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Light-Emitting Diode (LED) Traffic Signal and Uninterruptible Power Supply (UPS) Usage: A Nationwide Survey

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16. Abstract A national survey was conducted to gather information regarding the use of light-emitting diode (LED) traffic lights and uninterruptible power supply (UPS) systems in traffic signal controller cabinets. A survey was mailed out to the individual districts within Illinois DOT, all 49 other state DOTs, and to 79 of the largest cities in the US to find out the degree of utilization and satisfaction about LED traffic signals and UPS systems. At the State DOT level, there was a significant usage of LED lights in traffic signals. The most commonly used brands were Gelcore and Dialight. These accounted for approximately 95% of all LEDs in use at the state level. These results are also echoed in that both Dialight and Gelcore scored over 3.5 (out of 4.0) on the opinion-based degree of satisfaction ratings. At the city level, Dialight and Gelcore were also the most popular brands, and accounted for 91% of all LEDs in use. Dialight scored a near perfect rating of 3.923 and Gelcore also did very well with a satisfaction rating of 3.333. Finally, at the IDOT district level, Dialight was the most commonly used LED (accounting for about 95% of all LEDs in use), and also scored the highest satisfaction rating, at 3.833. The UPS Usage indicates that at the State DOT level, there was some usage of UPS systems, but it had not achieved widespread acceptance. From the 7 states that indicated using UPS systems, 7 different brands of UPS systems were identified. At the city level, there was even less acceptance of UPS systems at the time of this survey, with only 4 cities reported using 6 different brands. All 6 of these brands were in use by only a single city, so no average ratings were available.					
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EXECUTIVE SUMMARY

This study was conducted to gather information regarding the use of light-emitting diode (LED) traffic lights and uninterruptible power supply (UPS) systems in traffic signal controller cabinets. The Illinois Department of Transportation (IDOT) supported this study and the Traffic Operations Lab (TOL) at the University of Illinois at Urbana-Champaign conducted it. A survey was mailed out to the individual districts within IDOT, all 49 other state DOTs, and to 79 of the largest cities in the United States (chosen from the World Almanac 2001 edition) to find out the degree of utilization and satisfaction about LED traffic signals and UPS systems. The survey sent to the states was requested to be returned on or around December 28, 2000. The survey sent to the selected cities was requested to be returned on or around May 7, 2001. A copy of the survey is given in Appendix 1. Thirty-six states and 25 cities responded to the survey. The results of the survey are compiled here in 3 chapters. Chapter 2 is the LED portion of the study; Chapter 3 is the UPS portion of the study; and Chapter 4 is a final general question.

Chapter 2 (LED Usage) indicates that at the State DOT level, there was a significant usage of LED lights in traffic signals. The most commonly used brands were Ecolux/Diolux/Gelcore and Dialight. These accounted for approximately 95% of all LEDs in use at the state level. These results are also echoed in that both Dialight and Ecolux/Diolux/Gelcore scored over 3.5 (out of 4.0) on the opinion-based degree of satisfaction ratings. At the city level, Dialight and Ecolux/Diolux/Gelcore were also the most popular brands, and accounted for 91% of all LEDs in use. Dialight scored a near perfect rating of 3.923 (out of 4.0) and Ecolux/Diolux/Gelcore also did very well with a satisfaction rating of 3.333 (out of 4.0). Finally, at the IDOT district level, Dialight was the most commonly used LED (accounting for about 95% of all LEDs in use), and also scored the highest satisfaction rating, at 3.833 (out of 4.0).

Chapter 3 (UPS Usage) indicates that at the State DOT level, there was some usage of UPS systems, but it had not achieved widespread acceptance. From the 7 states that indicated using UPS systems, 7 different brands of UPS systems were identified. Of these 7 brands, only 2 were in use in more than 1 state. Clary was the most widely used brand, and had an average satisfaction score of 3.667 (out of 4.0), but Electro-Tech was the most used brand (with 100 installations in a single state which gave a 3 out of 4 in satisfaction). At the city level, there was even less acceptance of UPS systems at the time of this survey, with only 4 cities reporting their use. From these 4 cities, 6 different brands (Myers, IPC, Linear Dynamics, Clary, Dimensions Unlimited, and Electro-Tech) of UPS systems were identified. All 6 of these brands were in use by only a single city, so no average ratings were available. Of these brands, Dimensions, Unlimited had the most installations (with 26, and was given a satisfaction rating of 4 out of 4.)

I. INTRODUCTION

This study was conducted to gather information regarding the use of light-emitting diode (LED) traffic lights and uninterruptible power supply (UPS) systems in traffic signal controller cabinets. The Illinois Department of Transportation (IDOT) supported this study and the Traffic Operations Lab (TOL) at the University of Illinois at Urbana-Champaign conducted it. A survey was mailed out to the individual districts within IDOT, all 49 other state DOTs, and to 79 of the largest cities in the United States (chosen from the World Almanac 2001 edition) to find out the degree of utilization and satisfaction about LED traffic signals and UPS systems. The survey sent to the states was requested to be returned on or around December 28, 2000. The survey sent to the selected cities was requested to be returned on or around May 7, 2001. Attached as Appendix 1 is a sample of the survey that was mailed. The results of the survey are compiled here in 3 chapters. Chapter 2 is the LED portion of the study; Chapter 3 is the UPS portion of the study; and Chapter 4 is a final general question.

II. LED USAGE AND SATISFACTION

The survey results about LED traffic signals are reported in 3 sections. Section 1 will be the results from the state departments of transportation. Section 2 will be the results from the cities. Section 3 will be the results from the districts within IDOT.

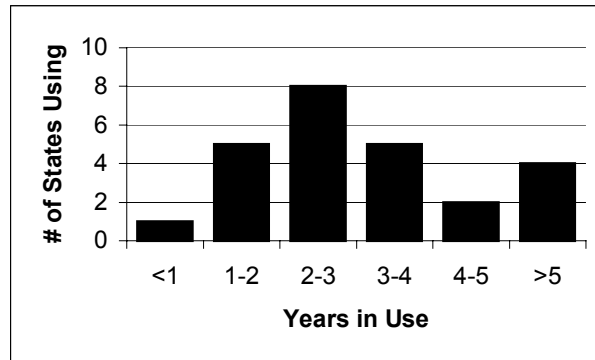
II. 1. LEDs in State DOTs

Of the 49 states that were sent a survey, 36 responded to the survey. Surveys were received from: Alabama; Alaska; Arizona; Arkansas; California; Colorado; Connecticut; Delaware; Florida; Georgia; Idaho; Iowa; Kentucky; Maryland; Massachusetts; Minnesota; Mississippi; Missouri; Nebraska; Nevada; New Hampshire; New Mexico; New York; North Carolina; North Dakota; Ohio; Oregon; Pennsylvania; Rhode Island; South Carolina; South Dakota; Utah; Virginia; Washington; West Virginia; Wyoming.

II. 1. 1. Use and Duration

Of these responding states, 30 states were using LEDs, and 1 additional state (Maryland) was in a testing phase. The remaining 5 states (Arkansas, Georgia, Idaho, Ohio and South Carolina) indicated that they were not using LEDs, and had various concerns regarding their use. LEDs had been in use in these states from as short as 6 months to as long as 8 years at the time of the survey.

Chart 1: Use and Duration of LEDs at State DOTs



II. 1. 2. Brands and Degree of Satisfaction

From these 30 states, 5 brands of LED were identified as being in use (see Table 1). These brands are: Dialight; Ecolux/Diolux/Gelcore; Precision Solar; Leotek; and Electro-Tech. The states using LEDs were also asked to rate the brands based on their level of satisfaction, with 1 being 'Very Unsatisfied', 2 being 'Somewhat Unsatisfied', 3 being 'Somewhat Satisfied', 4 being 'Very Satisfied', and 0 being 'No Opinion'.

Table 1: LED Satisfaction Levels of State DOTs

Brand	Total no of states using brand	No of 'no opinion' responses	No of responses	Average Rating*	Range		Standard Deviation
					Low	High	
Dialight	22	5	17	3.529	2	4	0.717
Ecolux/Diolux/Gelcore	21	6	15	3.533	3	4	0.516
Precision Solar	10	2	8	3.375	3	4	0.744
Leotek	8	3	5	2.800	1	4	1.304
Electro-Tech	6	0	6	3.500	2	4	0.837

(*Averages and standard deviations were determined from the total number of responses excluding the 'no opinion' responses.)

The degree of satisfaction for Dialight, Gelcore, and Electro-Tech was slightly higher than Precision Solar, and all four were higher rated than Leotek. Not only the average satisfaction score is important, the range and standard deviation are both important to consider as well. It is desirable to have a small range and standard deviation. The range and standard deviation was the highest for Leotek, and lowest for Gelcore and Precision Solar. At least one state was very unsatisfied with Leotek, two states were somewhat unsatisfied with Dialight, and another state was somewhat unsatisfied with Electro-Tech.

II. 1. 3. Numbers in Use

The survey also asked the number of LEDs used by the DOTs. Some respondents did not give an exact number, but said words such as 'many', 'thousands', 'hundreds' or provided numbers such as '400+' or '1000±'. Many states provided exact totals. The total of each brand used by these DOTs is as follows:

Table 2: LED Brands and Quantities used by State DOTs

Brand	Total no of responses	No of responses - exact totals	Quantity of brand in use	Average no in use*	Range	
					Low	High
Ecolux/Diolux/Gelcore	21	13	107684	8283	10	70000
Dialight	22	12	44446	3704	2	25000
Precision Solar	10	6	2898	483	1	2000
Leotek	8	6	1781	297	3	1000
Electro-Tech	6	3	4001	1334	1	3000

(*Averages were determined from the 'number of responses – exact totals'.)

II. 1. 4. Written Procedures for LEDs

The survey asked what, if any, written procedures were in effect on the use of LEDs in traffic signals, and to include a copy of these procedures, if available. Eight states (Alaska, California, Colorado, Missouri, New York, Pennsylvania, Virginia and Washington) reported having a written procedure on the use of LEDs in traffic signals.

II. 1. 5. Specifications for the Procurement of LEDs

The next question asked if any states had a specification for the procurement of LED traffic signal modules, and to include a copy of these specifications, if available. Twenty states reported having some sort of specification for the procurement of LEDs (Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Massachusetts, Minnesota, Missouri, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Utah, Virginia and Wyoming). Several states reported using the interim ITE specifications, the majority reported having their own specifications, or just having an approved products list that the LEDs must be on to be used.

Copies of either the written procedures or the procurement specifications were provided by sixteen states (Alaska, Arizona, California, Colorado, Connecticut, Florida, Minnesota, Missouri, North Carolina, North Dakota, Ohio, Oregon, Rhode Island, Utah, Virginia and Wyoming.)

II. 1. 6. Colors Used

We were also interested in determining which LED colors (solid and arrows) were used in the field. Table 3 is based on the 30 states that responded to the survey. All of the states were using solid red LEDs and about 67% were using red arrow LEDs. About 77% were using solid green LEDs and 63% were using green arrow LEDs. Only 47% used solid yellow LEDs and 43% used yellow arrow LEDs. About 73% used pedestrian LED heads.

Table 3: Specific LED Usage by State DOTs

LED Type	No of states using this type	No of states not using this type
Red-Solid	30	0
Red-Arrow	20	10
Green-Solid	23	7
Green-Arrow	15	15
Yellow-Solid	14	16
Yellow-Arrow	9	21
Other-Solid*	2	28
Other-Arrow**	4	26
Pedestrian Head	22	8

* One state is using red and green flashers, the other is using solar-powered red and yellow beacons

** All four states are using a combination green & yellow arrow

II. 1. 7. Problems with LEDs and Solutions

The last LED-specific question asked on the survey was: Please briefly describe the main problem(s) you have had with the LEDs specified in the previous question, and describe how you dealt with them.

The responses received are as follows:

- Short-term failure.
- Power supplies go out because of power surges or lightning. We are able to return for warranty repair.
- Blanking on span-mounted signals – changed specs.
- A higher than expected failure rate on some models – vendor complaint form filed.
- A product recall on one model – made company pay recall costs.
- Early models failed due to water entry.
- Some have poor directional properties and some had sun glare problems.
- Electro-Techs screw-in modules do not always align up with the existing lens.
- We have had some failures and have received replacements under warranty. No major problems have occurred.
- Strings of bulbs going bad, lightning strikes, replacing fuses.
- Had some problems with strobes on the Dialights. Had quite a bit of failures with Leotek, approximately 10%. Fuses are blowing on the reds. Have not heard of too many problems with Ecolux (Gelcore).
- Not very useful on span wires in windy areas. We use mostly mast-arm poles and LEDs work very well there.
- The LED modules have about a 5% failure rate, usually covered by warranties.
- Snow packing in tunnel visors and not melting. Lasts for the duration of the snowstorm.
- The main issue was to make the LED compatible with our current monitor. This was solved by working with the manufacturer.
- Initial Dialight modules were susceptible to water damage. A specification revision requiring the lens to be sealed to the housing resolved this problem.
- Conflict monitor circuits are required in each LED light. Also, we use the ITE specification option; i.e. we require that all LEDs (red, green, and yellow) must have this circuit and verify it before being installed in the field. (Any model LED after the certification.) LEDs are being tested now, therefore we are not recommending any model.
- Evolution of LED technology provides the opportunity to improve LED signal features and gain better efficiency and life as well. Specifications sometimes change frequently as we seek the greatest advantage.
- No major problems to date.
- Lightning strikes in close proximity to signals knocks out LEDs.
- The Leotek LEDs are the only yellow indications the state has. These yellow indications do not have the intensity the state would like to see.
- Sometimes with earlier NEMA TS1 type equipment lights (LED) will flicker. Changing out load switches has repaired the problem. Only problem

mentioned thus far has been “cone of visibility”, there is a need to focus the heads.

- No significant problems in the first 12 months of retrofitting / new installations of existing and/or new traffic signals. Note: Statewide retrofit / new installation of traffic signals currently underway for rigid mount red and green signal indications (no span wire installations.)
- LEDs are not reaching 3 to 5 year projected life.
- In span wire applications, with moderate to heavy winds, the motorist would lose the signal from the LED module primarily due to the limited “angularity” of the module. Dialight is the only company where we have an increased “angularity” due to the manufacture of some of their modules.
- With Dialight, we have experienced numerous failures ranging from sections of LED to total indication failure. Although under warranty, slow replacement has caused heartburn.

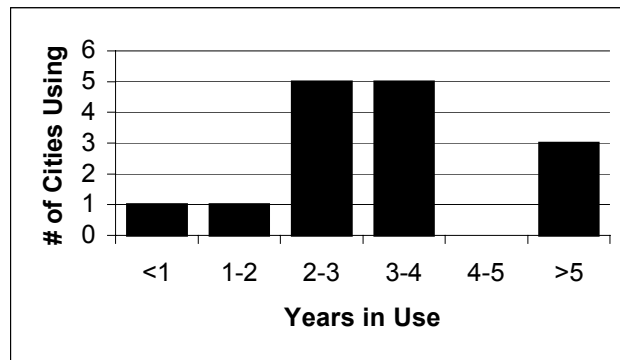
II. 2. LEDs in City DOTs

Of the 79 cities that were sent a survey, 25 responded to the survey. Surveys were received from: Anchorage, AK; Atlanta, GA; Dallas, TX; Denver, CO; Detroit, MI; Fort Worth, TX; Greensboro, NC; Honolulu, HI; Huntington Beach, CA; Jacksonville, FL; Lincoln, NE; Louisville, KY; Miami, FL; Minneapolis, MN; Mobile, AL; New York, NY; Newark, NJ; Omaha, NE; Phoenix, AZ; Sacramento, CA; San Francisco, CA; St. Louis, MO; St. Paul, MN; Toledo, OH; and Wichita, KS.

II. 2. 1. Use and Duration

Of these responding cities, 17 cities were using LEDs, and 5 additional cities (Jacksonville, Miami, Mobile, San Francisco and Toledo) were evaluating and/or testing LEDs in the field. The remaining 3 cities (Dallas, Detroit and Louisville) indicated that they were not using LEDs and some also had various concerns regarding their use. LEDs had been in use in these cities from as short as 1 month to as long as 6 years at the time of the survey.

Chart 2: Use and Duration of LEDs at Selected Cities



II. 2. 2. Brands and Degree of Satisfaction

From these 17 cities, 7 brands of LED were identified as being in use. These brands are: Dialight; Ecolux/Diolux/Gelcore; Precision Solar; Leotek; Electro-Tech; Synchronex; and Atlite. The cities using LEDs were also asked to rate the brands based on their level of satisfaction, with 1 being 'Very Unsatisfied', 2 being 'Somewhat Unsatisfied', 3 being 'Somewhat Satisfied', 4 being 'Very Satisfied', and 0 being 'No Opinion'.

Table 4: LED Satisfaction Levels of Selected Cities

Brand	Total no of cities using brand	No of 'no opinion' responses	No of responses	Average Rating*	Range		Standard Deviation
					Low	High	
Dialight	14	1	13	3.923	3	4	0.277
Ecolux/Diolux/Gelcore	10	1	9	3.333	1	4	1.118
Precision Solar	3	0	3	2.667	1	4	1.528
Leotek	3	0	3	3.000	2	4	1.000
Electro-Tech	2	0	2	1.500	1	2	0.707
Synchronex	1	1	0	n/a	n/a	n/a	n/a
Atlite	1	0	1	4.000	n/a	n/a	n/a

(*Averages and standard deviations were determined from the total number of responses excluding the 'no opinion' responses.)

The degree of satisfaction for Dialight, Atlite, Leotek, and Gelcore were higher than Precision Solar and Electro-Tech. Synchronex did not have an average. Not only the average satisfaction score is important, the range and standard deviation are both important to consider as well. It is desirable to have a small range and a low standard deviation. The range and standard deviation was the highest for Precision Solar, and lowest for Dialight. At least one city was very unsatisfied with Precision Solar, two cities were somewhat unsatisfied with Gelcore, and two other cities were rather unsatisfied with Electro-Tech.

II. 2. 3. Numbers in Use

The survey also asked the number of LEDs used by the cities. Some respondents did not give an exact number, but said words such as 'many', 'thousands', 'hundreds', or provided numbers such as '400+' or '1000±'. Many cities provided exact totals. The total of each brand used by these cities is as follows:

Table 5: LED Brands and Quantities used by Selected Cities

Brand	Total no of responses	No of responses - exact totals	Quantity of brand in use	Average no in use*	Range	
					Low	High
Dialight	14	11	36178	3289	50	20000
Ecolux/Diolux/Gelcore	10	9	32760	3640	50	19000
Precision Solar	3	2	1410	705	60	1350
Leotek	3	2	1109	555	50	1059
Electro-Tech	2	2	85	43	25	60
Synchronex	1	1	4000	4000	4000	4000
Atlite	1	1	500	500	500	500

(*Averages were determined from the 'number of responses – exact totals'.)

II. 2. 4. Written Procedures for LEDs

The survey asked what, if any, written procedures were in effect on the use of LEDs in traffic signals, and to include a copy of these procedures, if available. Four of the selected cities (Anchorage, Fort Worth, Sacramento and St. Paul) reported having a written procedure on the use of LEDs in traffic signals.

II. 2. 5. Specifications for the Procurement of LEDs

The next question asked if any of the selected cities had a specification for the procurement of LED traffic signal modules, and to include a copy of these specifications, if available. Thirteen of the selected cities (Anchorage, Atlanta, Fort Worth, Honolulu, Lincoln, Minneapolis, New York, Newark, Omaha, Phoenix, Sacramento, San Francisco and St. Paul) reported having some sort of specification for the procurement of LEDs. One city reported using the interim ITE specifications, the majority reported having their own specifications, or used their state DOT approved products list that the LEDs must be on to be used.

Copies of either the written procedures or the procurement specifications were provided by seven cities (Atlanta, New York City, Newark, Omaha, Phoenix, San Francisco, and St. Paul.)

II. 2. 6. Colors Used

We were also interested in determining which LED colors (solid and arrows) were used in the field. Table 6 is based on the 20 cities that responded to the survey (2 respondents did not answer this portion.) All of the cities were using solid red LEDs and 60% were using red arrow LEDs. 75% were using solid green LEDs and 50% were using green arrow LEDs. Only 25% used solid yellow LEDs and 20% used yellow arrow LEDs. 85% used pedestrian LED heads.

Table 6: Specific LED Usage by Selected Cities

LED Type	No of cities using this type	No of cities not using this	unknown**
Red-Solid	20	0	2
Red-Arrow	12	8	2
Green-Solid	15	5	2
Green-Arrow	10	10	2
Yellow-Solid	5	15	2
Yellow-Arrow	4	16	2
Other-Solid*	1	19	2
Other-Arrow	0	20	2
Pedestrian Head	17	3	2

* One city is using yellow flashing beacons

** Two cities that indicated using LEDs did not specify the manner in which they are being used

II. 2. 7. Problems with LEDs and Solutions

The last LED-specific question asked on the survey was: Please briefly describe the main problem(s) you have had with the LEDs specified in the previous question, and describe how you dealt with them.

The responses received are as follows:

- Early mortality – we replace 1 Dialight failure per week (greens & peds)
- In some high speed, high volume intersections; we like the LED signals to cut down on maintenance and to add more “punch” to heighten visibility.
- All of our failures have been covered under warranty.
- LED failures and complete unit failures.
- Controlling brightness & extraneous visibility. Refacing helps.
- Solid ball red started flashing upon installation. R&R’d alignment problems. Realigned.
- Degradation of light output in earlier models.
- Fading.
- Since installation, had 25 failures (approximately 0.4%). Failed lenses replaced under manufacturer warranty. We are very satisfied with this product.
- Precision Solar has the highest failure rate and the connecting means for the d/w is of poor design.
- Ecolux (Gelcore) had power supply problems causing high failure rate. (I understand that has now been corrected.) Leotek has had some problems with physical construction failure – lens separation from the case, etc. Dialight thus far has been the best product we have used, that is, fewer failures.
- Short total life (Leotek green 6-8 months). Out of about 8000 LED units have average 24 per month fail and about 10% with strong failure but still in operation.

- We have a few test sites, and will be installing them in various signal contracts at 50+ locations this year. We intend to use them for all vehicle indications.
- Green LEDs are too bright. We stopped using them.
- Early Diolux (Gelcore) models had circuit failures and heat-related dimming, but these issues were corrected by the manufacturer. 5-year warranty has covered all failures.

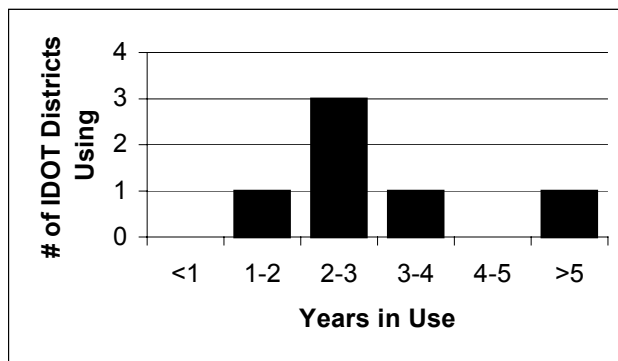
II. 3. LED in IDOT Districts

Of the 9 IDOT districts that were sent a survey, 8 responded to the survey. Surveys were received from: District 2 - Dixon; District 3 – Ottawa; District 4 – Peoria; District 5 – Paris; District 6 – Springfield; District 7 – Effingham; District 8 – Collinsville; and District 9 - Carbondale.

II. 3. 1. Use and Duration

Of these responding districts, 6 districts were using LEDs, and the remaining 2 districts (District 5 – Paris and District 6 - Springfield) indicated that they were not using LEDs at that time. LEDs had been in use in these districts from as short as 1 month to as long as 5 years at the time of the survey.

Chart 3: Use and Duration of LEDs for IDOT Districts



II. 3. 2. Brands and Degree of Satisfaction

From these 6 districts, 3 brands of LED were identified as being in use. These brands are: Dialight; Ecolux/Diolux/Gelcore; and Leotek. The districts using LEDs were also asked to rate the brands based on their level of satisfaction, with 1 being 'Very Unsatisfied', 2 being 'Somewhat Unsatisfied', 3 being 'Somewhat Satisfied', 4 being 'Very Satisfied', and 0 being 'No Opinion'.

Table 7: LED Satisfaction Levels of IDOT Districts

Brand	Total no of districts using brand	No of 'no opinion' responses	No of responses	Average Rating*	Range		Standard Deviation
					Low	High	
Dialight	6	0	6	3.833	3	4	0.408
Ecolux/Diolux/Gelcore	2	0	2	3.500	3	4	0.707
Leotek	1	0	1	1.000	n/a	n/a	n/a

(*Averages and standard deviations were determined from the total number of responses excluding the 'no opinion' responses.)

The degree of satisfaction for Dialight and Gelcore were significantly higher than Leotek. Not only the average satisfaction score is important, the range and standard deviation are both important to consider as well. It is desirable to have a small range and a low standard deviation. The range and standard deviation was lowest for Dialight, and there was insufficient data to provide conclusive results for Gelcore and Leotek. One district was very unsatisfied with Leotek, other districts were either somewhat satisfied or very satisfied with Dialight and Gelcore.

II. 3. 3. Numbers in Use

The survey also asked the number of LEDs used by the IDOT districts. All respondents provided exact totals, which makes for a more exact total. The total of each brand used by these IDOT districts is as follows:

Table 8: LED Brands and Quantities used by IDOT Districts

Brand	Total no of responses	No of responses - exact totals	Quantity of brand in use	Average no in use*	Range	
					Low	High
Dialight	6	6	395	66	1	266
Ecolux/Diolux/Gelcore	2	2	17	9	2	15
Leotek	1	1	6	6	6	6

(*Averages were determined from the 'number of responses – exact totals'.)

II. 3. 4. Written Procedures for LEDs

The survey asked what, if any, written procedures were in effect on the use of LEDs in traffic signals, and to include a copy of these procedures, if available. None of the districts reported having a written procedure on the use of LEDs in traffic signals.

II. 3. 5. Specifications for the Procurement of LEDs

The next question asked if any of the districts had a specification for the procurement of LED traffic signal modules, and to include a copy of these specifications, if available. One of the districts (District 3 - Ottawa) reported having some sort of specification for the procurement of LEDs. This specification was drafted for the Veterans Parkway Phase II.

II. 3. 6. Colors Used

We were also interested in determining which LED colors (solid and arrows) were used in the field. Table 9 is based on the 8 districts that responded to this survey. Half of the districts were using solid red LEDs and about 38% were using red arrow LEDs. 25% were using solid green LEDs and 25% were using green arrow LEDs. 25% were using solid yellow LEDs and about 13% were using yellow arrow LEDs. 25% were using pedestrian LED heads.

Table 9: Specific LED Usage by IDOT Districts

LED Type	No of districts using this	No of districts not using this type
Red-Solid	4	4
Red-Arrow	3	5
Green-Solid	2	6
Green-Arrow	2	6
Yellow-Solid	2	6
Yellow-Arrow	1	7
Other-Solid*	2	6
Other-Arrow	0	8
Pedestrian Head	2	6

* One city is flashing yellow beacons, the other is using flashing red & yellow beacons.

II. 3. 7. Problems with LEDs and Solutions

The last LED-specific question asked on the survey was: Please briefly describe the main problem(s) you have had with the LEDs specified in the previous question, and describe how you dealt with them.

The responses received are as follows:

- One Dialight DuraLED leaked water and failed. The unit was replaced under warranty immediately.

- Dialight – Green LEDs had insufficient load switching in original design – current model is OK.
- The Dialight DuraLEDs have a better lens that allows for better viewing angles without the normal cutoff for side viewing. The Ecolux are acceptable for most mast-arm and post-mounted applications.
- The power supply has failed on a couple of the McCain-supplied LEDs. They were under warranty & replaced with no problems.

III. UPS USAGE AND SATISFACTION

The results of the UPS portion of this study are reported in 3 sections in this report. Section 1 will be the results from the state departments of transportation. Section 2 will be the results from the cities. Section 3 will be the results from the districts within IDOT.

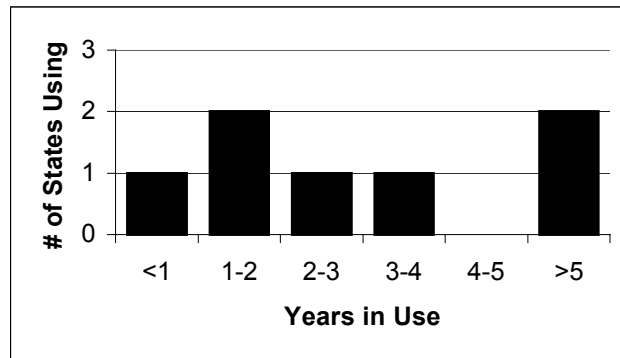
III. 1. UPS in State DOTs

Of the 49 states that were sent a survey, 36 responded to the survey. Surveys were received from: Alabama; Alaska; Arizona; Arkansas; California; Colorado; Connecticut; Delaware; Florida; Georgia; Idaho; Iowa; Kentucky; Maryland; Massachusetts; Minnesota; Mississippi; Missouri; Nebraska; Nevada; New Hampshire; New Mexico; New York; North Carolina; North Dakota; Ohio; Oregon; Pennsylvania; Rhode Island; South Carolina; South Dakota; Utah; Virginia; Washington; West Virginia; Wyoming.

III. 1. 1. Use and Duration

Of these responding states, 7 states were using UPS systems (Alaska, California, Colorado, Florida, Minnesota, Utah and Washington). The remaining 29 states indicated that they were not using UPS systems, and had various concerns regarding their use. UPS systems had been in use in these states from as short as 1 month to as long as 5+ years at the time of the survey.

Chart 4: Use and Duration of UPS Systems at State DOTs



III. 1. 2. Brands and Degree of Satisfaction

From these 7 states, 7 brands of UPS systems were identified as being in use. These brands are: Clary; Online Power; APC; Lite Saver; UTCS; Dimensions, Unlimited; and Electro-Tech. The states using UPS systems were also asked to rate the brands based on their level of satisfaction, with 1 being 'Very Unsatisfied', 2 being 'Somewhat Unsatisfied', 3 being 'Somewhat Satisfied', 4 being 'Very Satisfied', and 0 being 'No Opinion'.

Table 10: UPS Satisfaction Levels of State DOTs

Brand	Total no of states using brand	No of 'no opinion' responses	No of responses	Average Rating*	Range		Standard Deviation
					Low	High	
Clary	3	0	3	3.667	3	4	0.577
Online Power	2	0	2	1.500	1	2	0.707
APC	1	0	1	4.000	n/a	n/a	n/a
Lite Saver	1	0	1	1.000	n/a	n/a	n/a
UTCS	1	0	1	4.000	n/a	n/a	n/a
Dimensions, Unlimited	1	1	0	n/a	n/a	n/a	n/a
Electro-Tech	1	0	1	3.000	n/a	n/a	n/a

(*Averages and standard deviations were determined from the total number of responses excluding the 'no opinion' responses.)

The degree of satisfaction for Clary, APC, and UTCS were higher than Electro-Tech, and much higher than Online Power and Lite Saver. The average satisfaction score is important, as are the range and standard deviation. Clary was used by three states and they were satisfied. Both states that used Online Power were unsatisfied with the product. The product from APC, Lite Saver, UTCS, Dimensions Unlimited, and Electro-Tech all were used by only a single state, so the data is very limited.

III. 1. 3. Numbers in Use

The survey also asked the number of UPS systems used by the DOTs. All respondents gave an exact total. The total of each brand used by these DOTs is as follows:

Table 11: UPS Brands and Quantities used by State DOTs

Brand	Total no of responses	No of responses - exact totals	Quantity of brand in use	Average no in use*	Range	
					Low	High
Clary	3	3	9	3	1	5
Online Power	2	2	2	1	1	1
APC	1	1	30	30	30	30
Lite Saver	1	1	1	1	1	1
UTCS	1	1	1	1	1	1
Dimensions, Unlimited	1	1	1	1	1	1
Electro-Tech	1	1	100	100	100	100

(*Averages were determined from the 'number of responses – exact totals'.)

In terms of quantity, Electro-tech and APC were used more than others, but Clary was used by more states.

III. 1. 4. Written Procedures for UPS Systems

The next question asked what, if any, written procedures were in effect on the use of UPS systems in traffic signals, and to include a copy of these procedures, if available. Only one state, California, reported having a written procedure on the use of UPS systems in traffic signals.

III. 1. 5. Utilization of UPS Systems at Intersections

The next question asked the states how they utilized the UPS system at intersections, and for what conditions. Three states used UPS to operate LED signals in normal mode; two used it to operate incandescent red lights in flashing mode; one state used it to operate incandescent lights in normal mode; and one other state used it to operate LED red lights in flashing mode.

Table 12: Specific UPS Usage by State DOTs

Condition	Total no of states using for this condition
To operate incandescent red lights in flashing mode only	2
To operate incandescent lights in normal mode	1
To operate LED red lights in flashing mode	1
To operate LED signal in normal mode	3
All of the above	0
Other*	1

* ATMS applications

III. 1. 6. Problems with UPS Systems and Solutions

The last UPS-specific question asked on the survey was: Please briefly describe the main problem(s) you have had with the UPS specified in the previous question, and describe how you dealt with them.

The responses received are as follows:

- Very unsatisfied with Litesaver & Online Power UPS brands
- We have had no problems
- No major problems to date
- Battery life, charging unit, resistance to high heat factors
- No problems thus far. Used in ATMS cabinets and hub sites.
- Battery capacity & life

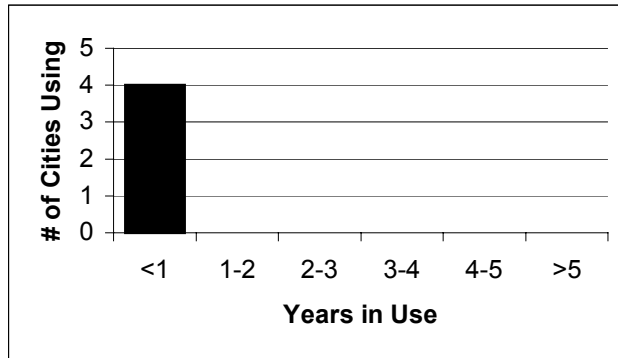
III. 2. UPS Systems in City DOTs

Of the 79 cities that were sent a survey, 25 responded to the survey. Surveys were received from: Anchorage, AK; Atlanta, GA; Dallas, TX; Denver, CO; Detroit, MI; Fort Worth, TX; Greensboro, NC; Honolulu, HI; Huntington Beach, CA; Jacksonville, FL; Lincoln, NE; Louisville, KY; Miami, FL; Minneapolis, MN; Mobile, AL; New York, NY; Newark, NJ; Omaha, NE; Phoenix, AZ; Sacramento, CA; San Francisco, CA; St. Louis, MO; St. Paul, MN; Toledo, OH; and Wichita, KS.

III. 2. 1. Use and Duration

Of these responding cities, 4 cities were using UPS systems (Atlanta; Sacramento; St. Louis; and St. Paul). The remaining 21 cities indicated that they were not using UPS systems, and had various concerns regarding their use. UPS systems had been in use in these cities for only a short time period, all under 1 year.

Chart 5: Use and Duration of UPS Systems at Selected Cities



III. 2. 2. Brands and Degree of Satisfaction

From these 4 cities, 6 brands of UPS systems were identified as being in use. These brands are: Myers; IPC; Linear Dynamics; Clary; Dimensions, Unlimited; and Electro-Tech. The cities using UPS systems were also asked to rate the brands based on their level of satisfaction, with 1 being 'Very Unsatisfied', 2 being 'Somewhat Unsatisfied', 3 being 'Somewhat Satisfied', 4 being 'Very Satisfied', and 0 being 'No Opinion'.

Table 13: UPS Satisfaction Levels of Selected Cities

Brand	Total no of cities using brand	No of 'no opinion' responses	No of responses	Average Rating*	Range		Standard Deviation
					Low	High	
Myers	1	0	1	3.000	n/a	n/a	n/a
IPC	1	1	0	n/a	n/a	n/a	n/a
Linear Dynamics	1	0	1	4.000	n/a	n/a	n/a
Clary	1	0	1	3.000	n/a	n/a	n/a
Dimensions, Unlimited	1	0	1	4.000	n/a	n/a	n/a
Electro-Tech	1	0	1	4.000	n/a	n/a	n/a

(*Averages and standard deviations were determined from the total number of responses excluding the 'no opinion' responses.)

The degree of satisfaction for Linear Dynamics, Dimensions Unlimited, and Electro-Tech were higher than Myers, Clary, and IPC. Not only the average satisfaction score is important, however, and the range and standard deviation are both important to consider as well. All brands listed in this portion of the survey were used by only a single city, so the data is very limited.

III. 2. 3. Numbers in Use

The survey also asked the number of UPS systems used by the cities. All respondents gave an exact total. The total of each brand used by these cities is as follows:

Table 14: UPS Brands and Quantities used by Selected Cities

Brand	Total no of responses	No of responses - exact totals	Quantity of brand in use	Average no in use*	Range	
					Low	High
Myers	1	1	1	1	1	1
IPC	1	1	8	8	8	8
Linear Dynamics	1	1	3	3	3	3
Clary	1	1	1	1	1	1
Dimensions, Unlimited	1	1	26	26	26	26
Electro-Tech	1	1	1	1	1	1

(*Averages were determined from the 'number of responses – exact totals'.)

III. 2. 4. Written Procedures for UPS Systems

The survey asked what, if any, written procedures were in effect on the use of UPS systems in traffic signals, and to include a copy of these procedures, if available. No cities reported having a written procedure on the use of UPS systems in traffic signals.

III. 2. 5. Utilization of UPS Systems at Intersections

The next question asked the cities how they utilized the UPS system at intersections, and for what conditions. Two cities used UPS to operate LED red lights in flashing mode; one city used it to operate incandescent red lights in flashing mode; and one other city used it to operate incandescent lights in normal mode.

Table 15: Specific UPS Usage by Selected Cities

Condition	Total no of cities using for this condition
To operate incandescent red lights in flashing mode only	1
To operate incandescent lights in normal mode	1
To operate LED red lights in flashing mode	2
To operate LED signal in normal mode	0
All of the above	0
Other	0

III. 2. 6. Problems with UPS Systems and Solutions

The last UPS-specific question asked on the survey was: Please briefly describe the main problem(s) you have had with the UPS specified in the previous question, and describe how you dealt with them.

The responses received are as follows:

- Dimensions DUI 1000/24 was ordered with options for flash mode – no instructions on connections were provided to make it possible.
- Delivery of battery backup system was delayed
- Dimensions, Unlimited has been in UPS systems for many years but have had to spend much time with them to perfect traffic signal application. They are small, compact, and it seems that this is the forerunner as we get the bugs worked out. Clary is a nice unit, but it is expensive and bulky.

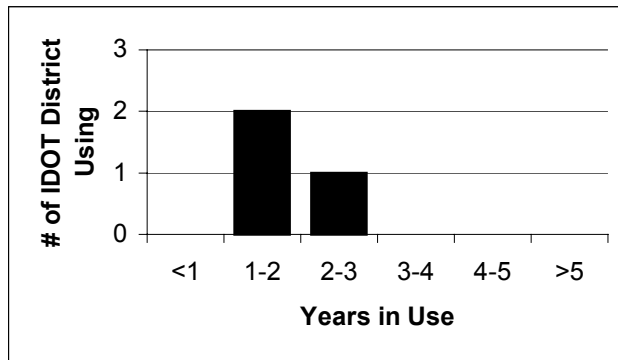
III. 3. UPS Systems in IDOT Districts

Of the 9 IDOT districts that were sent a survey, 8 responded to the survey. Surveys were received from: District 2 - Dixon; District 3 – Ottawa; District 4 – Peoria; District 5 – Paris; District 6 – Springfield; District 7 – Effingham; District 8 – Collinsville; and District 9 - Carbondale.

III. 3. 1. Use and Duration

Of these responding districts, 3 districts (District 3 – Ottawa; District 4 – Peoria; and District 9 – Carbondale) were using UPS systems, and the remaining 5 districts indicated that they were not using UPS systems at this time. UPS systems had been in use in these districts for approximately 1 to 3 years at the time of the survey.

Chart 6: Use and Duration of UPS Systems at IDOT Districts



III. 3. 2. Brands and Degree of Satisfaction

From these 3 districts, 4 brands of UPS systems were identified as being in use. These brands are: TPSI; APC; Power Systems; and MGE. The districts using UPS systems were also asked to rate the brands based on their level of satisfaction, with 1 being ‘Very Unsatisfied’, 2 being ‘Somewhat Unsatisfied’, 3 being ‘Somewhat Satisfied’, 4 being ‘Very Satisfied’, and 0 being ‘No Opinion’.

Table 16: UPS Satisfaction Levels of IDOT Districts

Brand	Total no of districts using brand	No of 'no opinion' responses	No of responses	Average Rating*	Range		Standard Deviation
					Low	High	
APC	3	0	3	2.667	2	3	0.471
TPSI	1	0	1	3.000	n/a	n/a	n/a
Power Systems	1	0	1	4.000	n/a	n/a	n/a
MGE	1	0	1	2.000	n/a	n/a	n/a

(*Averages and standard deviations were determined from the total number of responses excluding the ‘no opinion’ responses.)

The degree of satisfaction for Power Systems and TPSI are both higher than APC and MGE. Not only the average satisfaction score is important, however, and the range and standard deviation are both important to consider as well. Three of the four brands listed in this portion of the survey were used by only a single district, so the data is very inconclusive.

III. 3. 3. Numbers and Use

The survey also asked the number of UPSs used by the IDOT districts. All respondents gave an exact total. The total of each brand used by these cities is as follows:

Table 17: UPS Brands and Quantities used by IDOT Districts

Brand	Total no of responses	No of responses - exact totals	Quantity of brand in use	Average no in use*	Range	
					Low	High
APC	3	3	4	1	1	2
TPSI	1	1	1	1	1	1
Power Systems	1	1	1	1	1	1
MGE	1	1	2	2	2	2

(*Averages were determined from the ‘number of responses – exact totals’.)

III. 3. 4. Written Procedures for UPS Systems

The survey asked what, if any, written procedures were in effect on the use of UPS systems in traffic signals, and to include a copy of these procedures, if available. No districts reported having a written procedure on the use of UPS systems in traffic signals.

III. 3. 5. Utilization of UPS Systems at Intersections

The next question asked the cities how they utilized the UPS system at intersections, and for what conditions. Three districts used UPS systems to operate LED red lights in flashing mode, but no other mode was used.

Table 18: Specific UPS Usage – IDOT Districts

Condition	Total no of districts using for this condition
To operate incandescent red lights in flashing mode only	0
To operate incandescent lights in normal mode	0
To operate LED red lights in flashing mode	3
To operate LED signal in normal mode	0
All of the above	0
Other	0

III. 3. 6. Problems with UPS Systems and Solutions

The last UPS-specific question asked on the survey was: Please briefly describe the main problem(s) you have had with the UPS specified in the previous question, and describe how you dealt with them.

The responses received are as follows:

- The batteries take up a lot of space. Need to piggyback on an additional cabinet. This also keeps batteries separate from signal cable and equipment. If cabinet gets hit, it may leak on signal cables & equipment. Need to check batteries regularly to make sure they are working.
- APC does not meet NEMA specifications for operating temperature. It is less costly and has been working reasonably well in all types of weather for the past 2.5 years.
- The output of the UPS has failed off leaving the intersection dark after power was restored. The UPS has to be reset manually. We have installed bypass relays to insure that the intersection is not dark after power is restored.

IV. COMMENTS ON UPS OR LED USE IN TRAFFIC SIGNALS

The final question on the survey was a general wrap-up question. We were interested in gathering general comments about UPS or LED use in traffic signals.

Responses from the states are as follows:

- Issue of yellow LED not meeting specs needs resolution especially from a cost-savings perspective. Maintenance of UPS is key to its success. There is a need for better maintenance budgeting to keep UPS upgraded and operational.
- Costs for both are high. Will consider use when price is more competitive.
- I think this is a good idea. We have plans to do some spot installations with red LEDs and flashing all red during power failures.
- First use of backup battery system in traffic signals was for “red-flash” only. Future systems will have ability for “full-operation” when a signal is 100% LED.
- LEDs have decreased the service calls by 60% and power bills by 75-80% at intersections with all LEDs. UPSs are too new to our region to have an opinion.
- We currently flash incandescent “red” side and amber main street. LED deployment will expand capability.
- Fully intend to begin using LEDs for reds in signals. Do not believe we can afford UPS at traffic signals.
- Although we have allowed LED indications to be used by cities at intersections on our routes. I have concerns with snow not melting from LED heads and concerns that cities will not replace indications with significant LED failures.
- We are evaluating LED signals on our test track, and we are installing LED overhead dynamic message signs. We have two amber LED message signs in operation right now. In similar fashion, we are investigating the use of UPS at key intersections, but we have not installed a system yet.
- UPS – Problems prioritizing which of approximately 1100 signal locations should have UPS. Maintenance concerns. Power outage lengths and low frequency of occurrence do not justify UPS. LED – Now specified in all of the DOT highway funded projects and at all state highway locations.
- We are currently exploring expansion of the use of UPS with our signaling systems through committees and forums.
- We have our first intersection under construction now that will use both UPS and LEDs. The UPS is designed to run the signals in full normal operation for 24 hours.
- We use yellow LEDs, but not in signals. Yellow LEDs are used on barricade boards, rigid mount flashers. LEDs are also used on mast arm signals only. We currently are evaluating wide angle LEDs for use on span wire applications. We will be adding LEDs to our approved products list and revising our procurement specs soon.
- Yellow LED ITE specs need to be more realistic (levels are too high). Vertical and horizontal viewing angles should be increased. A procedure

regarding replacement of LEDs needs to be developed regarding when LEDs should be replaced.

- We are awaiting the results of two studies on the response to varying intensities of yellow signals. Once a new ITE intensity requirement is developed and adopted we will likely change to use of all three colors in the vehicular heads. Upon the total implementation of LEDs in the signal faces, we are likely to begin more serious consideration of UPS backup.
- Test all LED brand models and types before its use. We installed generator panel on the side of the cabinet in case of power outage, we move portable generator and plug it into it, thus running an intersection on a portable generator.
- We explored the use of UPS in traffic signals and decided that there are too many signals to warrant a change in practice to provide full operation or limited operation during commercial power outages. When the UPS is expended, operation still defaults to “dark signal”, which is covered in the vehicle operators manual. Regarding LED signals, it would be very nice if the industry would produce a signal specifically for LEDs that could provide a rapid replacement option and lighter heads, possibly with less bulk. There is more to the technology than the light source.
- A limited number of local municipalities are beginning to consider the use of UPS systems at a limited number of sites.
- We will begin using red LEDs in January 2001. We have developed our specification and will begin procurement soon.
- To obtain LEDs we rely on the ITE specs.
- Low power consumption of LEDs has greatly reduced power bills. Group replacement time can now be spent on other critical maintenance needs. Currently adding LEDs to all new state signal construction projects.
- UPS – Good application for critical signals.
- We are actively placing LEDs in all new signal & renovation projects. As far as UPS, our cabinets are quite complex and limited with regard to interior space. We rarely have power outages at signals and when we do, they are very short in duration. Within the state, it would be very difficult to justify the expense in placing UPS at all intersections. Perhaps we may use UPS at high ADT intersections or interchanges.
- We are currently going to a complete LED replacement of incandescents that are existing. This will be statewide. All new signal upgrades or new installations will be completely LED. We are currently looking at UPS systems for critical intersections.

Responses from the cities are as follows:

- Did not have a lot of load switch problems with LEDs. Dialight greens have a hard time around high voltage power lines (sometimes fail.) Need voltage cut-off on greens so it cannot be on while not detected by conflict monitor. Sometimes snow packs in visors and does not melt.
- With soaring energy costs, as well as maintenance costs, it is imperative that LED should be tested and used in conjunction with UPS.
- The use of LED has greatly reduced the city’s maintenance and energy costs.

- I have not yet determined a method of prioritization to determine which intersections should get UPS technology. Also, as we are the maintaining agency for the state DOT, that DOT has not devised a plan for such installations. We will hook up local agency-supplied generators when power outages occur.
- LEDs provide energy savings and reduced maintenance costs.
- We plan to use UPS once we get it. We plan to get UPS after we fund yellows.
- Local electric company will not allow UPS for signals. Cost for UPS is prohibitive since 99.9% of the time, power is maintained.
- Involvement with LEDs are limited. We have approximately 6 ea LEDs in a traffic signal system of over 7000 lamps with a high level of satisfaction. We are currently exploring the probable use of LEDs in all traffic signals.
- LEDs have improved maintenance life and cost savings.
- At this time, we are currently not using UPS technology on traffic signal equipment. We are not aware of any proven systems that would warrant evaluation. Other concerns include: power outage durations are unpredictable, so, how long will UPS run the intersection? No matter how long the UPS is engineered to operate you are still going to have outages that last longer. The size and number of batteries required would be quite large and would create a huge hazardous waste stream and maintenance nightmare. We are currently installing red LEDs at many locations. We are not committed to replacing all incandescent red sections with LEDs. There are issues still needing resolution, such as monitoring of low voltage illumination.
- Batteries and UPS will only be as reliable as the battery maintenance program. LEDs are still over-driven. I do not believe we will see 8 years of operation on even 50% of the units.
- We are aggressively pursuing installation of LED signal indicators city-wide. Largely due to the recent California energy crisis, as well as UPS for critical locations. All new signal contracts (new signals, upgrades, etc.) are going to install LED units. We strongly favor the use of Type 2 (screwbase) LED vehicle indication modules because they are easier to install, replace, retrofit, and due to a lack of standardization by manufacturers of Type 1 modules.
- LEDs make UPS systems now cost-effective.
- We are actively pursuing a program to change reds to LEDs.
- As costs come down, LEDs are an even better value than when we initially used them.

Responses from the IDOT districts are as follows:

- In flashing beacon installations, the LEDs provide a crisp on/off display.
- We are seeing power usage at about 1/5th of the usage with all incandescent lamps. This allows us to use a higher level of surge protection and makes UPS backup much more feasible.
- LED assemblies require no preventive maintenance and consume far less energy. LEDs should be used in the majority of traffic signal installations (viewing angles acceptable except maybe for a span-wire installation.) A UPS system should be used in conjunction with LEDs to allow for (at the

minimum) the intersection to flash all-red in the event of a power failure. This increases safety for the motorist and ensures that they will more likely obey the state law and stop at a dark signal.

- We think the advantages of UPS systems are far outweighed by the extra expense of maintenance. Our budget will not allow for us to perform proper maintenance on these devices.

V. SUMMARY AND CONCLUSIONS

A survey was mailed out to the individual districts within IDOT, all 49 other state DOTs, and to 79 of the largest cities in the United States to find out the degree of utilization and satisfaction about LED traffic signals and UPS systems. Thirty-six states and 25 cities responded to the survey.

There was a significant usage of LED lights in traffic signals at the State DOT level. The most commonly used brands were Gelcore and Dialight that accounted for approximately 95% of all LEDs in use at the state level. The degree of satisfaction with these two brands was over 3.5 (out of 4) indicating a very strong satisfaction. At the city level, Dialight and Gelcore were also the most popular brands, and accounted for 91% of all LEDs in use. Dialight scored a near perfect rating of 3.923 and Gelcore also did very well with a satisfaction rating of 3.33. Finally, at the IDOT district level, Dialight was the most commonly used LED (accounting for about 95% of all LEDs in use), and also scored the highest satisfaction rating, at 3.83 (out of 4.0).

There was some usage of UPS systems at the State DOT level, but it had not achieved widespread acceptance. From the 7 states that indicated using UPS systems, 7 different brands of UPS systems were identified. At the city level, there was even less acceptance of UPS systems at the time of this survey, with only 4 cities reporting their use. From these 4 cities, 6 different brands of UPS systems were identified. All 6 of these brands were in use by only a single city, so no average ratings were available. Of these brands, Dimensions, Unlimited had the most installations (with 26, and was given a satisfaction rating of 4 out of 4.)

APPENDIX 1

SURVEY OF STATE DOTs AND SELECTED CITIES ON THE USE OF UPSs AND LEDs IN TRAFFIC SIGNALS

Illinois Department of Transportation (DOT) and the University of Illinois at Urbana-Champaign is conducting this survey to gather information on the use of Light Emitting Diodes (LED) and Uninterrupted Power Supply (UPS) in traffic signals. If you have any questions or comments, please contact Yogesh Gautam of IDOT at 217-782-3452, gautamyp@nt.dot.state.il.us, or Professor Ray Benekohal at (217-244-6288, rbenekoh@uiuc.edu).

Thank you very much for your cooperation

1. Would you like to get a summary of this survey?

- a. Yes b. No

2. Please provide the following Information:

Your Name: _____
Title: _____
Organization _____
Address: _____
Phone/ Fax: _____
E-mail: _____

PART I, LED

3. Does your organization use LED in traffic signals?

a. Yes, which brand, how many, and how long have you been using them (best estimate)?

<u>LED brand name</u>	<u>How many</u>	<u>How long</u>
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____

b. No (skip to Question 9)

4. Do you have a written procedure on the use of LED in traffic signals?

- a. Yes, (please include a copy)
b. No

5. Do you have a specification for the procurement of LED vehicle traffic signal modules?

- a. Yes, (please include a copy)
b. No

6. Do you use the LED lenses (solid ball or arrow) for the following indications? (check all that apply)

	<u>SOLID BALL</u>		<u>ARROW</u>	
a. Red	Yes	No	Yes	No
b. Green	Yes	No	Yes	No
c. Yellow	Yes	No	Yes	No
d. Other (specify) _____	Yes	No	Yes	No
e. Pedestrian Walk/Don't Walk			Yes	No

7. How satisfied are you with the LED lenses in traffic signals?

<u>LED brand name</u>	<u>How satisfied?</u>				
	<u>Very</u> <u>Unsatisfied</u>	<u>Somewhat</u> <u>Unsatisfied</u>	<u>Somewhat</u> <u>Satisfied</u>	<u>Very</u> <u>Satisfied</u>	<u>No</u> <u>Opinion</u>
1. (specify) _____	1	2	3	4	0
2. (specify) _____	1	2	3	4	0
3. (specify) _____	1	2	3	4	0
4. (specify) _____	1	2	3	4	0
5. (specify) _____	1	2	3	4	0

8. Please briefly describe the main problem(s) you have had with the LED specified in the previous question, and describe how did you deal with them.

PART II, UPS

9. Does your organization use UPS in traffic signals

a. Yes, which brand, how many, and how long have you been using them (best estimate)?

<u>UPS brand name (specify)</u>	<u>How many</u>	<u>How long</u>
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____

b. No (skip to Question 14)

10. Do you have a written procedure on the use of UPS in traffic signals?

- a. Yes, (please include a copy.)
- b. No

11. The UPS is used for the following conditions:
- a. To operate incandescent red lights in flashing mode only
 - b. To operate incandescent lights in normal mode
 - c. To operate LED red lights in flashing mode
 - d. To operate LED signal in normal mode
 - e. All of the above
 - f. Other (please specify)_____

12. How satisfied are you with the UPS brands in traffic signals?

UPS brand name	How satisfied?				
	Very <u>Unsatisfied</u>	Somewhat <u>Unsatisfied</u>	Somewhat <u>Satisfied</u>	Very <u>Satisfied</u>	No <u>Opinion</u>
1. (specify)_____	1	2	3	4	0
2. (specify)_____	1	2	3	4	0
3. (specify)_____	1	2	3	4	0
4. (specify)_____	1	2	3	4	0
5. (specify)_____	1	2	3	4	0

13. Please briefly describe the main problem(s) you have had with the UPS specified in the previous question, and describe how did you deal with them.

14. Do you have any comments about UPS or LED use in traffic signals?

THANK YOU FOR YOUR PARTICIPATION IN THIS STUDY

Please return this survey and all attachments by **December 28, 2000** to:
 Professor Ray Benekohal
 University of Illinois
 205 N. Mathews Ave
 Urbana, IL 61801