HILLCROFT AVENUE

BEFORE/AFTER STUDY USING VIDEO-BASED CONFLICT ANALYTICS

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PREPARED FOR THE CITY OF HOUSTON

PREPARED BY DKS ASSOCIATES, TRANSOFT SOLUTIONS, AND TOGETHER FOR SAFER ROADS
INTRODUCTION

A New Vision for Hillcroft Avenue was a project prioritized by the Mayor’s Safer Streets Initiative which was announced in April 2019 in the Gulfton neighborhood. It was moved forward by Connect Community and Together for Safer Roads. The project was focused on improving safety and includes pedestrian safety enhancements, traffic signal improvements, and reallocation of space that includes lane narrowing and bicycle facilities.

This memo summarizes an innovative, quick action before-and-after study to provide an early indication of the impact of the New Vision for Hillcroft Avenue projects and strategies. Using video analytics to identify road user speeds, trajectories, and conflicts, the study team has been able to quantify – just a few weeks after completion – safety-related benefits of the project, especially for people walking, biking, and rolling.

IDENTIFYING SAFETY NEEDS

A safety needs identification study was conducted by Traffic Engineers, Inc. (TEI) prior to construction to analyze existing conditions and develop project recommendations.1 Transoft Solutions (as Brisk Synergies) conducted video analytics, in parallel to this study, on near-misses and traffic violations at two intersections and provided outputs of their analysis to the project team. Understanding near-misses, conflicts, and road user behaviors can provide an additional layer of understanding to a safety assessment.

From the 2019 study: “A detailed crash analysis was conducted to identify potential vehicle crash trends and roadway deficiencies within the study area. The study area (0.4 miles of Hillcroft Avenue) had a total of 333 reported crashes between 2014 and 2018. The crash rate for Hillcroft Avenue within the study area is 360 crashes per 100 million vehicle miles traveled, a rate that is two times the state average compared to similar urban roadways. Twelve of those crashes involved a person walking and ten involved a person bicycling. There were two fatalities during the study period; both were people walking.”

Recommendations from the study included a signalized intersection at Dashwood Drive, signal retiming along the corridor, additional modifications to the High Star Drive / Westward Street intersection, driveway consolidation, and reallocation of cross section to improve safety for all road users.

**SAFETY PROJECT ELEMENTS**

Safety improvements were implemented along Hillcroft, High Star, and Westward that included: wider sidewalks, shared-use bikeways, and new traffic signals for safer pedestrian access; improved access to METRO stops; and reallocation of roadway, reducing general purpose vehicular travel lanes from 8 to 6.

**PRELIMINARY “AFTER CONDITIONS” STUDY AND FINDINGS**

A video conflict analytics study conducted just a few weeks after the project was completed revealed the following when compared to data collected before the project was built:

- Speeds of motor vehicles involved in conflicts (as identified by the video analytics tools) were reduced after implementation.
- Average passenger car speeds through the Hillcroft/Dashwood and Hillcroft/Bellaire intersections reduced by 5-10 mph after installation.
- At Hillcroft/Dashwood, pre-project speeds averaged 28-30 mph in the before condition, and reduced to 18-20 mph after construction was completed. This change has a significant effect on injury outcomes if pedestrians of bicyclists were to be involved in future collisions.
- Rapid before-and-after evaluation of safety treatments using conflict analysis is an effective way to identify early indications of project impact.

The study team concludes that the project brings early indications of success to improve safety and recommend further study to confirm these findings with collision data at a later data.
IDENTIFYING SAFETY NEEDS: BEFORE CONDITIONS STUDY

The safety assessment conducted for Hillcroft Avenue between Bellaire Boulevard and High Star Drive is based on data collected by Houston Public Works along the corridor, field reviews, virtual site visits, and citizen input about their experiences along the corridor with assistance from local high school interns. The study also leveraged Transoft Solutions to conduct near-misses conflict analysis on “Before” conditions at two intersections: Hillcroft Avenue at Bellaire Boulevard and Hillcroft Avenue at Dashwood Drive. Transoft provided outputs of their analysis to the project team for further review. The following subsections will describe key findings from the “Before” conditions at the two study intersections.

KEY FINDINGS FROM THE “BEFORE” CONDITIONS

The “Before” conditions study highlighted multiple conditions with safety needs including the following:

1. **High corridor crash rates:** A crash analysis study identified a total of 333 reported crashes between 2014 and 2018. The crash rate was 360 crashes per 100 million vehicle miles traveled which is twice the state average on similar urban roadways.
   - Twelve of those crashes involved pedestrians and 10 involved bicyclists. There were two pedestrian fatalities during the time period.
   - Considering the high number of people crossing Hillcroft Avenue at Dashwood Drive and at Bellaire Boulevard, both intersections had the greatest concentration of pedestrian and bicycle crashes, as shown in Figure 1.

2. **High Vehicular Speeds:** The speed limit along Hillcroft Avenue is 35 miles per hour. Speed data collected in May 2019 indicated that the 85th percentile speed (the speed at which 85% of drivers...
traveled at or below) was 41.5 mph, which was 6.5 mph higher than the posted speed limit. Further, more than 7 percent seven percent of vehicles on Hillcroft Avenue were traveling greater than 45 mph. The wide four-lane roadway (47-feet wide in each direction) encourages these operating speeds due to its design.

3. **High Volume of Transit Use and Pedestrians:**
   - Approximately 40 percent of all Gulfton residents use walking, biking, or transit as primary modes of transportation.
   - Hillcroft Avenue has strong public transit connections with four bus routes (METRO Bus Route 47 Hillcroft, METRO Bus Route 9 Gulfton, METRO Bus Routes 2 Bellaire, 402 Bellaire Quickline) with stops within the study area. METRO transit data indicates that on an average day approximately 2,370 people board or alight the bus within the study area.
     - Roughly 1,550 boardings and alightings occur at the intersection of Hillcroft Avenue and Bellaire Boulevard. The eastbound and westbound bus stops at the intersection rank within the top 65 (of nearly 9,000) for total activity.
     - Approximately 530 people board or alight the bus along Hillcroft at Dashwood Drive.

4. **Lack of Safe & Visible Crossings:**
   - There is a lack of safe and visible crossings for people walking or bicycling along or across Hillcroft Avenue.
     - At the signalized intersection of Hillcroft at Bellaire Boulevard, the pedestrian signal timings were inadequate for crossing during a single walk phase, which resulted in violations (e.g., crossing on red) and near-miss conflicts as depicted by the video analytics “Before” conditions analysis.
     - At the unsignalized intersection of Hillcroft at Dashwood Drive, many people still cross the street despite the lack of a signalized crossing. Pedestrians were recorded dodging vehicles as part of the study. The Dashwood Drive intersection is a popular crossing point due to the Fiesta Mart and the location of 47 Hillcroft bus stops.

5. **Other concerns:**
   - Unsafe turning onto Hillcroft from Dashwood Drive due to the high number of lanes and high oncoming traffic speeds
   - There were many observations related to narrow sidewalks and lack of shade along most of the corridor
   - Lack of lighting was often mentioned by community members
Figure 2 shows some of the identified unsafe conditions at the “Before” condition sites.
A typical before-and-after safety study relies on an analysis of collision frequency. This requires waiting several years (at least three, and typically five) to have valid data to compare the two time periods. But incorporating video analytics has allowed the City and its partners to conduct a preliminary study of safety conditions weeks after project completion. This innovative technology does not replace traditional safety data analysis, but it provides early insights about the safety benefits of the Hillcroft Avenue project just a few weeks after implementation.

Conflict-based analysis relies on machine learning and artificial intelligence to analyze large data sets. In this case, the Transoft Solutions tool uses video analytics to assess the type, speed, and trajectory of every object that enters the field of view. When two of these objects come into conflict, the system records and analyzes details about that conflict, including its predictive potential for a future collision event. The “how close to a crash event?” question is determined and defined by a term called Post Encroachment Time (PET), which measures time between two road users crossing over a point of conflict. A smaller PET is one of the factors that relates to higher potential risk. Other factors include:

- Vehicle size and speed
- The difference between the sizes of conflicting road users (e.g., a motor vehicle and pedestrian conflict)
- The trajectory angle of road users (e.g., two vehicles traveling in opposite directions would likely have a more severe collision that two vehicles traveling the same direction).

After all data points are ingested and organized in the system, the output data is then analyzed and made available in a dashboard that includes charts, graphs, video clips, and access to the raw data for researchers and agency staff to further interpret and share.
The methodology used for the video analytics is illustrated in Figure 3.

**Video Data Collection**

1. **Video Data Collection**: Once Hillcroft & Bellaire and Hillcroft & Dashwood were selected as the locations of interest, Transoft worked with the City to assist in the camera setup process. This involves indicating how many cameras to use per study site (based on the size and geometry), the location of the cameras, and how many days of video footage to collect. Table 1 indicates the number of camera, dates, and total hours per location.
Table 1. Video Collection Dates and Locations

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cameras</td>
<td>Dates</td>
</tr>
<tr>
<td>Hillcroft &amp; Bellaire</td>
<td>3</td>
<td>May 21st to 23rd 2019</td>
</tr>
<tr>
<td>Hillcroft &amp; Dashwood</td>
<td>2</td>
<td>May 8th to 12th 2019</td>
</tr>
</tbody>
</table>

Video footage was collected mostly between 9 AM and 6 PM. Samples of the camera fields of view are shown in Figure 4.

a) Before  

![Before Image](image1)

b) After  

![After Image](image2)

Figure 4. Sample Camera Views at Hillcroft & Dashwood

Once the video was collected, it was uploaded directly onto the Transoft platform.
2. **Video Calibration & Validation:** To process the data, calibration was performed on the obtained video footage. The calibration process involves spatial mapping of the camera’s field of view onto an aerial image and defining relevant traffic movements. Once the calibration is complete, validation was performed to ensure that the results will be accurate.

3. **Video Processing:** At this stage, the video gets processed. This involves the use of computer vision to detect all the road users, track them, and then the application of safety algorithms to compute the safety, violation, and traffic flow data.

4. **Dashboard Results, Analysis, & Reporting:** The results were then made accessible through the online dashboard (Figure 5). Data was provided on every road user observed during recording (counts, speeds, safety related events, and speeding violations). Data is also provided as raw data (csv files), charts & graphs, and illustrations (videos & heatmaps). The data was then utilized by DKS to perform their analysis.

5. **Countermeasure Implementation and Evaluation:** As a treatment was implemented at this location, the previous process was repeated for the before and the after periods to evaluate.
HILLCROFT AVENUE AT DASHWOOD DRIVE: “AFTER” CONDITIONS

The project team conducted virtual site visits (see Figure 6) and confirmed the implementation of the following improvements at the intersection of Hillcroft Avenue at Dashwood Drive:

- Re-designed roadway cross-section
  - Converted the outside 14’ travel lane into a raised island and a protected bicycle lane
  - Narrowed two inside vehicular lanes from 11’ to 10’ to reduce vehicular speeds
  - Provided floating bus stop next to the outside lane for easy boarding and alighting
  - Provided wider sidewalks (6’ to 8’) behind the bike lane to avoid the conflict with the vehicular traffic

- Signalized the intersection with protected left-turn signals, yellow-retro reflective back-plating, and a bicycle signal head with mast-arm signage for improved operation and safety for bicyclists

- Provided additional signage: “Yield to Pedestrian”

- Added crosswalk markings

- Installed intersection illumination

- Added stop bar marking prior to the crosswalk to enhance safety of the crossing pedestrians

Figure 6. Hillcroft/Dashwood Before (top) and After (bottom) Conditions
**Early Sign of Improvements:** The project team reviewed the Safety Analysis and Traffic Analysis dashboards as well as recorded near-miss conflict videos by Transoft Solutions to evaluate and compare the “Before” and “After” conditions. Although the studies of “Before” and “After” were conducted three years apart using different software versions, the team observed the following signs of safety improvements:

**Vehicle Speeds when a Conflict Occurs:** The scatter plot below (Figure 7) shows the speed of passenger cars when a conflict with a cyclist was detected. The SRE value designates a “traffic conflict” – defined as any traffic interaction. Lower SRE values correlate to more severe traffic conflicts. Below are some observations based on the scatter plot:

- The speeds of vehicles involved in conflicts are lower in the “After” condition than the “Before” condition.
- The highest conflict speed in the “After” condition is 42 mph versus 63 mph in the “Before” condition.
- There are no conflicts above 35 miles per hour when SRE value was 5 seconds or less in the “After” condition compared to more than 10 conflicts of this combination in the “Before” condition.
  - Based on referenced studies by Vision Zero Network,² vehicles driving at 30 mph can result in fatality in 5 out 10 pedestrian-involved crashes (i.e., fatality rate of 50%) while speeds of 40 mph can result in 90% fatality rate.

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² [https://visionzeronetwork.org/resources/safety-over-speed/](https://visionzeronetwork.org/resources/safety-over-speed/)
Therefore, the reduction of speed in the “After” study suggests improvements to crash severity if crashes were to happen at this site.

**Regarding Conflict Frequency:** While the frequency of observed conflicts in the “After” study appears to be somewhat lower compared to the “Before” study, it is important to note that the two scenarios were analyzed using different versions of the Transoft tools. Therefore, it is difficult to confirm with confidence that the frequency of conflicts reduced in the “After” condition.
Passenger Vehicle Speed Trends: The line diagram (Figure 8) shows that the average vehicle speeds at the intersection reduced by a range of about 7 to 15 mph. This can be attributed to the implementation of safety countermeasures like lane narrowing, reducing the number of through lanes, and signalizing the intersection.

- The reduction in speed can significantly improve chances of survival if vehicles were to hit pedestrians or bicyclists.
- The lower speeds improve attention and provide additional reaction time, which can lead to fewer crashes.

The bar chart (Figure 9) shows that not only are the average vehicle speeds lower, but also that most vehicles are traveling at considerably slower and more consistent speeds in the “After” Condition.

![Figure 8. Hillcroft/Dashwood Intersection Average Passenger Car Speeds](image1)

![Figure 9. Hillcroft/Dashwood Intersection Passenger Car Speed Distribution](image2)
Cyclist/Pedestrian Speed Trends: From the Traffic Analysis of Transoft’s Dashboard (Figure 10), the average cyclist and pedestrian speeds have slightly increased in the “After” condition. Further, the speed distribution graph in Figure 11 illustrates that pedestrians’ and bicyclists’ speeds are more concentrated after the project was completed. While a full understanding of the causation is unknown, these findings may indicate that bicyclists and pedestrians are more likely to travel through the newly-designed intersection without as many interactions with motor vehicles, since the different road user types are better separated in space (marked lanes, improved crosswalks) and time (signal phasing).
HILLCROFT AVENUE AT BELLAIRE BOULEVARD: “AFTER” CONDITIONS

The project team conducted virtual site visits (See Figure 12) and confirmed the implementation of the following improvements at the intersection of Hillcroft Avenue at Bellaire Boulevard:

- Redesigned roadway cross section
  - Converted the outside 14’ travel lane into a raised island and a protected bicycle lane
  - Narrowed two inside vehicular lanes from 11’ to 10’
  - Provided floating bus stop next to the outside lane for easy boarding and alighting
  - Provided wider sidewalks (6’ to 8’) behind the bike lane to avoid the conflict with vehicular traffic
- Improved signal timing and visibility
  - Allowed for one-stage pedestrian crossing and removed two-stage pedestrian crossings
  - Added yellow retroreflective backplates for improved traffic signal visibility
  - Added a supplemental left-turn signal for improved visibility and system efficiency along Hillcroft Avenue
  - Installed a push button and pedestrian signal along Hillcroft Ave
- Provided additional signage of bicycle lanes and crossings
- Restriped the crosswalk markings for pedestrians and bicyclists to improve visibility
- Added stop bar pavement marking prior to the crosswalks to enhance safety of the crossing pedestrians

Figure 12. Hillcroft/Bellaire Intersection Before (top) and After (bottom) Conditions
Early Sign of Improvements: The study team reviewed the Safety Analysis and Traffic Analysis dashboards and conflict videos to evaluate and compare the “Before” and “After” conditions at the intersection of Hillcroft Avenue at Bellaire. The team noticed that there was ongoing construction equipment in the videos which may have affected the results at this intersection. Below are some high-level observations:

Vehicle Speeds when a Conflict Occurs: The scatter plot below (Figure 13) shows the speed of passenger cars when a conflict with a cyclist was detected. The SRE value designates a "traffic conflict" – defined as any traffic interaction. Lower SRE values correlate to more severe traffic conflicts. Below are some observations based on the scatter plot:

- Overall, average vehicles speeds are similar in the “Before” and “After” conditions.
- Top-end speeds are lower in the “After” condition. The highest conflict speed recorded in the “After” condition was approximately 32 mph, while there are at least eight conflicts with higher vehicle speeds in the “Before” condition, including two greater than 55 mph.

Regarding Conflict Frequency: While the frequency of observed conflicts in the “After” study appears to be significantly lower compared to the “Before” study, it is important to note that the two scenarios were analyzed using different versions of the Transoft tools. Therefore, it is difficult to confirm with confidence that the frequency of conflicts reduced in the “After” condition.

Figure 13. Hillcroft/Bellaire Intersection Conflict Speeds
Passenger Car Speed Trends: The line diagram (Figure 14) shows that the average vehicle speeds at the intersection reduced by approximately 5 to 10 mph. This may be attributed to implementation of safety countermeasures like lane narrowing, reducing the number of through lanes, and signalizing the intersection.

- The reduction in speed can significantly improve chances of survival if vehicles were to hit pedestrians.
- Lower motor vehicle speeds improve attention and increase the ability of drivers to react, which can lead to fewer crashes.

The bar chart (Figure 15) shows that not only are the average vehicle speeds lower, but also that most vehicles are traveling at lower and more consistent speeds in the “After” Condition.

![Figure 14. Hillcroft/Bellaire Intersection Average Passenger Car Speeds](image1)

![Figure 15. Hillcroft/Bellaire Intersection Passenger Car Speed Distribution](image2)
**Cyclist/Pedestrian Speed Trends:** The speed distribution graph (Figure 16) indicates that pedestrians’ and bicyclists’ speeds are more concentrated after the project was completed. While a full understanding of the causation is unknown, these findings may indicate that bicyclists and pedestrians are more likely to travel through the newly-designed intersection without as many interactions with motor vehicles, since the different road user types are better separated in space (marked lanes, improved crosswalks) and time (signal phasing).
STUDY LIMITATIONS AND LESSONS FOR FUTURE APPLICATION

This study generated several lessons that the study team plans to use for future analyses of this type.

**Value of Rapid Evaluation using Video Analytics Technology.** It is feasible to use innovative technologies to collect data soon after a project is completed and get an early understanding of the ability for projects and strategies to enhance safety for all road users.

**Differences in the Before and After Video Analytics.** Due to the longer time frame (nearly 3 years) between the analysis of the “Before” and “After” conditions, it was difficult to make direct comparisons. The Transoft Solutions software was changed during that time, so the tools and methodology applied in 2019 were different from the 2022 analysis. To a lesser degree, changes to the road-user mix, driving and travel behavior, traffic patterns, and land use might have affected results, especially since the “Before” study was conducted prior to the COVID pandemic. Thus, metrics like the frequency of conflicts were not able to be analyzed by the study team.

**Maintaining Video Files Over Time.** The 2019 recorded videos of the “Before” analysis were not retained, and therefore unavailable to the project team during the 2022 “After” study. Had they been saved and made available, Transoft Solutions could have applied their new tools and methodology to the 2019 videos for a better comparison of the pre- and post-construction conditions.

**Interpreting Bicycle and Pedestrian Speeds.** Bicyclist and pedestrian speeds increased after the implementation of the project, but the correlation to safety is unknown. One interpretation could conclude people walking, biking, and rolling faster indicates benefits; but another could conclude that increased pedestrian crossing speed may be connected to risky behaviors. Additional research is needed to determine the potential impact of bicyclist and pedestrian speeds (when captured in this manner) on safety risk.

**Analysis of Vehicle Types.** This study focused on passenger cars, bicyclists, and pedestrians. Future studies could include additional motor vehicle body types (e.g., buses, vans, large trucks) as well as other modes like scooters, which are becoming more prevalent in some geographies. Interactions among these vehicles might generate additional insights.
CONCLUSION AND RECOMMENDATIONS

The analysis of the “Before” and “After” study showed reduction of motor vehicle drivers’ speeds as a result of the project implementation, which can result in reduced frequency and severity of crashes. Slower vehicle speeds allow drivers more time to react to a potential conflict, and if a collision does occur, the resulting injuries are less severe at slower speeds.

These early benefits can help stakeholders and agencies justify the use of the same treatments at similar locations. The use of video analytics can help agencies conduct before-and-after safety project evaluations in much shorter time frames compared to waiting multiple years to obtain statistically significant crash data, especially for projects that target vulnerable road users. Using these tools, the study team can proactively screen and diagnose safety issues before crashes occur.

The team recommends expanded use of this rapid analysis tool at more locations, and a follow-up study to confirm these findings with before/after crash data when that information is available.