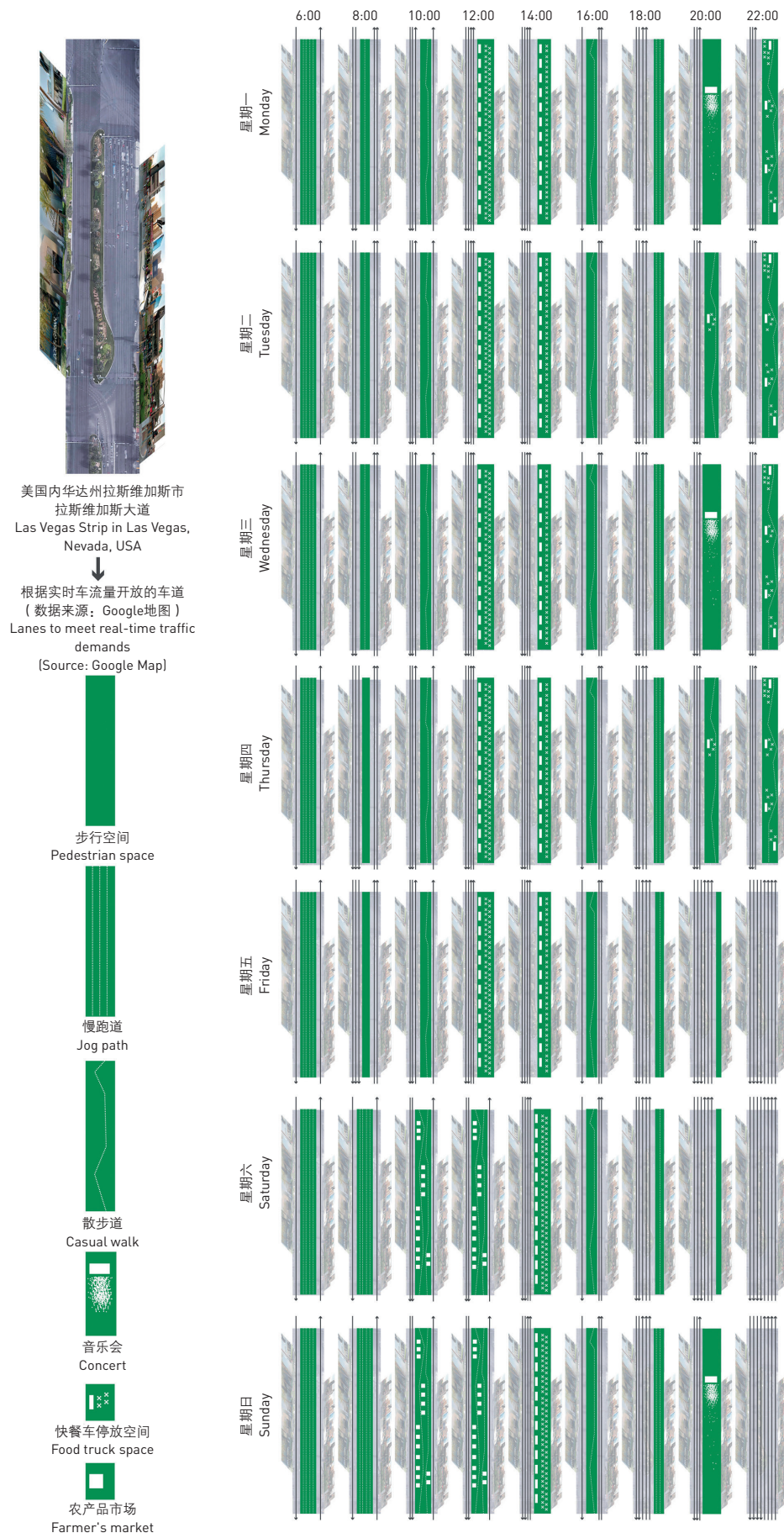
目前，美国景观设计师协会已着手建立新型交通与新兴技术小组（NMETC），从景观设计师所关注的生态环境、公共空间和人文关怀等角度展望无人驾驶城市的未来。作为NMETC的成员之一，笔者深感景观设计师有必要在这一宏大变革中发声。道路柔化是一个理想化概念，其实现程度必然需从经济、社会、政策及具体场地情况等角度进行多重验证。笔者相信，向大众传递这一概念背后的价值观与概念本身同样重要。作为覆盖面最广的城市基础设施，道路系统在满足交通功能的同时，应提供更多的生态和社会服务，而无人驾驶技术则为实现这一目标提供了全新的可能。LAF

致谢

感谢Olin设计事务所景观设计师纳撒尼尔·伍腾及W建筑事务所设计师黄杰对本文的贡献。

③ 更多信息可访问Coord公司官网。

④ 更多信息可访问优步公司官网。





星期一 Monday 10:00

© Luo Yadan



星期一 Monday 12:00

© Luo Yadan



星期一 Monday 22:00

© Luo Yadan

- | | |
|-------------------------|--|
| 8. 拉斯维加斯市拉斯维加斯大道的柔性路权计划 | 8. Adaptable right of way proposition for the Las Vegas Strip, Las Vegas |
| 9. 改造后的拉斯维加斯大道——早高峰时段场景 | 9. Peak-hour scenario of the transformed Las Vegas Strip |
| 10. 改造后的拉斯维加斯大道——午间场景 | 10. Noon scenario of the transformed Las Vegas Strip |
| 11. 改造后的拉斯维加斯大道——晚间场景 | 11. Night scenario of the transformed Las Vegas Strip |

site in the U.S., I was shocked that vegetation and public space within the site were completely wiped out for autonomous vehicle testing. Will it be true that future ride efficiency would be improved at the cost of destroying urban ecology? Will the problem become severer that pedestrians have to give the right of way to vehicles in future urban construction? Obviously, it is smart and necessary to integrate ecological restoration and pedestrian space into future transportation system construction. This is also the goal of the proposal of the Road Softening Program.

The New Mobility and Emerging Technologies Subcommittee (NMETS), established by American Society of Landscape Architects, aims at providing landscape architects' perspectives to future autonomous urbanism in eco-environment, public space, and humanity. As a NMETS member, I deeply stand by that landscape architects should have a voice in this grand revolution. Although the concept of road softening has to be further tested in economy, society, policy, as well as specific site conditions, I believe that conveying the values behind this concept is as important as the concept itself. As the most extensive urban infrastructure, road systems are assumed to provide more ecological and social services — autonomous vehicle technology may offer a great opportunity for this vision. **LAF**

ACKNOWLEDGEMENT

Many thanks to Nathaniel Wooten, landscape designer of the OLIN Studio, and Chieh Huang, designer of W Architecture, for their Contribution to this article.

REFERENCES

- [1] Ohnsman, A. (2018, October 10). Waymo Racks up 10 Million Test Miles Ahead of Launching its Robotaxi Business. Retrieved from <https://www.forbes.com/sites/alanohnsman/2018/10/10/waymo-racks-up-10-million-test-miles-ahead-of-launching-its-robotaxi-business/#63bcc67c7eb>
- [2] SAE International. (2018). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. Retrieved from https://www.sae.org/standards/content/j3016_201806/
- [3] Sina Science and Technology. (2018, July 4). Baidu's auto-driving bus "Apolong" commenced mass production and rolled off the assembly line officially. Retrieved from <http://tech.sina.com.cn/roll/2018-07-04/doc-ihvevauxk1759322.shtml>
- [4] National Conference of State Legislatures. (2019, March 19). Autonomous Vehicles | Self-driving Vehicles Enacted Legislation. Retrieved from <http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx>
- [5] National Association of City Transportation Officials. (2017). Blueprint Autonomous Urbanism. Retrieved from <https://nacto.org/publication/bau/>
- [6] New York State Department of Motor Vehicles. (2011). Driver's Manual: Chapter 8: Defensive Driving. Retrieved from <https://dmv.ny.gov/about-dmv/chapter-8-defensive-driving>
- [7] Anderson, J. M., Kalra, N., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, T. A. (2014). Autonomous Vehicle Technology: A Guide for Policymakers. Retrieved from https://www.rand.org/pubs/research_reports/RR443-2.html
- [8] Makarem, L., & Gillet, D. (2011). Decentralized Coordination of Autonomous Vehicles at intersections. IFAC Proceedings Volumes, 44(1), 13046-13051.
- [9] Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. Journal of Environmental Management, 197, 522-538.