





Table of Contents

I. INTRODUCTION	Page 1
A. Purpose	Page 1
B. Traffic System Design Devices	Page 2
C. Project Types	Page 2
1. Capital Projects	Page 2
2. Pavement & Rehabilitation Projects	Page 3
3. Traffic Section Projects	Page 3
4. Developer / Subdivision Projects	Page 3
D. Maintenance of Traffic Considerations	Page 3
E. Roles and Responsibilities	Page 4
F. Traffic Design Manual Updates	Page 7
II. THE TRAFFIC DESIGN PROCESS	Page 9
A. Request	Page 9
B. Establish Need for Traffic System Design Elements	Page 9
C. Notify DelDOT Community Relations	Page 10
D. Design Process Checklist	Page 11
E. Plan Preparation	Page 11
F. Design Review	Page 12
G. Cost Estimate	Page 12
H. Handoff Package	Page 12
I. Construction	Page 13
J. Activation	Page 13
K. As-Built Plans	Page 14
III. PLAN PREPARATION.....	Page 15
A. Required Contract Documents	Page 15
1. Title Sheet	Page 17
2. Plan Sheet	Page 17
3. Specifications	Page 20
4. Traffic Statement (Cost Estimate).....	Page 20
B. Preparation of Design Plans.....	Page 21
1. Collect Preliminary Data	Page 22
2. Prepare Base Plans.....	Page 22
3. Perform Field Survey.....	Page 24
4. Preliminary Design Plans.....	Page 25
a. Development.....	Page 25
b. Review	Page 26
5. Semi-Final Design Plans	Page 27
a. Development.....	Page 27



b.	Initial Traffic Statement (Cost Estimate).....	Page 27
c.	Review	Page 28
d.	90% Plan Submission	Page 28
6.	Final (PS&E) Design Plans.....	Page 28
a.	Development.....	Page 28
b.	Final Traffic Statement (Cost Estimate)	Page 29
c.	Obtain Signatures.....	Page 29
d.	Construction Handoff.....	Page 30
IV.	TRAFFIC SIGNALS	Page 33
A.	Traffic Signal Justification Study	Page 33
1.	Study Initiation	Page 33
2.	Traffic Data Collection	Page 33
3.	Signal Warrant Analysis	Page 36
a.	Applicability.....	Page 36
b.	Timetable	Page 38
4.	Safety Considerations Using the Highway Safety Manual.....	Page 39
5.	Alternative Intersection Treatments	Page 40
6.	Capacity Analysis.....	Page 41
a.	Evaluation Methodologies	Page 41
b.	Measures of Effectiveness	Page 41
c.	Signal Timing / Phasing	Page 42
7.	Documentation of Results	Page 42
a.	Technical Memo / Presentation	Page 42
b.	Signal Design Request Form.....	Page 44
8.	Signal Phasing Change	Page 44
9.	Signal Deactivation.....	Page 44
B.	Types of Signal Projects	Page 45
1.	Traffic Control Signal.....	Page 45
2.	Hazard Identification Beacon (HIB).....	Page 45
3.	Intersection Control Beacon (ICB)	Page 46
4.	Emergency-Vehicle Signals and Hybrid Beacons	Page 47
5.	Railroad Crossing.....	Page 47
6.	Movable Bridges	Page 48
7.	Temporary Signal	Page 49
8.	Innovative Intersection Safety Treatments	Page 49
a.	Rectangular Rapid Flash Beacons (RRFB).....	Page 50
b.	Pedestrian Hybrid Beacon (HAWK).....	Page 50
C.	Preliminary Design Plan Elements	Page 52
1.	Pole Design.....	Page 52
a.	Type	Page 52
b.	Configuration	Page 55



c.	Placement	Page 58
(1)	Clear Zone	Page 58
(2)	Utility Clearance.....	Page 59
2.	Signal Head Design.....	Page 59
a.	Number of Signal Heads	Page 59
b.	Signal Head Configurations.....	Page 60
c.	Signal Indication Size.....	Page 61
d.	Visibility.....	Page 62
e.	Signal Head Placement	Page 62
(1)	Vertical Placement	Page 62
(2)	Lateral Placement	Page 63
f.	Shielding of Signal Faces	Page 71
g.	Optically Programmed Signal Heads.....	Page 72
3.	Cabinet Placement.....	Page 72
4.	Pedestrian Considerations	Page 74
a.	Pedestrian Signal Guidelines.....	Page 74
b.	ADA Compliance	Page 74
5.	Signal System Interconnection	Page 75
6.	Power Source	Page 75
D.	Final Design Plan Elements	Page 76
1.	Conduit Design.....	Page 76
a.	Sizes	Page 76
b.	Installation Methods.....	Page 77
c.	Conduit Fill Capacity	Page 77
2.	Junction Wells / Junction Boxes.....	Page 80
a.	Types & Sizes.....	Page 80
b.	Location.....	Page 80
3.	Detection	Page 81
a.	Function	Page 81
b.	Design	Page 82
4.	Wiring	Page 84
a.	Mast Arm Pole Cabling.....	Page 86
b.	Span Wire Cabling.....	Page 86
c.	Pedestrian Signal.....	Page 87
d.	Detector Wiring.....	Page 87
e.	Overhead Cabling.....	Page 87
f.	Interconnect.....	Page 88
g.	Grounding	Page 88
h.	Power Feed	Page 88
5.	Phasing	Page 89
6.	Control Cabinet.....	Page 90
7.	Pole & Cabinet Base.....	Page 91
8.	Signing	Page 94
a.	Overhead.....	Page 94



b. Ground Mounted	Page 95
9. Pavement Markings	Page 95
10. Maintenance of Traffic.....	Page 96
11. Timesheet	Page 96
12. Supplemental Equipment	Page 97
13. Traffic Statement	Page 97
E. Signal Timing & Phasing	Page 99
1. General.....	Page 99
2. Timing Parameters.....	Page 100
a. Cycle Length	Page 100
b. Vehicle Clearance Interval	Page 102
c. Yellow Change Interval	Page 102
d. Red Clearance Interval (All-Red).....	Page 104
3. Phasing.....	Page 108
a. NEMA Phasing.....	Page 108
b. Selecting Appropriate Phasing.....	Page 109
c. Left Turn Treatment.....	Page 109
(1) Separate Left-Turn Lanes.....	Page 110
(2) Left-Turn Phasing	Page 110
(3) Lead / Lag Lefts	Page 113
(4) Yellow (Left-Turn) Trap	Page 114
(5) Flashing Red Arrow	Page 115
(6) Flashing Yellow Arrow.....	Page 116
(7) Other	Page 116
d. Split Phasing.....	Page 116
4. Types of Control.....	Page 117
a. Selection Considerations	Page 119
(1) Volume Characteristics	Page 119
(2) Other Characteristics	Page 119
b. Elements of Control	Page 119
(1) Pre-timed Control	Page 119
(2) Basic Timing Parameters.....	Page 122
c. Controllers.....	Page 122
5. System Compatibility	Page 123
a. Uncoordinated Signals	Page 123
b. Coordinated Signals	Page 124
c. Signal Pre-Emption / Priority	Page 127
6. Pedestrians.....	Page 128
a. Signal Guidelines.....	Page 128
b. Timing Requirements.....	Page 129
(1) Walking Speeds.....	Page 130
(2) Minimum Clearance Times	Page 130
c. Rest in Walk	Page 131
d. Accessible Pedestrian Signals (APS).....	Page 131



e.	Countdown Pedestrian Signals	Page 132
f.	Alternative Pedestrian Phasing Options	Page 133
V.	ITS DEVICES	Page 135
A.	Types of Devices.....	Page 135
1.	General.....	Page 135
2.	Communication Infrastructure	Page 135
3.	System Detection	Page 136
4.	CCTV Cameras	Page 140
5.	CMS Boards	Page 141
6.	Weather Stations	Page 142
7.	WTMC	Page 143
8.	Variable Speed Limit Signs	Page 144
9.	New Technology.....	Page 144
B.	Preliminary Design Plan Elements	Page 144
1.	Location	Page 144
2.	Power	Page 145
3.	Communication.....	Page 146
C.	Final Design Plan Elements	Page 146
1.	Conduit Design	Page 146
a.	Sizes	Page 146
b.	Installation Methods.....	Page 147
c.	Conduit Fill Capacity	Page 148
2.	Junction Wells	Page 149
a.	Types & Sizes.....	Page 149
b.	Location.....	Page 149
3.	Wiring	Page 149
4.	Control Cabinet	Page 150
a.	Types	Page 150
b.	Location.....	Page 150
c.	Cabinet Base and Conduits	Page 150
5.	Pole / Structure	Page 151
a.	Types	Page 151
b.	Pole Bases	Page 151
c.	Conduits	Page 152
6.	Maintenance of Traffic.....	Page 152
7.	Traffic Statement	Page 153



Appendices

- A. DelDOT Traffic Systems Design Directive
- B. Memo – Signal Agreements (March 30, 2012)
- C. Traffic Systems Design Handoff Form
- D. Standard Traffic Title Sheet
- E. Sample Traffic Control Signal Plan Sheets
- F. Sample Traffic Statement
- G. Sample Signal Study
- H. Sample Highway Safety Manual Predictive Method
- I. Guidelines for Conducting CMS Analysis
- J. Signal Design / Modification Request Form
- K. Signal Deactivation Guidance
- L. Request for APS Application Form
- M. Memo – Requests for Electric Power Service (April 7, 2020)
- N. Wiring Guidelines
- O. Soil Boring Request Form Sample
- P. Design Criteria for Overhead Mounted Street Name Signs
- Q. Yellow Trap Guidelines
- R. Traffic Signal Preemption at Highway-Rail Grade Crossings Guidance
- S. Timing Guidelines for Countdown Pedestrian Signals
- T. Sample Plan – Fiber Pathway
- U. Sample Plan – RTMS Design
- V. Sample Plan – CCTV Camera Design
- W. Sample Plan – Permanently-Mounted CMS Board
- X. Sample Plan – Weather Station
- Y. Sample Plan – WTMC Repeater Site
- Z. M60 Timesheet Training



List of Figures

IV-1	Sag Calculation	Page 54
IV-2	Typical Layouts of Signal Poles and Signal Heads.....	Page 56
IV-3	Signal Head Displays.....	Page 61
IV-4	Maximum Mounting Height of Signal Housings.....	Page 63
IV-5	Lateral Placement of Signal Heads	Pages 64 - 68
IV-5a	One Through Lane With One Left-Turn Lane (Protected-Permissive Left-Turn Phasing)	Page 64
IV-5b	One Through Lane With One Left-Turn Lane (Protected-Permissive Left-Turn Phasing FRA)	Page 64
IV-5c	One Through Lane With One Left-Turn Lane (Protected-Only Left-Turn Phasing)	Page 64
IV-5d	Two Through Lanes With One Left-Turn Lane (Protected-Permissive Left-Turn Phasing)	Page 65
IV-5e	Two Through Lanes With One Left-Turn Lane (Protected- Permissive Left-Turn Phasing FRA)	Page 65
IV-5f	Two Through Lanes With One Left-Turn Lane (Protected-Only Left-Turn Phasing)	Page 65
IV-5g	Two Through Lanes With Two Left-Turn Lanes (Protected-Only Left-Turn Phasing)	Page 66
IV-5h	Three Through Lanes With Two Left-Turn Lanes (Protected-Only Right-Turn Phasing)	Page 66
IV-5i	Two Through Lanes With One Right-Turn Lane (Protected-Permissive Phasing)	Page 66
IV-5j	Two Through Lanes With One Right-Turn Lane (Permissive Right-Turn Phasing)	Page 67
IV-5k	One Through Lane, One Shared Through/Right Lane, and One Right-Turn Lane (Protected-Permissive Right-Turn Phasing)	Page 67
IV-5l	Two Through Lanes With One Right-Turn Lane (Protected-Permissive Right-Turn Phasing FRA)	Page 67
IV-5m	Two Through Lanes With One Right-Turn Lane (Protected-Only Right-Turn Phasing)	Page 68
IV-5n	One Shared Left/Through/Right Lane (Permissive Left-Turn Phasing)	Page 68
IV-5o	One Left-Turn Lane With One Through Lane (Permissive Left-Turn Phasing)	Page 68
IV-6	Lateral Placement of Signal Heads (Split Phasing)	Pages 69 - 71



IV-6a	One Left-Turn Lane With One Shared Left/Through Lane (Split Phasing)	Pages 69
IV-6b	One Shared Left/Through Lane With One Through Lane (Split Phasing).....	Pages 69
IV-6c	One Left, One Shared Left/Through, One Through, and One Right-Turn Lane (Split Phasing)	Pages 70
IV-6d	One Left-Turn Lane, One Through Lane, and One Right-Turn Lane (Split)	Pages 70
IV-6e	One Shared Left/Through Lane and One Right-Turn Lane (Split Phasing)	Pages 70
IV-6f	One Shared Left/Through/Right Lane (Split Phasing)	Page 71
IV-7	Standard NEMA Phasing Convention	Page 90
IV-8	Typical Intersection Movements and Corresponding NEMA Phasing Convention	Page 90
IV-9	Intersection Conflict Points	Page 105
IV-10	Guidelines for Determining Left-Turn Lane Signal Phasing Treatment	Page 111
IV-11	Yellow Trap with Protected/Permissive Left-Turn Phasing.....	Page 115
IV-12	Sequence of Phases for Dual-Ring 8-Phase Controller Unit.....	Page 123
IV-13	Placement of Optical Detectors	Page 127
IV-14	Clearance Interval Time Calculations	Page 131



List of Tables

III-1	Requirements for Plans, Specifications, and Engineer’s Estimate	Page 16
III-2	Typical Traffic Base Plan Features	Page 23
IV-1	Cross-Sectional Areas of Electrical and Fiber Optic Cables	Page 78
IV-2	Fill Capacities of Typical Conduit Sizes Used by DelDOT Traffic.....	Page 78
IV-2A	Fill Capacities of Typical HDPE Conduit Sizes Used by DelDOT Traffic.....	Page 79
IV-2B	Fill Capacities of Typical Rigid Conduit Sizes Used by DelDOT Traffic.....	Page 79
IV-3	Detector Setbacks.....	Page 83
IV-4	Wiring Diagram Supplemental Information	Page 85
IV-5	Pole Base Type Selection for Varying Soil Conditions	Page 93
IV-6	10 th Percentile Speed Estimate	Page 106
IV-7	Signal Coordination Benefits and Drawbacks	Page 125
IV-8	Safety Benefits Associated with Signal Coordination or Progression	Page 126
V-1	Cross-Sectional Areas of Electrical and Fiber Optic Cables.....	Page 148



List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities
ADT	Average Daily Traffic
APS	Accessible Pedestrian Signals
ATC	Advanced Traffic Controller
CADD	Computer-aided Design and Drafting
CCTV	Closed-Circuit Television
CDMA	Code Division Multiple Access
CFR	Code of Federal Regulations
CMF	Crash Modification Factors
CMS	Critical Movement Summation
Construction Group	DelDOT Traffic Systems Construction Group
DE MUTCD	Delaware Manual on Uniform Traffic Control Devices (<i>citations reflect 2011 edition</i>)
DelDOT	Delaware Department of Transportation
DelTRAC	DelDOT's Transportation Management Program
Design Group	DelDOT Traffic Systems Design Group
Designer	Developer, Consultant, or DelDOT Traffic Staff Preparing Plans
DMS	Dynamic Message Signs
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
HAWK	High-Intensity Activated Crosswalk
HCM	Highway Capacity Manual
HDPE	High-Density Polyethylene
HIB	Hazard Identification Beacons
HSM	Highway Safety Manual
ICB	Intersection Control Beacons
ISD	Intersection Sight Distance
ITE	Institute of Transportation Engineers
ITMS	Integrated Transportation Management System
ITS	Intelligent Transportation Systems
LOS	Level of Service
Maintenance Group	DelDOT Traffic Systems Maintenance Group
MOE	Measure of Effectiveness
MOT	Maintenance of Traffic
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NTCIP	National Transportation Communications for ITS Protocol
OIT	DelDOT's Office of Information Technology
Operations Group	DelDOT Transportation Management Center, or TMC
PR	Public Relations
PROWAG	Draft Public Rights-of-Way Accessibility Guidelines
PS&E	Plans, Specifications and Estimates
PVC	Polyvinyl Chloride
RRFB	Rectangular Rapid Flash Beacons
RTMS	Remote Traffic Microwave Sensors
Safety Group	DelDOT Traffic Safety Group
Studies Group	DelDOT Traffic Studies Group
SSC	Signing, Striping, and Conduit
TIS	Traffic Impact Study
TMC	DelDOT Transportation Management Center
WTMC	Radio Frequency for Traveler Information



List of Common Reference Manuals

All signals and ITS traffic devices designed or modified in the State of Delaware should comply with the following policies, guidelines, and standards. Due to the design flexibility inherent in many of these references, the Delaware Traffic Design Manual has been developed to provide additional guidance regarding preferred design practices in Delaware.

- AASHTO – A Policy on Geometric Design of Highways and Streets
- AASHTO – Highway Safety Manual (HSM)
- AASHTO – Roadside Design Guide
- DeIDOT – Traffic Lighting Policy
- DeIDOT – Delaware Manual on Uniform Traffic Control Devices (DE MUTCD)
- DeIDOT – Road Design Manual
- DeIDOT – Standard Specifications for Road and Bridge Construction
- DeIDOT – Development Coordination Manual
- DeIDOT – Standard Construction Details
- DeIDOT – Work Zone Safety and Mobility Procedures and Guidelines
- DeIDOT – Accessible Pedestrian Standards Facilities in the Public Right-of-Way
- FHWA – Manual on Uniform Traffic Control Devices (MUTCD)
- FHWA – Railroad-Highway Grade Crossing Handbook
- IEEE – National Electrical Safety Code (NESC)
- National Electrical Manufacturers Association (NEMA) - Codes and Standards
- NFPA – National Electrical Code (NEC)
- ITE – Manual of Traffic Engineering Studies
- TRB – Highway Capacity Manual (HCM)