Maps in Apps: ArcIMS at the Chicago Transit Authority
Track: Transportation
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The department of Data Services at the Chicago Transit Authority uses ArcIMS and ASP (Active Server Pages) to create maps and reports for its intranet users. Embedding ArcIMS components within stand-alone ASP applications, such as a web-based Bus Location Information System, has lead to improvements in data collection techniques and reporting accuracy. In addition to web-based reports, tools are created to help manage transit-related assets, such as an inventory of bus stop signs and locations.

The following applications are discussed in this paper:

- Automated Vehicle Announcement System (AVAS) Timepoints Viewer
- Automated Vehicle Location (AVL) Viewer – Beta
- CTA Bus Stops and Signs Viewer

Each application was developed in-house with Apache HTTP Server 2.0.49, Apache Tomcat 4.0.5, and Sun Java System Active Server Pages 4.0 on the Sun Solaris platform, and uses ASP and JavaScript to interact with Oracle 9i databases.

Refer to **APPENDIX A** for a List of Figures, Tables and Contact Information.

About CTA

The CTA operates the nation's second largest public transportation system and covers the City of Chicago and 40 surrounding suburbs. On an average weekday, nearly 1.5 million customer trips are taken on CTA. Buses provide about 1 million passenger trips a day and serve more than 12,000 posted bus stops. There are approximately 2,000 buses that operate over 152 routes and 2,273 route miles. Rail accounts for roughly 500,000 rides each day, serving 144 stations. CTA's 1,190 rapid transit cars operate over seven routes and approximately 222 miles of track.

AVAS and AVL

In January 2004, as a result of an ongoing Automated Vehicle Announcement System (AVAS) project, CTA began storing archive vehicle location data in Oracle while developing queries to determine summary statistics such as schedule adherence and operator performance[1]. In late 2004, Data Services introduced a website called "BLIS" (the Bus Location Information System) providing summary statistics for the Automated Vehicle Location (AVL) data. The website allows access to two weeks of detailed AVL data at a time (the rest being archived for trends analysis) and is widely used at CTA within Bus Operations.

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[1] Once the task of matching actual bus schedules to the data on the buses was solved. The AVAS was implemented in 2000 in response to the American with Disabilities Act which drove the need to automate stop announcements. Currently, all of CTA's 152 bus routes are fully accessible to customers with disabilities. AVAS also provides post-time schedule adherence and passenger counting data at the stop-level.

The Bus Location Information System uses the arrival time of "timepoints" for computation of schedule adherence.[2] Each vehicle is required to pass a certain location at a given time, what is now referred to as a "timepoint circle". [**Figure 1**]
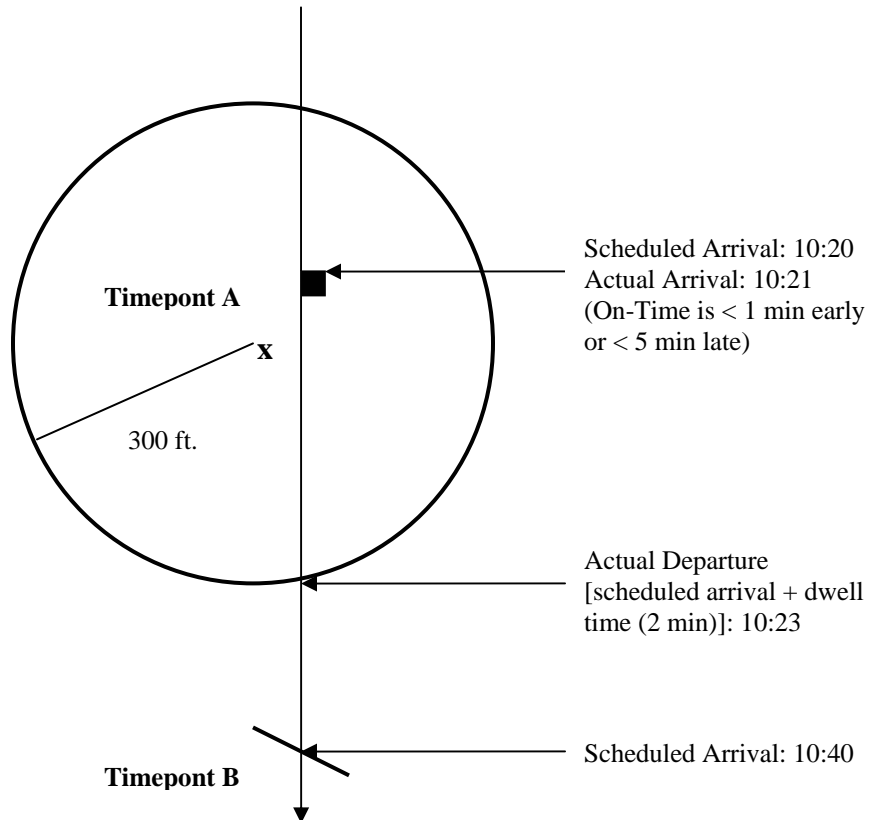

Scheduled Arrival: 10:20
Actual Arrival: 10:21
(On-Time is < 1 min early or < 5 min late)

Timepont A

x

300 ft.

Actual Departure
[scheduled arrival + dwell time (2 min)]: 10:23

Scheduled Arrival: 10:40

Timepont B

Figure 1 – Example of Bus Arriving and Departing Timepoint Circle On Time[3]

The size and placement of timepoint circles are critical to the AVL component of AVAS. For example, all buses must layover within the circle, otherwise they are reported as arriving late or leaving early. If a circle is not large enough to capture where the driver is taking his/her layover, it must be adjusted (or the operator told to layover elsewhere).[4]

ArcIMS is used to view timepoint circles while interacting with the Bus Location Information System, and to aid in making adjustments to timepoint circles if necessary. Below is an example taken from the BLIS website of bus terminals with possible late departure problems. The "Map"

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[2] Except in the case of Terminal Departures where departure time is used for computation of schedule adherence as there is no arrival time for the beginning of a trip.

[3] Once the computed distance to the timepoint is 100 feet or less the bus is said to "arrive." A bus arrives at a timepoint when it determines that it is the closest it will get to the recorded latitude and longitude of the timepoint. Most timepoints are set as a 300 foot radius circle. Some terminals are larger to account for a larger area for layovers.

[4] A bus layover is a location where the buses wait between trips. Sometimes this is a dedicated stop where passengers are not allowed to board.

hyperlink opens an ArcIMS map service which queries SDE for the Place ID and buffer distance (yellow highlight) of the requested timepoint, as well as x/y coordinates.

Route	Time Point	Time Point Map	Trips	Avg Schedule Diff.	Absolute Avg Schedule Diff.	Trips Early	% Early	Diff. When Early	Trips Late	% Late	Diff. When Late	Terminal Departure Performance
79	79 Lk	Map	2986	3.0	3.2	91	3%	-2.3	504	17%	9.4	80%
151	Un Stn	Map	2098	3.0	3.6	173	8%	-2.6	409	19%	11.2	72%
14	103Sto	Map	1337	2.9	6.0	85	6%	-24.1	383	29%	11.2	65%
6	79 Ssh	Map	1325	4.2	4.3	9	1%	-2.8	376	28%	8.3	71%
9	BplClk	Map	1791	3.3	3.8	121	7%	-2.7	373	21%	10.6	72%
8	79 Hal	Map	1589	3.5	3.7	52	3%	-2.8	338	21%	9.5	75%

Table 1 – BLIS - Bus Terminals with Possible Late Departure Problems
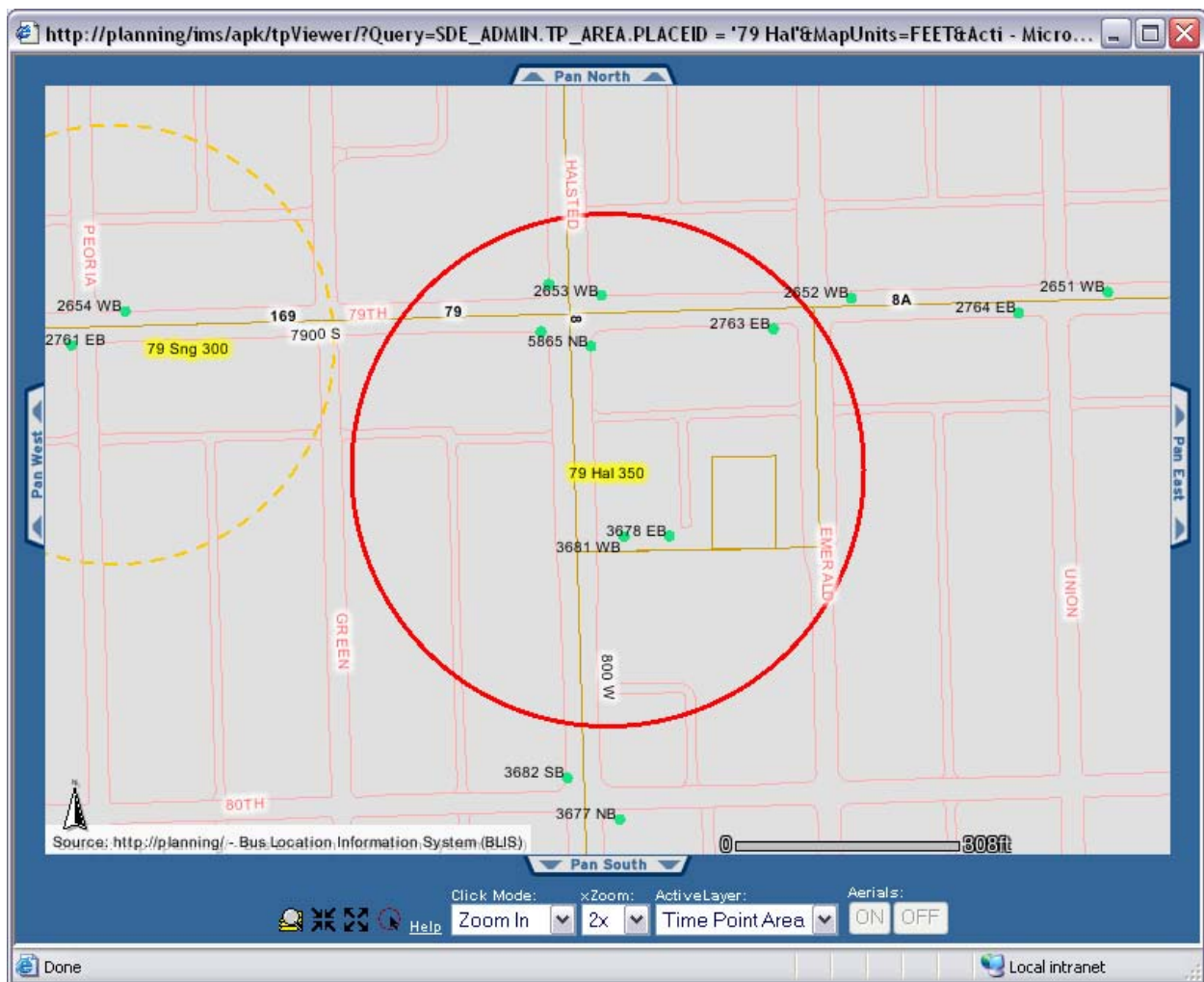
Figure 2 – AVAS Timepoints Viewer – 79th Halsted Timepoint
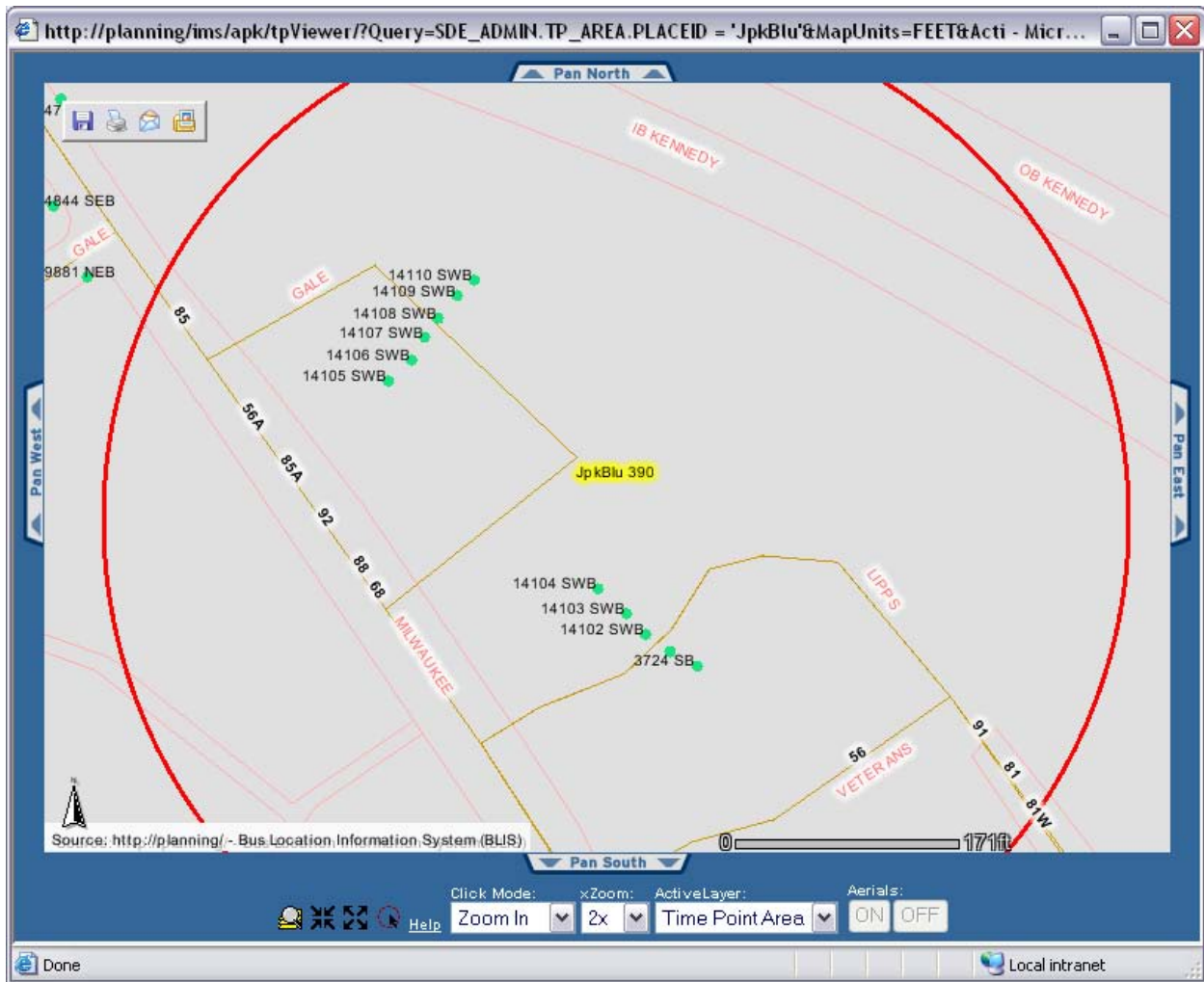
Figure 3 – AVAS Timepoints Viewer – Jefferson Park Blue Line Timepoint

In the above example, the radius of the Terminal timepoint is larger than normal (390' as opposed to 300') to provide operators with a larger area to layover and to cover both sides of the Terminal bay where buses stop. Of equal importance is the placement of the center of the timepoint when determining the area coverage.

Because this is a Terminal timepoint, any passengers alighting from a stop (green dot) inside the timepoint circle will be attributed to the departing trip as reported in BLIS. In all other cases, it is the arrival time of timepoint circles that is used for computation of schedule adherence.
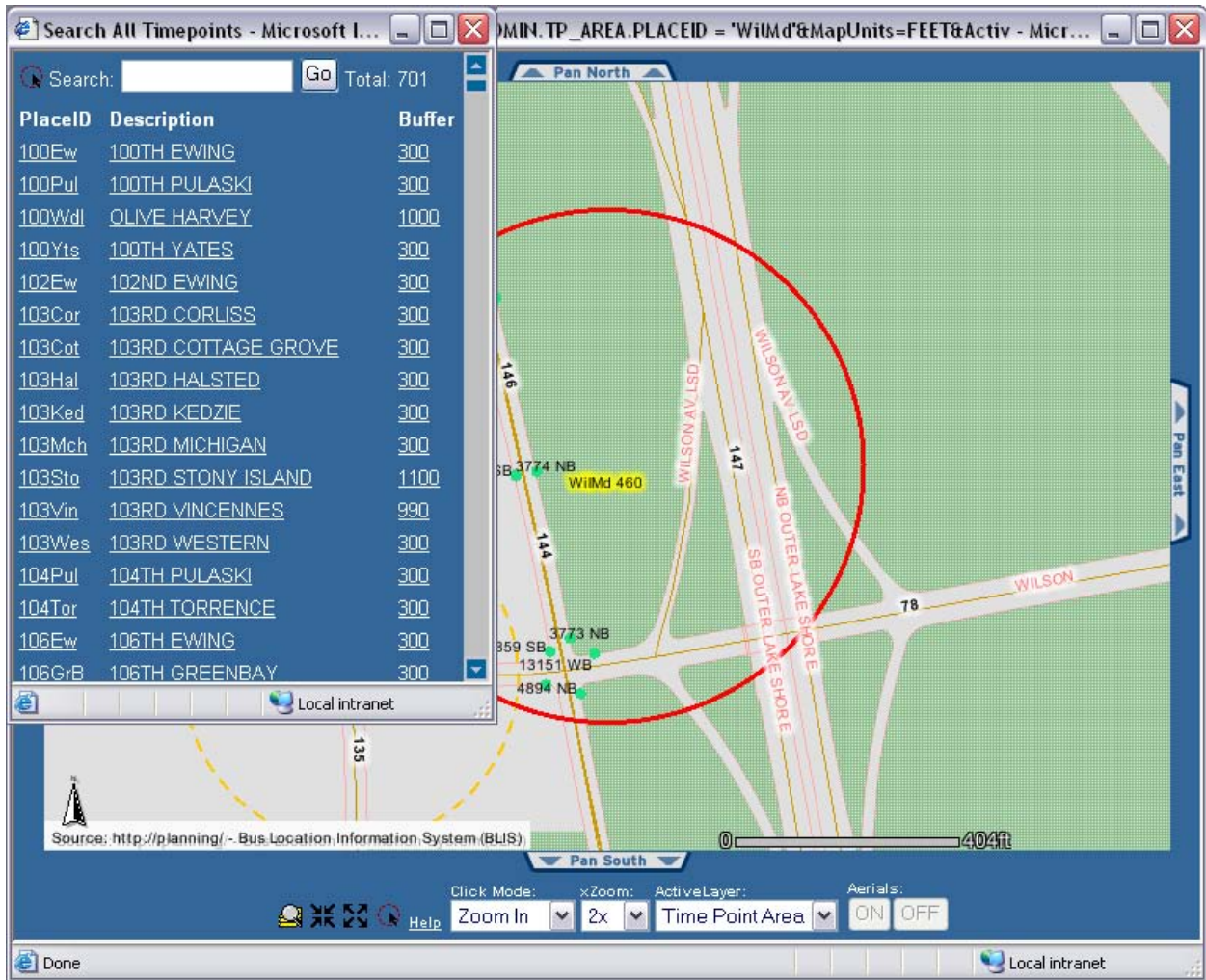
Figure 4 – AVAS Timepoints Viewer – Wilson Marine Timepoint

In the above example, a user has selected the option to view all timepoints (in the toolbar). Clicking any of the timepoint links will refresh the map service.

AVL Viewer – Beta

The *AVL Viewer – Beta* was created to allow users of the BLIS website to 'drill down' into stop-level detail information, for instance, when a vehicle is reported 10, 15, or even 20 minutes off of its scheduled operating time. Vehicle behavior (described as "event types" in the AVL database) is integral to BLIS, and particularly well suited to mapping using ArcIMS. [**Figure 5**]

Further, ArcIMS provides visual representation of vehicle behavior on the street, making it easier to spot anomalies in operator behavior due to physical or technical obstacles (such as points of traffic congestion or GPS/odometer problems).

Event ID	Event Type
2	Distance
3	Serviced Stop
4	UnServiced Stop
5	Unknown Stop
6	Route
7	Run ID
8	Operator ID
11	End of Route
12	New Route
15	Trip
16	Timepoint

Event Type	Map Symbol
Distance (500 feet)	↑
Serviced stop	↑
Unserviced stop	↑
Unknown stop	△
Timepoint Record	↑
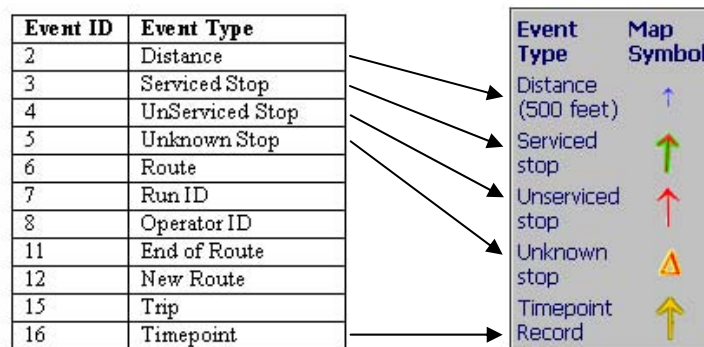
Figure 5 – Event Types in AVL Data (Oracle) and Event Types Used in ArcIMS

The following example from BLIS shows timepoint adherence for a single trip.[5] The system provides detail stop-level data 10 minutes before and 10 minutes after the reported actual time of the vehicle on the street. Clicking on "Map" launches an ArcIMS map service showing the events around a chosen record.

Daytype	Route	Time Point	Actual Time[6]	Scheduled Time	Diff	Block ID	Trip ID	Run ID	Badge[7]	Bus	Map
SU	14	103Sto	12:00:45	11:51:00	9.8	1788783	13293184	1624	xxxxx	5400	Map
SU	14	100Yts	12:05:53	11:56:00	9.9	1788783	13293184	1624	xxxxx	5400	Map
SU	14	87 Jef	12:18:03	12:03:00	15.1	1788783	13293184	1624	xxxxx	5400	Map
SU	14	79 Jef	12:22:25	12:08:00	14.4	1788783	13293184	1624	xxxxx	5400	Map
SU	14	67 Jef	12:29:30	12:15:30	14.0	1788783	13293184	1624	xxxxx	5400	Map
SU	14	MadMch	12:52:21	12:33:30	18.9	1788783	13293184	1624	xxxxx	5400	Map

Table 2 – BLIS - Report on Timepoint Adherence for Trip ID 13293184

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[5] The system reports timepoint adherence at the Trip ID level. A Trip ID is a unique scheduling identification that represents an individual trip in the schedule. All Trip IDs are unique to each schedule pick. Schedule adherence analysis using ArcIMS is possible because of schedule-matched timepoint data on the bus.

[6] Actual arrival time of timepoint circle used for computation of schedule adherence.

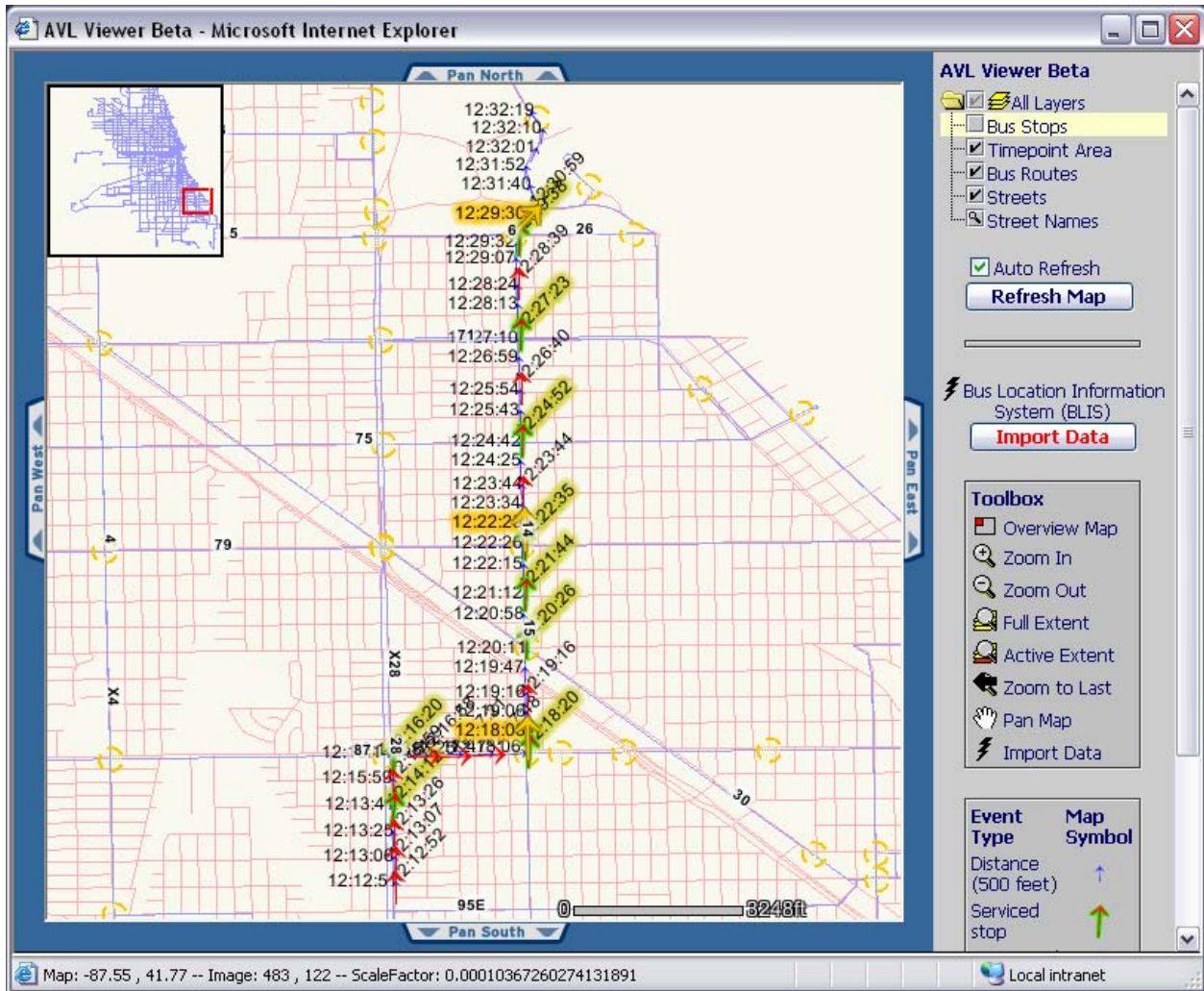[7] Badge is hidden to preserve operator anonymity.

Figure 6 – AVL Viewer – Acetate Layer

As shown in **Figure 6**, ASP is used to connect to an Oracle database containing the event data and x/y coordinates.[8] A related table stores the symbology and text (in ArcXML) for each event type [**Figure 5**]. ASP queries the event data, relating the symbology and text tables for all records. A complete XML string for the creation of an acetate layer is constructed and returned to the client viewer.

One of the limitations to creating maps like this is that even though the TextMarkerSymbol acetate layer will scale when navigating through the map, the text of the acetate layer becomes illegible at certain scales because of the number of events being shown. This problem is easily remedied by zooming further into the map [**Figure 7**].

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[8] Technical Note: The click event from pressing "Import Data" (aimsClick.js) creates a request which is sent to an ASP page using the traditional sendToServer() function. The reply is processed in aimsCustom.js and a response string is prepared. Back at the client, processXML()is called, and the code in aimsCustom.js is executed.
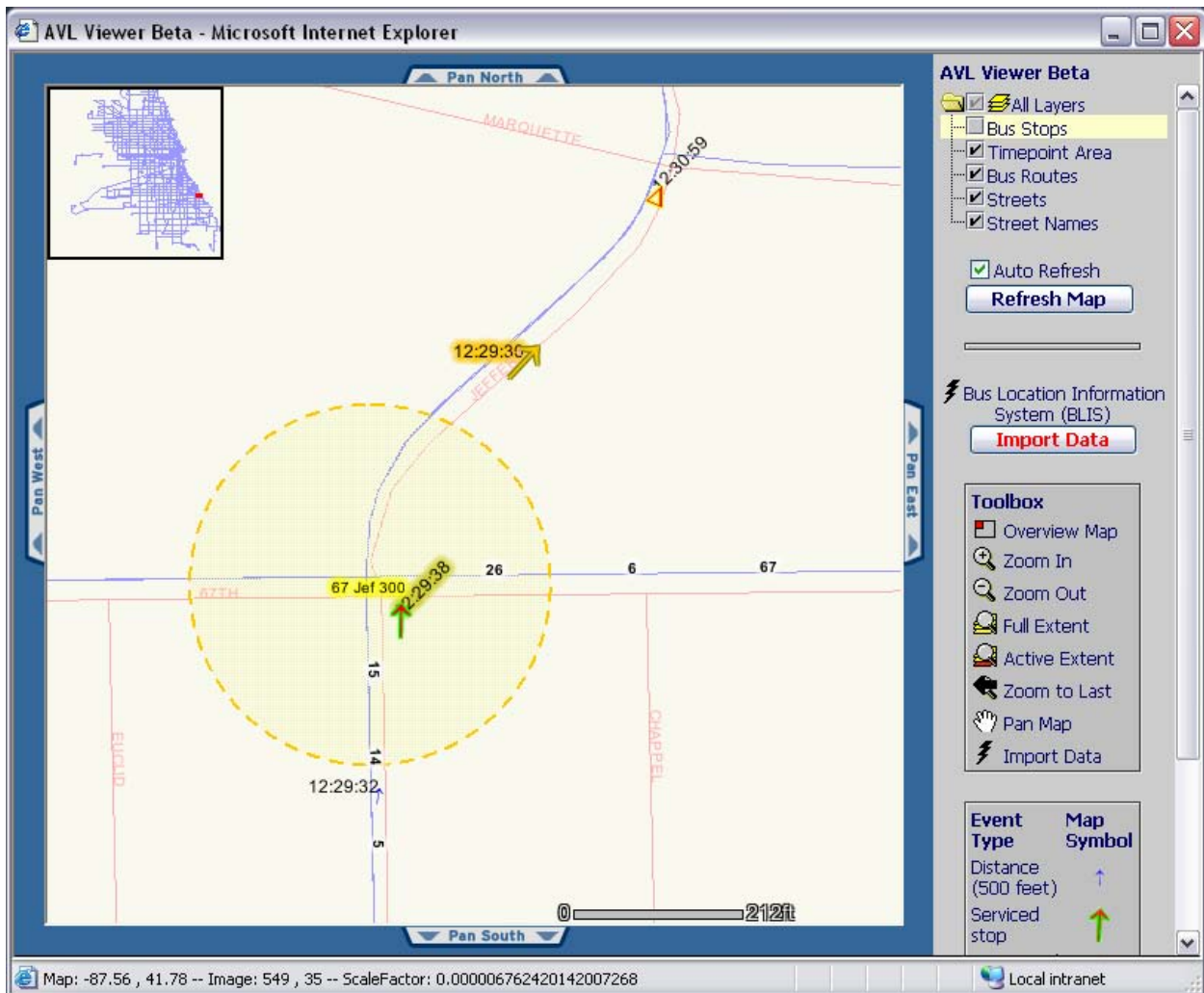
Figure 7 – AVL Viewer – Timepoint Arrival

As **Figure 7** shows, arrival time is computed once the vehicle is determined to be 100 feet or less from the center of the timepoint, but is only written to the data after the vehicle exits the timepoint circle. This explains why a serviced stop occurring at 12:29:38 appears on the map before the arrival time (timepoint record) occurring at 12:29:30.

Future development of the *AVL Viewer – Beta* will likely include a "find a bus," "find a run" or "find an operator" query tool integrated with the BLIS website. A need for such a tool has been identified in the Operations, Customer Service, and Law Departments at CTA.

Bus Stops and Signs Viewer

The Bus Stops and Signs Viewer was developed to help streamline the process of updating stop locations and to cut back on the time spent maintaining an accurate database of bus stop signs for each of CTA's more than 12,000 posted stops. Detailed stop-level information is also critical to projects such as AVAS which requires accurate geolocation of stops on board buses.

The left frame of the viewer shows the round trip sequence of stops on each route. For routes that have branches or special routings at certain times of the day, those stops are often listed at the end of the "regular" routing.

A user begins his/her search by selecting a route from the drop-down list [**Figure 8**]. A "Route ID" is passed as a URL parameter to the stops ASP page (left frame), the signs ASP page (lower-right frame), and to the ArcIMS map service in the upper-right frame.

Figure 8 – CTA Bus Stops and Signs Viewer – Route Map

All frames are updated automatically based on the route selected. Stops are listed sequentially. Clicking on "Stop Id" passes the stop id parameter to the ArcIMS map service in the upper-right frame [**Figure 9**].
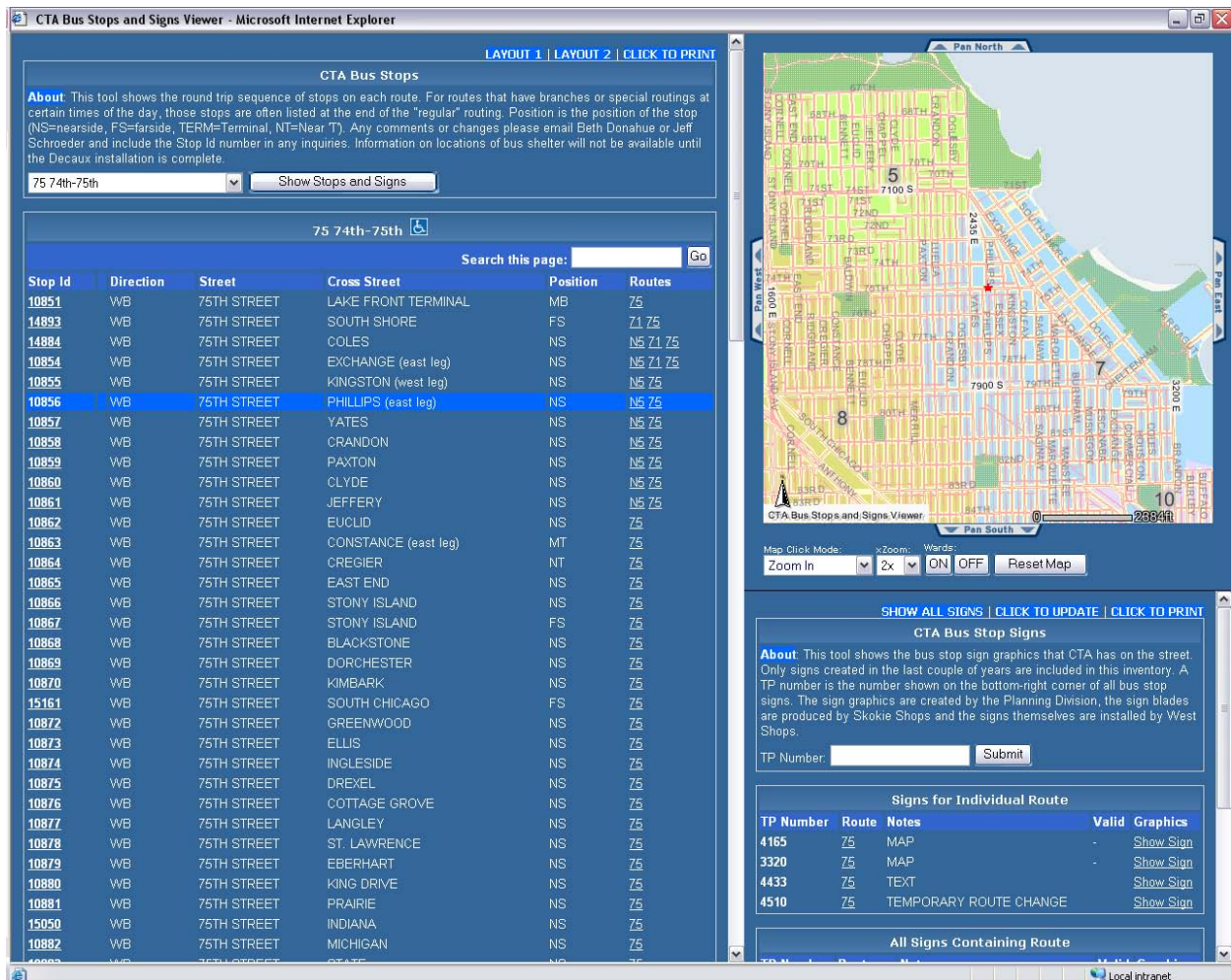

Figure 9 – CTA Bus Stops and Signs Viewer – Stop Map

The lower-right frame shows the bus stop sign graphics that CTA has on the street. Only signs created in recent years are included in this inventory. A user may query this inventory using route or TP Number (which is printed on the bottom-right corner of all bus stop signs). Clicking on the link for "Show Sign" will open the bus stop sign graphic [**Figure 10**].

"Click to Update" allows the person in charge of updating the signs inventory in Oracle to add new records and graphics.

Future development of the *CTA Bus Stops and Signs Viewer* will involve Data Services working with Traffic Engineering on keeping their sign inventory up-to-date, and providing access to more stop detail information, such as photos and videos.

Figure 10 – CTA Bus Stops and Signs Viewer – Signs

Conclusion

The process of implementing enterprise-wide ArcIMS websites can be a daunting experience. Knowing what to build and how it will best serve its users is the right direction to start in. Building a useful ArcIMS website is far less challenging when building upon the success of existing web-based applications, such as the Bus Location Information System at CTA. Modifications to the default HTML/JavaScript-based viewer, while initially time-consuming (especially for an agency with limited staff and resources), will result in code that is recyclable, faster loading (due to a potentially smaller footprint), and hand-tailored to the particular client/server environment of an organization. Making ArcIMS perform a specific task well, rather than attempting to create a universal map service, is perhaps the best advice.

APPENDIX A

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