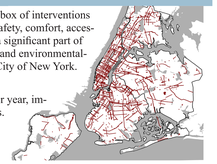
Project Tracking Application using a Hierarchical Database Model: Street Improvement Projects New Yrok City Department of Transportation

Street Improvement Projects

Street Improvement Projects (SIP) utilize a broad toolbox of interventions to reengineer city streets with the goal of improving safety, comfort, accessibility, and mobility for all roadway users. They are a significant part of NYC DOT's mission to provide for the safe, efficient and environmentally responsible movement of people and goods in the City of New York.



NYC DOT implements more than 100 SIP projects per year, implemented by 8 different units, each with unique goals.

Traffic Calming, Transit Prioritization

Traffic Calming, Bike Infrastructure Development

Traffic Calming, Bike Infrastructure, & Plaza

Street Closure, Pedestrian Plaza implementation

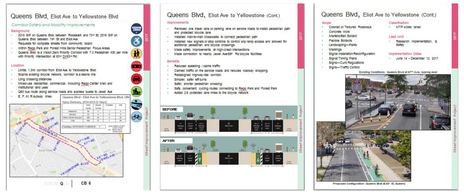
Historic Tracking

Historically SIP projects were tracked for the program in a master tracking sheet and at the project level in a summary document.

Excel tracking sheet	PDF project description
Maintained centrally by program manager	Maintained by project manager
Project name	Project background
One-line project description	High level description
Implementation dates	High level treatment descriptions
Project manager name and unit	Project images and map

Problems:

- Not query-able
- No spatial data
- Imprecise project extents (often traced over Google Maps)
- No treatment geography
- Treatment data limited to high-profile treatments



This system made it very challenging and labor intensive to answer questions about the program as a whole or even specific projects. Finding all of the projects that contained a specific treatment (for example) became an exercise in archeology and institutional memory. Programmatic analysis was nearly impossible.

NYC DOT decided to design and build a new system to track the SIPs that would utilize distributed data entry process.

Database Model

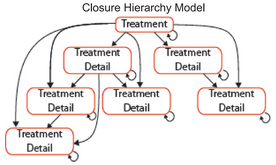
SIP project tracking system requirements:

- Record all **project** and **treatment details**
- Account for **different project types**
- Allow for diversity of treatment details (different **treatments have differing levels of details**)
- **Standardize treatment attributes** and related geographic information
- Facilitate the adoption of **new treatments and modifications** to existing treatment options
- Data entry must be possible by the Project Manager and **not require specialized skills or software**
- Data must be **query-able and accessible** to analysts

Closure database model:

- Hierarchical **tree structure** representation of the data
- Stores **relationships** between each node to each of its descendants (including itself)
- Data is stored in **two tables** (data and relationships)
- Allows for detail and flexibility to store **treatments with differing levels of detail** in one schema

Closure Hierarchy Model



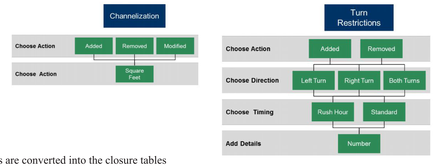
Projects are a collection of treatments:

- Project and treatment data are stored in separate, but related tables
- Project attributes describe the study and simple standardized
- Do not require Closure model

Treatments are a standardized collection of decisions:

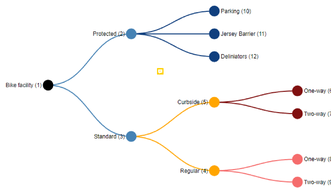
- Each potential treatment must be abstracted into a series of decisions.
- The decision trees that represent the various treatments do not need to have a uniform breadth or depth.
- Treatment trees define what is possible to record for any treatment
- Treatment trees may be changed to reflect new choices

Treatment Hierarchy Structures



Treatment decision trees are converted into the closure tables

- Each possible decision is represented in the Questions table.
- The relationships between the every decision in the treatment trees are added to the Question Path table.
- Each node and each decision path is unique.
- A 3rd attribute table is added to allow for freeform data fields (such as square feet), these fields must always be the last node in the tree.



Questions	
Question ID	Question
1	Bike Facility
2	Protected
3	Standard
4	Regular
5	Curbside
6	One-way
7	Two-way
8	One-way
9	Two-way
10	Parking
11	Jersey Barrier
12	Delinators

Question Path		
Ancestor	Descendant	Depth
1	1	0
1	2	1
1	3	1
1	4	2
1	5	2
1	6	3
1	7	3
1	8	3
1	9	3
1	10	2
1	11	2
1	12	2
2	2	0
2	10	1
2	11	1
2	12	1
3	3	0
3	4	1
3	5	1
3	6	2
3	7	2
3	8	2
3	9	2
4	4	0
4	8	1
4	9	1
8	8	0
9	9	0

The closure tables function as the limits of what treatment details the user can add to a project. These tables are static until changes are needed for new or modified treatments are available to project managers. Project data is primarily recorded in two related tables; a project attribute table and treatment attribute tables. The last decision point that the user passed though is what is recorded in the treatment attribute table. The effect of this is each treatment, regardless of the complexity is stored in a single row in the treatment attribute table. The data stored in the treatment table, is not easily decipherable on its own, but requires joining to the decision and decision path tables.

Data Exploration

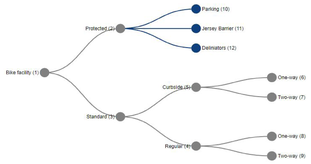
Data Exploration in the database:

This data structure is simple to work with in the database. It provides a lot of flexibility for querying at different levels of granularity or recreating the full treatment details from the last decision node.

The data structure allows for ad hock groupings within the hierarchy. Queries down the tree return all of the choices below a given node. This is used to find all treatments that include at least a particular decision. For example: Finding all protected bike paths, regardless of the specific details of the subsequent decisions.

```
SELECT q.*
FROM sip_questions q
JOIN (
    SELECT descendant d, depth
    FROM sip_questions_path
    -- All treatments with a protected bike facility
    WHERE ancestor = 2
) AS p ON q.qid = p.d
ORDER BY p.depth;
```

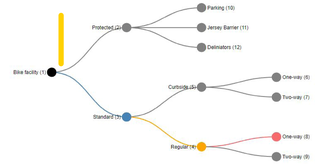
	qid integer	question text
1	2	Protected
2	10	Parking
3	11	Jersey Barrier
4	12	Deliniators



The treatment attributes that are recorded in association with a project are limited to the final decision node the user passed through. The ability to interpret the treatment relies on being able to recreate the full set of choices the user made. Recreating the full decision path of a treatment detail necessitates querying up the tree. For example: One-way (QID 8) is only a meaningful treatment description once the full path back to the root is reviled as a One-way standard non-curbside bike facility.

```
SELECT q.*
FROM sip_questions q
JOIN (
    SELECT ancestor a, depth
    FROM sip_questions_path
    -- All treatments with a one-way standard bike facility
    WHERE descendant = 8
    ) AS p ON q.qid = p.a
ORDER BY p.depth desc;
```

	qid integer	question text
1	1	Bike Facility
2	3	Standard
3	4	Regular
4	8	One-way

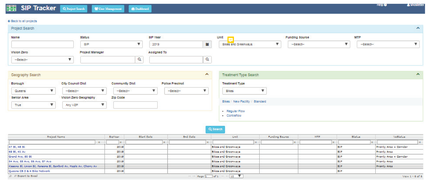


Data Exploration in the application:

The application provides planners, program managers, analysts and outreach/communications staff with the ability to quickly and easily explore the data.

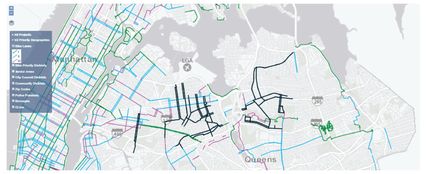
Project managers need to know what other projects are being developed and/or implemented near their project. To facilitate this, the application provides a number of reference layers that can be toggled in the map provide an overlay of:

- All projects (complete and under development)
- Political and administrative districts
- Priority geographies
- Existing bicycle network



For a more targeted search, the application provides a query tool that allows for searching for projects using three categories of criteria

- Project
- Geography
- Treatment



The treatment search utilizes the treatment decision trees to allow user defined specificity.

The results of the search in both the table and the map link to the projects' full detail page.

Data Entry

The primary purpose of the application is to facilitate the collection and storage of the project and treatment attributes. Data entry is intended to be done by the project manager.

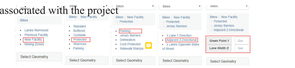
The data entry process is straightforward and consists of two levels, project and treatment.

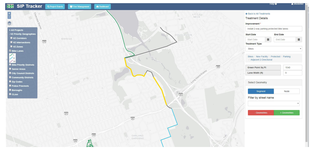
Project data entry process:

1. Enter project level attributes
2. Option to delegate the project to another user (share ownership)
3. Select project geography

Treatment data entry process:

1. Enter treatment level attributes
2. Enter treatment type details via navigating through question tree
3. Select treatment geography
4. Repeat for all other treatments associated with the project



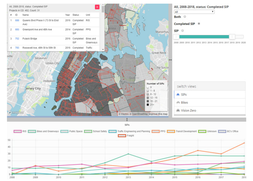


Applications

The availability of this data has facilitated a number of new initiatives that were not previously possible.

Planning

The dashboard enables unit directors ensure their group's work is appropriately distributed across the city and through time. **NYC DOT now uses the dashboard as a tool to plan future work programs at a high level, with the ability to quickly get the full project proposal details**. The dashboard provides a powerful tool to ensure that communities were not ever nor underrepresented in the SIP program's work portfolio.



Analysis

NYC DOT analyzed the equitability of the SIP program as a whole to ensure all New Yorkers were being served. This analysis explored the geographic distribution of projects throughout the city across a number of different demographic metrics.

NYC DOT has begun to analyze the full SIP work program's efficacy from a safety perspective. Every SIP project is, analyzed individually to ensure they are improving safety, but a holistic analysis has not historically been practical.

Credits

Project Team:

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Technologies:

PostgreSQL / PostGIS
C# .Net
Geoserver v2.8
OpenLayers 3
ESRI map services