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Complete Campus: Vanderbilt's Integrated Transportation Demand Management and Enhanced Mobility Program

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Abstract

The City of Nashville, Tennessee is one of the most rapidly growing urban areas in the United States. This increased growth has placed considerable strain on the region's transportation system, resulting in growing traffic congestion and greater dependence on single-occupant vehicle use, which also leads to more air pollution. With over 25,000 employees, 12,000 students, and many thousands of annual visitors, Vanderbilt University (located in Nashville) and the surrounding area represents a major activity center that places a significant and growing demand on the transportation network. As part of a campus land use master plan, the University has launched MOVEVU, an integrated transportation demand management and enhanced mobility program. Initiatives include transit improvements; first/last mile connections; shared use mobility device facilities and programs; transportation control measures; innovative projects; and education, outreach and incentives. This paper discusses development and implementation of the MOVEVU initiative, including stakeholder involvement, program activities, expected outcomes, and results to date, with the intent of presenting an innovative application that can be adopted by other locations experiencing similar transportation challenges.

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1. Introduction

The City of Nashville, Tennessee is one of the most rapidly growing urban areas in the United States. Known for its tourism as Music City, Nashville is also home to a vibrant technological community, houses several colleges and universities, and is a hub for the medical services industry. This increased growth has placed considerable strain on the region's transportation system, resulting in growing traffic congestion and greater dependence on single-

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occupant vehicle use, which also leads to more air pollution. A concurrent increase in housing values is forcing many workers, particularly those in the service industry, to live further away from their place of employment in order to find affordable housing, creating an untenable situation. These circumstances call for a proactive management approach directed at congestion mitigation and air quality.

Vanderbilt University (located in Nashville) is one of the state's largest employers and traffic generators. With over 25,000 employees, 12,000 students, and many thousands of annual visitors, the campus and surrounding area represents a major activity center that places a significant and growing demand on the transportation network (see Figure 1).

In November of 2015, Vanderbilt University (VU) administration launched a campus land use master plan initiative. Called FutureVU, the plan articulates a comprehensive vision for stewardship of the University's land and infrastructure (Vanderbilt, 2017; Vanderbilt, 2018a). This initiative quickly expanded beyond the typical campus plan, encompassing issues related to accessibility, sustainability, mobility and transportation, influenced by the University's guiding principles (Vanderbilt, 2018b).

Of particular interest was a desire to provide mobility and transportation options that prioritize alternative modes of transportation over single occupancy vehicles. This set in motion a commitment to implement an integrated transportation demand management and enhanced mobility program (MOVEVU), one that:

- maintains a safe and reliable transportation system for people and goods
- manages the negative impact of traffic congestion by providing alternatives to single occupant driving
- incorporates information technologies to improve traffic operations and help optimize traveler decisions
- aligns transportation decisions with economic development initiatives, land use planning, and open space conservation efforts
- integrates healthy community design strategies and active transportation to improve the public health outcomes of the built environment
- pursues solutions that promote social equity and contain costs for transportation and housing
- improves the connectivity between workforce and jobs by offering a range of options to manage commuting distances and travel times
- fosters regional collaboration to prioritize the most effective solutions

This paper discusses development and implementation of the MOVEVU initiative, including stakeholder involvement, program activities, expected outcomes, and results to date, with the intent of presenting an innovative application that can be adopted by other locations experiencing similar transportation challenges.

2. Stakeholder Involvement

The MOVEVU concept began when Vanderbilt embarked on a process of inclusive stakeholder engagement to envision a future transportation system that would be responsive to the mobility needs of its constituents and neighbors while also prioritizing the sustainable impact of the campus and the surrounding Nashville community. Several working groups were formed among VU faculty, staff and students, who met for several months to discuss and formulate recommendations related to transit improvements, cross-campus shuttle opportunities, rideshare options, campus biking and pedestrian infrastructure improvements (Vanderbilt University, 2018c). Concurrently, community input was provided by Nashville Mayor Briley's office and City Council members, as well as feedback from neighborhood groups. A focus of these discussions was the need to provide alternatives to the single-occupant vehicle as a primary mode of transportation in order to make better use of the VU footprint, improve sustainability, and offer healthier, more flexible forms of travel. This process led to two important conclusions: 1) VU must increase the priority consideration of those walking, bicycling, and taking transit to/from/within campus, and 2) VU must ensure travelers can complete their trip - recognizing people often arrive at their destination using a variety of modes, information sources, technology, and street infrastructure in moving from their origin to their destination.

These observations motivated the development of a conceptual approach designed to: 1) expand the supply and availability of sustainable alternatives, 2) provide the physical and intelligent infrastructure necessary to enable

alternative transportation, 3) control demand for the use of unsustainable modes, and 4) provide incentives for undertaking sustainable travel habits. The outcome of this effort was expected to be an improvement in air quality (lower vehicle emissions from a reduction in the total vehicle miles traveled, utilization of more sustainable vehicle alternatives) and reduced congestion (fewer cars on the road, greater use of off-peak travel periods). It was also anticipated that secondary benefits would accrue through: 1) improved travel times from reduced congestion for other metropolitan travelers due to decreased VU peak travel demand, and 2) the collection of a rich database of travel behavior information (derived from the implementation of service performance tracking and communication technologies) available for use by interested parties to identify further opportunities to enhance travel mobility and safety.

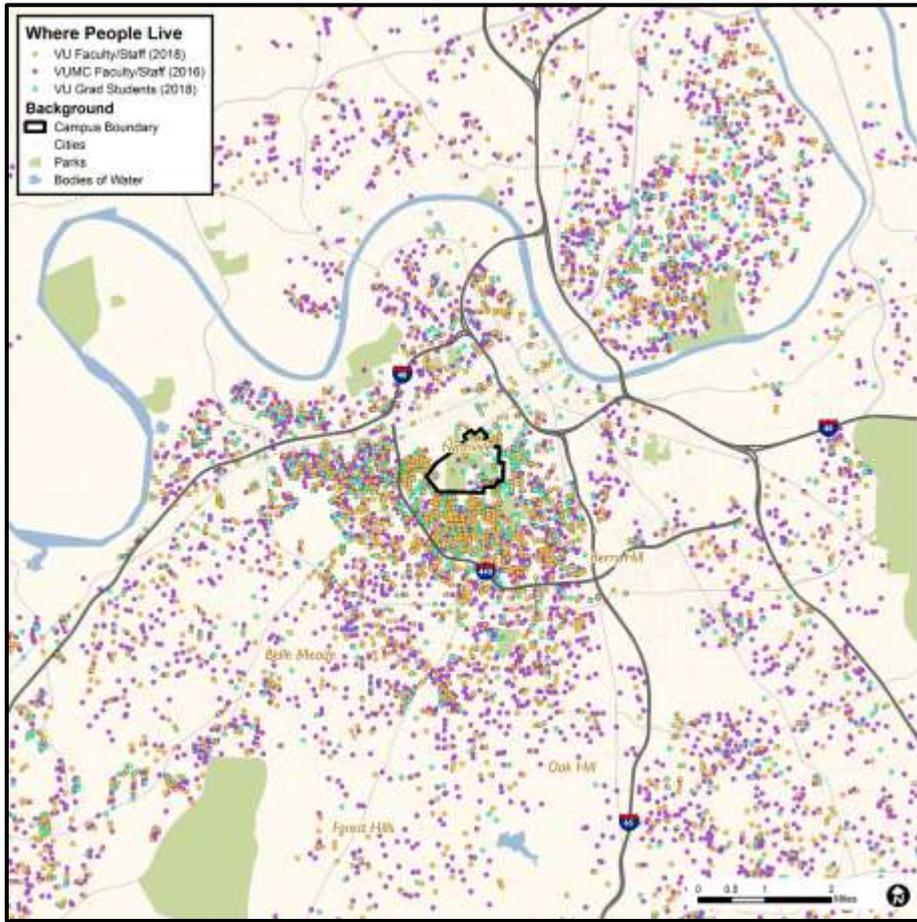


Figure 1. Location of VU Commuter Residences and Distance from Campus

In addition to its internal focus, VU began working with city and state officials to achieve a more robust impact on congestion management and air quality throughout the region, by offering connected and complementary travel options that would be more efficient and sustainable. Fundamental to these relationships is the existence of the Congestion Mitigation and Air Quality (CMAQ) improvement program. CMAQ provides dedicated federal funding to state departments of transportation to invest in initiatives that improve air quality and reduce congestion. With these funds, the Tennessee Department of Transportation (TDOT) awards grants through a competitive process to transportation projects and programs that reduce air emissions from cars, trucks and buses (mobile sources) in air

quality non-attainment and maintenance areas^{*}. These grants require a matching funding component from the applicant.

Nashville received a CMAQ grant as part of an earlier TDOT solicitation for the purpose of establishing a unified program to promote transportation options and encourage behavioral changes that can meaningfully reduce congestion in the metropolitan area. The approach being taken by the city is to encourage use of more sustainable transportation choices, where the target audience is travelers moving to/from/within the area.

Whereas Nashville's CMAQ mission is to inform the public with the goal of modifying travel behavior, MOVEVU focuses on a complementary approach directed at enabling travelers to modify their travel behavior. For this reason, VU applied for a separate CMAQ grant to address many of the University's proposed MOVEVU activities, with the intent of applying the grant to help catalyze program implementation. VU was recently notified of its selection as a CMAQ award recipient, receiving \$4.6 million from TDOT, to which VU has agreed to provide another \$4.6 million in matching funds. This award is particularly notable in terms of its size and the fact that VU is a private institution. TDOT's decision is indicative of the difference it believes that VU can make as a community leader and pilot of an integrated transportation demand management and enhanced mobility program that others can emulate.

As respective CMAQ award recipients, VU and Nashville are now engaged in a dialogue to seek ways to synchronize service offerings, share ridership data, and integrate fare collection methods. Additionally, VU, Nashville and TDOT are having synergistic discussions focused on extending integrated transportation demand management and enhanced mobility opportunities throughout the region.

3. MOVEVU Activities

The MOVEVU program is comprised of the following components: 1) transit improvements, 2) first/last mile connections, 3) shared use mobility device facilities and programs, 4) transportation control measures, 5) innovative projects, and 6) education, outreach and incentives. These activities are described below; Figures 2 and 3 provide visualizations of proposed MOVEVU enhancements.

3.1 Transit Improvements

- Transportation Hub - Create a multi-modal hub at the center of campus that becomes the heart of transportation-related campus activities, including a plaza for events/gatherings, bike/scooter share stations, bike repair shop, bike/scooter parking, information center to learn about transportation options, shuttle stops, and coordination of first/last mile, non-motorized connections around campus and to transit stops at the perimeter of campus.
- Better connections to transit – Work closely with the city, including potential financial partnerships, to support frequency and other service improvements to key transit routes that serve the Vanderbilt community. Ensure transit stops on the perimeter of campus are safe, comfortable, and convenient.

3.2 First/Last Mile Connections

- Campus Shuttle Fleet Expansion and Replacement - Obtain new campus shuttles that run on alternative fuel that reduce carbon footprint while maximizing accessibility. Shuttles will provide last mile access to parking lots and late-night safety service for students.
- Alternative Fuel and Lot Infrastructure for Shuttles - Upgrade existing shuttle lot for improved use and security, including ensuring that the appropriate fueling or charging infrastructure for sustainable vehicles is in place.
- Shuttle Operations - Fuel and labor costs to operate and maintain expanded shuttle service.
- Shuttle Shelters - Construct new shuttle shelter stops that are convenient, safe, well-lit and have appropriate wayfinding signage.
- EV Car Sharing – Partner with an EV car share provider to serve student needs for traveling off campus (e.g., malls, supermarkets) and for midday trips for commuters.

^{*} Nashville and the surrounding area qualifies as a non-attainment area.

- “Last Mile” Cart Fleet with Sustainable Technology – Consider acquisition of electric and/or hybrid carts to transport travelers to/from transportation hub to desired campus destinations, support handicapped travelers with accessibility needs, and utilize for other campus purposes (e.g., transporting supplies) when passenger demand is low.
- Create Ride Share Pick Up/Drop Off Locations - Create ride share pick-up and drop-off locations in strategic areas around campus to accommodate increased use of ride share services; utilize rideshare and carpool matching services.

3.3 Shared Use Mobility Device Facilities and Programs

- Bike/Scooter Share - Enable bike/scooter access within and surrounding campus.
- Shelters - Add bike/scooter shelters, positioned in high traffic areas and on the perimeter of campus, that protect bikes/scooters from the weather and include clear signage and stronger security.
- Bike Repair Stations - Add bike repair stations in key locations across campus that allow bike users to handle maintenance needs.
- Additional Shower Facilities - Construct additional shower facilities to make bike/scooter commuting more appealing and convenient.

3.4 Transportation Control Measures

- Walk and Roll Path & Greenways – Create a pedestrian (“walk”) and bicycle/scooter (“roll”) path that goes around the entire perimeter of campus, creating a much more inviting edge. Develop greenways throughout campus, as well as additional paths that can accommodate rollers and pedestrians.
- Raised Crosswalk Installations - Construct raised crosswalks in high-traffic areas to increase pedestrian and roller safety.
- Road Reclamation & Complete Streets - Remove parking from the center of campus, close roads and implement limited access pathways and complete streets in their place to make campus more pedestrian and roller friendly.

3.5 Innovative Projects

- Sensor & Bluetooth Technologies - Install tracking and communication system using smart technologies such that air quality and mobility performance can be monitored and travelers informed in real-time; includes communications infrastructure to enable receipt, storage and access to data streaming.
- Data Analytics - Services performed to assess the efficiency and effectiveness of system operations, measure corresponding congestion management and air quality benefits, and understand how people with connected devices move to and throughout campus.

3.6 Education, Outreach and Incentives

- Mobility Office – Create and staff a Mobility Office, charged with: 1) providing overarching vision and strategy for the various efforts taking place on campus, 2) interacting with leaders within the University, city and surrounding partners/neighborhoods to ensure expanded transportation coordination, and 3) providing education and communication efforts on campus and beyond.
- Car Share Subsidies - Provide subsidies for using car share services to encourage use of alternative modes to single occupancy vehicles.
- Daily Parking Charges, and Preferred Parking Rates for Alternative Transport Users - Offer monetary and convenience incentives to those who regularly use alternative modes of transportation and may need to occasionally travel to campus via a single-occupant vehicle. Charge daily for parking for people that travel in a single occupant vehicle, so they must pay for that choice each day.
- Subsidize Existing Transit Services - Offer commuters reduced rates for city/regional buses and commuter rail.
- Incentives for Low Emission Vehicle Car Use - Provide preferred parking and/or reduced parking vehicle rates incentives to travelers who commit to purchasing and using a low emission vehicle instead of a typical single-occupant vehicle.
- Encourage Use of Carpooling and Alternative Transportation - Offer fare subsidies and cash out programs to incentivize staff to not drive to campus, in order to make alternative transportation more appealing.
- Marketing Materials - Develop and disseminate marketing materials to educate and encourage employees, students and visitors to use available alternatives to the single-occupant vehicle and make more off-peak trips.

Recognizing that many of these activities require implementation in parallel, while others need to be phased in sequence, a detailed three-year implementation plan has been developed.



Figure 2. Subset of Components Included in the MOVEVU Initiative

4. Emissions Analysis

A key motivation behind MOVEVU is the reduction in air quality emissions. This prompted a detailed assessment of the potential for reducing harmful emissions based on travel behavior modifications that could be achieved, as described below.

Emissions estimates based on current (baseline year of 2017) travel behavior were performed by using the home addresses of VU commuters to determine quartile breakdowns of commuting distance for the overall VU population. This analysis produced a median daily round-trip distance of 19.6 miles, with some trips of up to 173 miles (see Figure 4). This data was then used to calculate actual commuting annual vehicle miles traveled (VMT) in baseline year 2017, which resulted in an estimate of slightly over 150 million VMT. The VU-specific VMT along with regional travel data was then input to the EPA MOVES2014a model (USEPA, 2015). As MOVES2014a also requires model type, fuel type and age distribution of vehicles, VU's parking permit database was used to generate this information.

As implementation of MOVEVU can be expected to produce emissions benefits over an extended period, a project lifetime impact date of 2050 was utilized. Going forward, a 2% annual growth rate for VU's employee and student populations was applied to be consistent with VU's growth rate over the past decade. A 15% reduction in parking places was assumed for the first full year of emission estimates as this is likely to occur independent of MOVEVU implementation[†]. In addition, a 50% reduction in available parking was assumed for 2050, due to the impact of the MOVEVU initiative.

[†] Some parking places are being removed in order to build new dormitories.

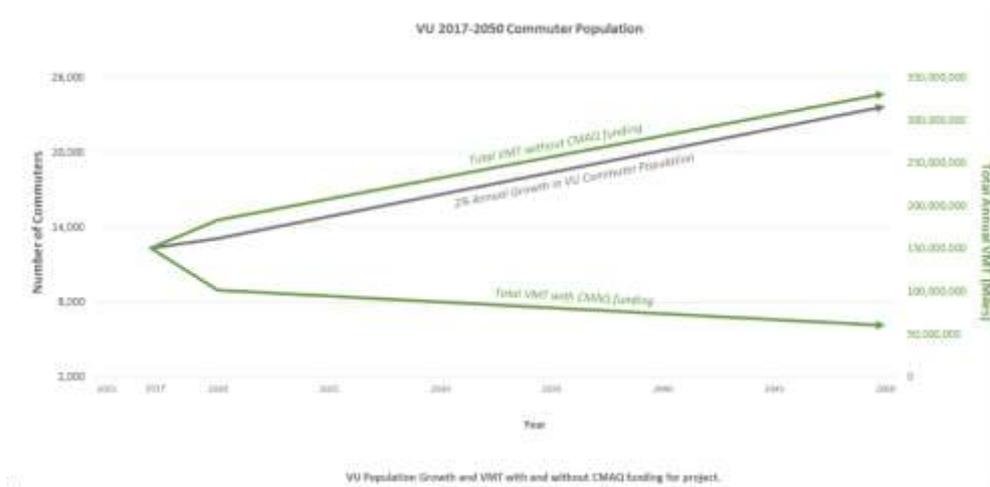


Figure 5. Trajectory of VU Commuter VMT Growth Over Time

	All Criteria Pollutants	PM2.5	NOx	VOC	CO
First Full Year Emissions Reduction (kg/year)	654,932	808	76,630	36,404	541,090
Emissions Reduction in 2050 (kg/year)	1,327,812	1,796	113,730	63,978	1,148,308
Lifetime Emissions Reduction (kg/life)	39,834,360	53,880	3,411,900	1,919,340	34,449,240

Figure 6. Emissions Reduction Estimates for the MOVEVU Program

5. Expected Outcomes

MOVEVU represents a unique undertaking for a variety of reasons, providing an opportunity to achieve a number of significant outcomes, as discussed below.

5.1 Collaboration between University Faculty, Staff, Administration and Students

The underpinning of the MOVEVU initiative was the result of a faculty, staff, administration and student collaboration that began with discussion groups on campus, grew to a more formalized concept, and continues today as MOVEVU is evolving. Of particular interest in this relationship is the extent to which faculty are relying on leadership from the VU administration while the administration is relying on faculty transportation planning expertise.

5.2 Integrated and Holistic Approach to Complex Issues

Many transportation demand management projects are characterized by a single enhancement, directed at a specific aspect of improved mobility. While these “one-off” initiatives have merit, they do not provide the opportunity to effect a transformational change in travel behavior. The MOVEVU program is built on the belief that a significant cultural, technological and infrastructure change is necessary to meet society’s mobility and sustainability needs going forward – in essence a “Complete Campus”.

5.3 Scalability within an Urban Area and Transferability to Other Major Employers

To have such a large body of travelers who are being offered sustainable transportation alternatives under a controlled environment represents an opportunity to profile a high visibility program that can be transferable to other large employers locally, regionally, nationally and internationally. This opportunity is important because changing the traveler behavior of a single large employer can have a more significant impact on congestion and air quality in an affected area than changing the travel behavior of several smaller employers.

5.4 Focused on the Linkage between Transportation and Affordable Housing

The interdependency between transportation and affordable housing has become an important consideration, as many workers are being priced out of living in close proximity to their employment location, particularly in urban areas. FutureVU is committed to building affordable housing closer to campus, inducing shorter employee travel times and making greater use of alternatives to single occupant vehicles. An interesting dynamic involves motivating the use of alternative modes of transport such that the University can remove some of its parking facilities and construct affordable housing in its place.

5.5 Use of Smart Technologies and Data Analytics

MOVEVU includes a distinct data analytics activity, for the purpose of enabling a more accurate assessment of the impact of program implementation in modifying travel behavior over time. This is being accomplished by instrumenting the campus and periphery with sensor technologies to capture trip origins, destinations, travel times and modes at various stages during the lifetime of the project. Beyond the benefits to the VU project, this approach offers the potential to produce improved methods for measuring air quality and mobility performance that are transferable to other locations.

5.6 Creation of a Real-World Laboratory for Mobility Research

The manner in which the University campus and its perimeter is being instrumented will create a real-world environment for performing mobility research. The data analytics that can be performed from the information transmitted by the system of sensors, combined with machine learning, will be able to support a variety of temporal and spatial applications related to: 1) air quality monitoring, 2) mode share, 3) vehicle occupancy, 4) origin-destination trip patterns, 5) travel time and congestion, 6) safety analysis, and 7) traveler behavior. This environment also provides a testbed to evaluate the benefits and drawbacks of deploying autonomous vehicles in a controlled setting.

5.7 Workforce Development

The involvement of the VU student population in transportation planning activities, through existing working groups and with MOVEVU implementation, represents an important opportunity for the next generation of leaders to gain knowledge and expertise related to sustainable transportation practices. As transportation is a critical infrastructure sector, and a large percentage of a nation's economy relies on a resilient and sustainable transportation system, active student engagement in an initiative such as MOVEVU can provide them with early exposure to a field that can evolve into a professional career. Creating these "real-world" opportunities is an important recruitment tool for a field where succession planning has become a pressing need.

6. Early Results

MOVEVU activities began with the conduct of a short-term pilot with ofo, an international bike share operator, to test dockless bike share on campus. The pilot officially launched on VU's campus in March 2018, with the delivery of 120 bikes. The University is using the data provided by ofo to map out individual bike trips, further analyze the effectiveness of current campus pathways, consider adjustments to paths and sidewalks to better accommodate this form of transportation, and reduce pedestrian and bicycle conflict. ofo also tracks health data by determining the amount of calories burned by the user for each trip, as well as the amount of carbon emissions saved by riding an ofo bike versus traveling the same distance in a car.

The first month of the pilot witnessed significant utilization of ofo bikes, with nearly 5,000 people registered to use the ofo app, and over 64,000 bike trips taken, covering 22,455 miles. The ofo pilot has allowed more people to ride bikes who normally might not, given a variety of barriers to personal bike ownership, including the cost to purchase a bike as well as maintenance. Moreover, access to bikes has been optimized by having ofo rebalance its fleet to high demand areas on campus and recover bikes outside of the geofence boundary and bring them back to campus daily.

Concurrently, VU has established its Mobility Office and hired an executive director, is in the process of preparing a detailed strategic and tactical implementation plan, and begun the process of qualifying vendors for the provision of shuttle operations. A communications plan has also been developed, with educational and promotional events already being held. Additionally, a campus schematic has been prepared that shows the types and placements of sensors to measure air quality and mobility, with an eye towards generating performance measures of interest that can be evaluated through data streaming and use of sophisticated analytics. All signs indicate that the MOVEVU initiative is establishing a solid foundation.

7. Concluding Remarks

VU's MOVEVU initiative represents an ambitious approach to changing travel behavior on a holistic and systematic level. The combination of alternative mode offerings, infrastructure improvements, expanded transit services, and incentives to decrease single occupant vehicle use represent a commitment to which the University administration, faculty, staff and students have endorsed. Moreover, as a major activity center, VU has attracted the support and cooperation of both local and regional government to extend these concepts and practices to a broader community. The types of data collection and analysis techniques inherent in the MOVEVU deployment also create new opportunities to perform mobility research, in addition to providing a testbed for emerging transportation technologies, such as the introduction of autonomous vehicles.

While this initiative is in its initial stages of deployment, the early results are quite promising. Should the MOVEVU program continue to grow and thrive, as expected, this project can be transformative in demonstrating how urban areas and major activity centers can achieve improved mobility, while offering healthier and more affordable lifestyles. The potential transferability of this Complete Campus "recipe" to other locales is significant.

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