AutoJ

User Manual

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USER MANUAL

AutoJ

For further details see the website www.autojtraffic.co.za.

This User Manual is for any recent version of AutoJ.

Contents

QUICK START

Enter your password; reply “yes” to ‘read only’.

INPUT

1. Enter **intersection name**.

2. Enter **traffic counts** in ***qtr*** (if you have quarter hour counts) otherwise in ***hr*** (for hourly counts).

3. Enter the **number of lanes** on each approach in ***GEOM*** (geometry).

(You do not have to specify the control type or any signal staging and timing information in AutoJ, but you can overwrite the calculated values if you wish.)

OUTPUT

1. Open **SMY** (summary) to view the performance of 5 priority and 21 signalized intersection types.

2. The maximum V/C, delay, queue, and Level of Service are shown (the signal timings have been optimized).

3. The best priority and traffic signal control are displayed above the table, and those within 10% of the best are highlighted in green.

4. To examine a control in detail, open that tab (e.g. 2 for a two stage signal, the +2 tab is the signal timing plan).

5. Refine your input as required.

6. “Save as”, giving file a new name.

(The recommended file name is the first few letters of the north- south road, an ampersand, the first few letters of the west - east road and the metric date, e.g. Main&West 240101. Using this naming method, you will easily identify AutoJ files, and the date can serve as the version number.)

DEFINITIONS

ar — **"All-red"** phase of any stage during which all the approaches are shown a red signal. It is the safety clearance period which allows traffic to clear the intersection before opposing vehicles are given a green signal.

In some countries red and yellow signals are displayed simultaneously during the "all-red" period as an early warning to the approaches about to be given a green signal, but this is not permitted in South Africa.

AADT — **Annual Average Daily Traffic** – the total traffic volume in a year, including school and public holidays and weekends, divided by 365.

ADT — **Average Daily Traffic** – the 24-hour traffic count during a typical weekday in an urban area. As weekends and holidays are excluded (because they are not typical) ADT is greater than AADT. ADT should be used in preference to AADT when doing urban traffic studies.

AWDT — **Average Weekday Traffic** – the average of Monday to Friday in a week without school or public holidays. Although Fridays often have higher off-peak traffic volumes than other weekdays (ADT is typically +5% higher) the peaks are similar, so it is generally acceptable to do a count on any weekday. AWDT is approximately equal to ADT in an urban area.

AM (PM) — **Ante Meridiem (Post Meridiem)** - The **morning** (a.m.) or **evening** (p.m.) peak hour or peak period, depending on the context. Traffic signals are normally set for a three-hour peak period based on the peak one-hour traffic volume.

AWS — **All-way Stop** control – commonly known as the 4-way Stop but could be 3-way at a T-junction.

C — **Capacity** (vehicles per hour) - for signals, nominally C = S x (g/c), but more correctly is adjusted for vehicle composition (e.g. heavy vehicles and buses), geometric considerations (e.g. grade, lane numbers and widths, turning penalties, pedestrian interference), start-up lost time and inter-green overruns.

μ — **Co-ordination** factor, expressed as a %. This factor was developed specifically for use in AutoJ and varies from 0% to 100%. It can be directly related to the Highway Capacity Manual arrival types (see table below for definitions). The co-ordination factor can be considered as the percentage of all vehicles that arrive during the green phase. This factor can also be used at a priority junction to allow for situations where platoons in both directions cross past the priority junction together:

- **100%** when **all** vehicles arrive during green phase.
- **50%** (default) when there are random or uniform arrivals, and vehicles are evenly spaced throughout the cycle.
- **0%** when entire platoon arrives during the red phase (no vehicles arrive during the green phase).

CLV — **Critical Lane Volume** (evu/hr/lane) - the equivalent volume in the lane which has the greatest utilization of capacity, i.e. the lane that needs the most green time.

c — **Cycle** time, in seconds, to go from the start (or end) of a particular phase, back to the start (or end) of that same phase again. Fixed time signals have fixed cycle times; actuated signals vary the time of each cycle.

d — **Delay (ave)** – average delay in seconds experienced by vehicles decelerating, waiting to be served (waiting to cross the stop line including delay while moving up in the queue) and accelerating. Most research studies exclude deceleration and acceleration delays for signals but include them for stop and yield controls. In AutoJ, the same is done but for an exact comparison of priority and signal delay, see Technical Manual (Intersection Traffic Engineering 1910).

D — **Delay (tot)** – total delay, in vehicle-hours per hour, experienced by vehicles that are delayed in any way, even if not stopping. If acceleration and deceleration delay is excluded, total delay exactly equals queue length numerically. In AutoJ, total delay and queue are taken to be equal even though this slightly overestimates queues at priority controls.

evu — **Equivalent Vehicle Units** - the total volume adjusted upwards to compensate for heavy vehicles and buses within the traffic stream. Sometimes called Passenger Car Units (PCU).

%grade — **Grade** – down (minus) or up (plus) slope on the approach to the stop line, expressed as a percentage; -2% to +2% is flat, 2% to 5% is a gentle incline, 5% to 8% is a steep incline and greater than 8% is very steep, seldom found.

g — **Green** - duration of green phase (in seconds) of any stage.

g/c — **Green to Cycle** time ratio, or percentage available green.

y + ar **Inter-green -** interval or time between the end of one green phase and the start of the next one, consisting of the yellow plus all-red phases.

ICD **Intersection Control Device**, the device or method by which the intersection is controlled. ICDs can be priority (stops, yields and roundabouts) or signal controls. Uncontrolled intersections have no ICD.

LOS **Level of Service**, rated from A to F in accordance with the Highway Capacity Manual.

mC **Mini-Circle**, a small raised or painted circle in the middle of single lane approach intersection to indicate to vehicles that they are to treat the intersection as a roundabout as for as possible.

off **Off-peak** – the period between the AM and PM peak periods, normally with similar flows in both directions. In urban areas, nights and weekends are also ''off-peak" and typically use the same signal settings as for weekday off-peak periods. "Unusual" peaks, such as at shopping centres on Saturdays or sports stadia before and after matches, might not be typically off-peak and the signals may need to be reset accordingly.

pk hr **Peak hour** – the highest hour/s during the day. In urban areas there are two peak hours, AM and PM. The urban AM peak hour generally occurs between 6:45 and 7:45 and the PM peak between 16:30 and 17:30. These are the busiest hours city-wide, even if they are not the hours with the highest traffic flow at a specific location.

pk **Peak periods** –Traffic signals generally start the peak programme before the peak starts (to prevent build up) and end sometime after (to allow the overflow to disperse), hence 6:00 to 9:00 and 15:30 to 18:30 are typically used for peak period programmes.

ph **Phase** – The signal display at any point in a cycle. A sequence of green, yellow and all-red phases combined constitute a stage. Pedestrian crossing phases (green man and flashing red man), if provided, can be displayed at the same time as the green disc vehicle phase, or they can be displayed as a separate stage (scramble stage).

Q **Queue** length, the average number of vehicles stopped and waiting to enter an intersection at any point in time. These can be per lane, per movement, per approach or per intersection depending on the context. Vehicles approaching the back of the queue and vehicles leaving from the stop line at the front of the queue are not in the queue, but vehicles moving up within the queue are in the queue.

QED **Quod E'rat Demonstrandum**, loosely translated as Quite Easily Done. AutoJ is QED.

r	**Red -** the period on an approach where the signal is not showing green or yellow.
RR	**Roundabout -** an intersection where all approaching vehicles must yield to vehicles in the circulating roadway. Vehicles approaching a roundabout or mini-circle give way to conflicting vehicles on their right who are already in the circular roadway (even if those vehicles entered the circulatory roadway after a vehicle waiting at the yield line) but not to those that have not yet crossed the yield line. If any approach is controlled in any way other than having to yield, or if the circulatory roadway is not free running, the intersection cannot be considered to be a roundabout, even if it is circular in shape.
S	**Saturation** flow, or the maximum flow rate in vehicles per hour at which an "infinite" queue of light vehicles can flow passed a point in a single lane of traffic in normal circumstances (flat road, good visibility, and adequate width paved lane). A saturation flow rate of 2 000 veh/hr is taken for AutoJ.
SARTSM	**South African Road Traffic Signs Manual,** including the SADC (Southern African Development Communities) RTSM.
stg	**Stage** – a unique combination of green, yellow and "all-red" phases displayed to an approach or approaches simultaneously. Often called a phase in South Africa, hence 3 phase or 4 phase traffic signals boards, but stage is the preferred term internationally. The minimum and simplest signal setting is two stages (**2**), made up of six phases.
T	**Through** traffic, consisting of left (L), straight (S) and right (R) turn traffic proceeding on the same green disc.
traf	**Traffic** – Vehicles, motorcycles, bicycles, pedestrians, and any other forms of conveyance. Commonly, traffic is used to refer to vehicles only, e.g. average daily traffic.
TWSC	**Two-Way Stop Control**, where one side is given priority (not stopped). Commonly called a Stop Street.
V	**Volume** in vehicles per hour (cars, trucks, buses and taxis). Motorcycles, bicycles and pedestrians are normally not counted in this total, and if counted, it is necessary to specify such. Ideally "volume" should be the demand volume, but usually is the counted volume. The demand volume is equal to the counted volume plus any queue waiting at the beginning and end of the counting period.
V/C	**Volume to Capacity ratio**, equal to the Volume divided by Capacity (Degree of Saturation is the Volume to Saturation flow ratio).

q **Volume** or traffic flow in vehicles per second (see V).

y **Yellow**, or amber, phase of any stage.

Co-Ordination Factor

The AutoJ co-ordination factor μ is related to the Highway Capacity Manual 2000 descriptions as follows:

HCM Exhibit 16-4 ARRIVAL TYPES

Arrival Type	Description	AutoJ Range	Suggested Factor
1	Dense platoon containing over 80% of the lane group volume, arriving at the red phase. This AT is representative of network links that may experience very poor progression quality as a result of conditions such as overall network signal optimization.	0% to 20%	+5%
2	Moderately dense platoon arriving in the middle of the red phase or dispersed platoon containing 40 to 80% of the lane group volume, arriving throughout the red phase. This AT is representative of unfavourable progression on two-way streets.	20% to 45%	+25%
3	Random arrivals in which the main platoon contains less than 40% of the lane group volume. This AT is representative of operations at isolated and non-interconnected signalized intersections characterized by highly dispersed platoons. It may also be used to represent co-ordinated operation in which the benefits of progression are minimal.	45% to 50%, (lower value used to allow for deceleration + acceleration delay)	+50%
4	Moderately dense platoon arriving in the middle of the green phase or dispersed platoon containing 40 to 80% of the lane group volume, arriving throughout the green phase. This AT is representative of favourable progression on a two-way street.	50% to 80%	+75%

5	Dense to moderately dense platoon containing over 80% of the lane group volume, arriving at the start of the green phase. This AT is representative of highly favourable progression quality, which may occur on routes with low to moderate side-street entries and which receive high-priority treatment in the signal timing plan.	80% to 100%	+95%
6	This arrival type is reserved for exceptional progression quality on routes with near-ideal progression characteristics. It is representative of very dense platoon progression over a number of closely spaced intersections with minimal or negligible side-street entries.	100%	+100%

AutoJ does not make provision for the co-efficient of variation of arrivals (**I**) (except as indicated above) because neither the signal settings nor the hourly delay calculation is sensitive to specific arrival patterns, i.e. the phase during the cycle at which vehicles arrive is far more important than the actual (deterministic, random, uniform, stochastic) arrival pattern.

CONTROL ABBREVIATIONS

AutoJ

Code	Standard Options
Xns	Stop (or yield) on north-south approaches (west-east run free)
Xwe	Stop (or yield) on west-east approaches (north-south run free)
XX	All-way stop (4-way stop)
mC	Mini circle
RR	Modern Roundabout
2	2 stage signal, 2 only (north-south then west-east)
3ns	3 stage signal, 2 + lagging green from north and south
3we	3 stage signal, 2 + lagging green from west and east
n3	3 stage signal, 2 + leading green from north
s3	3 stage signal, 2 + leading green from south
w3	3 stage signal, 2 + leading green from west
e3	3 stage signal, 2 + leading green from east
4nswe	4 stage signal, 2 + lagging green from north and south plus lagging green from west and east
n4we	4 stage signal, 2 + leading green from north plus lagging green from west and east
s4we	4 stage signal, 2 + leading green from south plus lagging green from west and east
w4ns	4 stage signal, 2 + leading green from west plus lagging green from north and south
e4ns	4 stage signal, 2 + leading green from east plus lagging green from north and south
nw4	4 stage signal, 2 + leading green from north plus leading green from west
ne4	4 stage signal, 2 + leading green from north plus leading green from east
sw4	4 stage signal, 2 + leading green from south plus leading green from west
se4	4 stage signal, 2 + leading green from south plus leading green from east
n-s-3	split 3 stage signal, green from north, then green from south, then west-east
w-e-3	split 3 stage signal, green from west, then green from east, then north-south
n-s-4we	split 4 stage signal, green from north, then green from south, then west-east plus lagging w-e
w-e-4ns	split 4 stage signal, green from west, then green from east, then north-south plus lagging n-s
n-s-w-e-4	split 4 stage signal, green from north, then green from south, then green from west, then east
ped	mid-block pedestrian signal

Code	**Non-standard Options** (not provided, amend a standard option or use +A)
ns3	3 stage signal, leading green from north and south
we3	3 stage signal, leading green from west and east
s5nswe	5 stage signal, lead green from south, lag green north-south and west-east
3n	3 stage lagging green from north only, e.g. T-junction or one-way

As can be seen from the table:

n, s, w, e = **north, south, east, and west.**

X = **Stop.** For **Yield** (**Y**) signs, use the stop sign results but average delay per vehicle will be 3 seconds less (capacity is the same for both).

mC, RR = **mini traffic circle,** modern **Roundabout** – In both cases all approaches must yield, whether a yield sign appears or not. A mini-circle operates in the same way as RR at low traffic volumes but at high traffic volumes mini-circles operate more like all-way Stops than roundabouts and hence are analysed accordingly.

2, 3 or 4 = **Number of traffic signal stages** – Traffic signals are indicated by the number of primary stages; these being **2**, **3,** or **4** stage signals.

A *leading* green right turn flash (early start) is indicated by placing the cardinal direction before the **number**, while for a *lagging* green right turn flash (late turn) the approaches on which the flash operates are placed after the number.

For separate or split stage signals, where an approach is given green on its own and not at the same time as any other approach, the cardinal directions are hyphenated before the number. For example, **n-s-3** is a staging where first the north approach is given a green disc simultaneously with a right flash, then that disc and the flash are terminated together; followed by a south through disc and right flash simultaneously, similarly terminated together; followed by the standard operation for west and east traffic together.

SIGNAL STAGING OPTIONS

You, along with every other motorist, expect to give way to opposing traffic before you turn right. Therefore, the traffic signal staging should be in that order, i.e. straight first and right turn flash after (lagging).

However, if a flash is needed from one side only **and** the opposing right turn is possible, the flash must **always** be **leading** to avoid the right turn trap (see AutoJ Technical Manual for more details).

Therefore, the 21 standard traffic signal control types in the table above include all possible control options for the intersection complying with this leading / lagging rule. Provision is therefore not made for double leading flashes or any other staging which is potentially inefficient, misleading, and less safe.

Users can however create their own versions of traffic signal stages and settings by modifying a standard option. For example, if double leading flashes are provided, use the double lagging flash option, renumber the stage sequence in the stage diagram (checking the inter-greens are still correct) and amend the stage start times in the timing diagram.

For more than 4 stages, use the nearest 3 or 4 stage option and manually add the additional stage(s) in the timing diagram. Alternatively use the +A (generic) spread sheet which allows the user to develop a signal timing plan for up to six stages.

At a T-junction or a one-way if AutoJ recommends a flash for a non-existent approach, e.g. **3ns** with no south leg, some manual adjustments are now required. In the above example, go to the +3ns signal plan and delete all the movements that are not possible. Then add the south flash time to the through north time to correct the timing diagram. The performance measures in 3ns will automatically adjust accordingly. The 3ns and +3ns tab names can then be changed to 3n and +3n if desired.

Another feature of AutoJ is that, by default if a left turn lane is present, the left turn running on the “inside” of a right turn flash is given the green flash signal at the same time as the right flash. If a left flash is not provided, simply delete that row wherever it appears in the timing diagram.

For **vehicle actuation**, it is simply necessary to add the green extension time in the appropriate timing diagram and the graphs will adjust accordingly. The performance measures will be based on the minimum green times chosen.

OPTIONAL USES OF AUTOJ

AutoJ (**Auto**mated **J**unction analysis) is a computer program which simulates an intersection performance under different control devices. Its original function was to automatically optimize traffic signal settings, but this has been expanded to include all intersection control types.

While intended for use by the traffic professional, AutoJ is simple enough to be used by anyone regardless of qualification or experience.

It is expected AutoJ will primarily be used for

Traffic Impact Assessments

And to produce SARTSM compliant

Signal Designs and Timing Plans

Or to do

Warrant Investigations

But can be used to undertake any of the following:

- **Simulating** any Control Device
    - up to three periods can be done at the same time.
- **Analysis** and comparison of all forms of intersection control.
- Identifying and recommending the **optimal Intersection Control Device** (ICD).
- Optimizing an intersection **design**.
- Exploring user generated **alternatives**.

- To input, analyse and print **traffic counts,** including:
    - quarter hourly turning volumes (up to 14 hrs without modification)
    - hourly turning volumes, including U-turns if required.
    - buses and heavy vehicles, weighted as required.
    - pedestrians and bicycles.
    - future traffic growth (or decline).
    - new development traffic to be added or subtracted.
    - missing volume data suggested for period(s) not counted.
    - Average Daily Traffic (ADT).

- To record and analyse **geometric design** for each approach, including:
  - number of lanes (user to specify, but recommendation is made)
  - auxiliary turning lane lengths (program warns if too short)
  - median width
  - approach speed
  - grade
  - right turning in gaps (allowed at traffic signal or not)
  - left turn slip roads (yield to cross traffic or freely enter downstream lane)
  - clearance distances for vehicles
  - pedestrian crossing distances and widths
  - pedestrian heads (provided or not)
- To specify **traffic signal time settings** including:
  - event table options (up to three periods per run)
  - cycle times
  - minimum greens, yellows and all-reds for main, leading, lagging, and pedestrian phases
  - green extensions
  - offsets
  - co-ordination efficiency (at signals and gaps at Stops)
- To adjust for **local driving habits** (City, Town, Village / Rural);
- To **compare all types of intersection control devices** simultaneously,

  including five priority options:
  - two-way Stop streets ("main" road not stopped) (two of)
  - all-way Stop streets.
  - mini circles
  - roundabouts

  and the following traffic signal options:
  - two stage traffic signals (one)
  - three stage signals, lagging and leading (six possibilities)
  - four stage signals, lagging, leading and combinations (nine possibilities)
  - separate split stage signals and combinations (five possibilities)
  - mid-block pedestrian signals (one)

    - user generated option (one);

- To calculate and display **signal timing** intervals, including:

    - 21 standard staging options (plus mid-block pedestrian crossing)
    - unlimited user staging options
    - main phase greens
    - yellow and all-red intervals
    - pedestrian crossing times (green man and flashing red man)
    - pre-timed or actuated minimums and maximums
    - with a graphical display of the chosen settings (staging diagram);

- To **simulate performance** (using measures of effectiveness) of each movement and totals, including:

    - green to cycle (g/c) ratios
    - volume to capacity (V/C) ratios
    - average delay
    - queue and total delay
    - level of service (two measures)
    - performance index (standard or user weighted as required);

- To **undertake specific investigations**, including:

    - **warrants** for traffic signals, roundabouts and stops.
    - **traffic impact assessments**
    - the effect of **development** traffic
    - the effect of **growth** and changing traffic patterns
    - **comparing existing and proposed** signal settings
    - **performance index** (PI)* comparisons
    - giving **priority** to selected movements, such as Bus Rapid Transit (BRT)
    - analysing up to **three periods at a time**
    - obtaining a **user-friendly visual display** of inputted data and results
    - **inputting user defined settings**
    - **research**, including testing imaginary options.

*__Note 1__: The **performance index** (PI) gives the actual performance of each control as a percentage of the best possible performance based on the following measures:

- the volume / capacity of the worst **movement** in each of the hours tested.
- the highest delay of the worst **movement** in each of the hours tested.
- the queue length (in vehicles) of the worst **movement** in the hours tested.

Note 2: The HCM favours delay as a measure of Level of Service. AutoJ does not require the user to choose only one measure but provides all measures, including delay, simultaneously.

- by default, V/C ratios comprise 60% of the PI (50% in peaks as improving the capacity in the two peak hours is normally the most important reason for selecting a control device),
- delay is weighted 25%, and
- the queue total is 15%.

Note 3: In general, increasing the weighting to V/C will favour signals and increasing the weighting given to delay will favour priority control. Weighting the queue heavily will reduce total vehicle operating costs but at the expense of smaller movements delay and capacity.

Note 4: Pedestrian (and bicycle) factors are given priority in signal timing which is built into the performance measures before weighting.

Note 5: Signal timings are designed to minimize V/C. Minimizing the V/C does not necessarily reduce overall delay.

Note 6: It is often found that different controls work best at different times of the day, for example a signal might be best in peaks, but a roundabout is best off-peak, or different staging works better during different periods. AutoJ chooses the overall best compromise but favours the best peak hour performer.

Note 7: It is recommended that the order of signal stages in the field is not changed during the day; stages should preferably not be skipped or even swapped during different periods as this can confuse motorists and can lead to crashes. If a motorist sees a right flash in a certain sequence at one time of the day, he/she comes to expect the flash to operate the same way each time and will sometimes drive accordingly. While it is possible to ignore this advice for leading greens, in general it is better to optimize the control for the critical period and to accept slightly sub-optimal staging during less critical times (when the effect on delay will be smaller) rather than to change control sequences or skip phases during the day where the effect on safety could be great.

Note 8: All controls within 10% of the optimal control are highlighted in green in the summary **SMY** table. It is however not necessary to only consider the control with the best performance index, particularly if the difference in PI is small. Typically, if a control or staging exists and is working adequately – it need not be changed for marginal or short-term gain.

Note 9: Users may choose a control based on Level of Service or other criteria rather than the PI. For example, excessive delay during a peak hour may necessitate a traffic signal to be installed. Because a signal installed only for that one peak hour will have relatively high delay during the remaining 23 hours, the intersection might have a worse PI than an alternative. Similarly, roundabouts will often have less delay than other control devices but may not be practical due to space, cost, or system constraints. Site conditions and other practical considerations may also result in a particular control being required; in which case the PI can be ignored. The PI is a guide, not a requirement.

Note 10: A useful hint is to delete the controls in **SMY** (summary) that you are not considering (e.g. delete all the priority options if you are only looking at traffic signals). This will make it easier to compare the controls you want.

Note 11: After completion of your design, "copy" and "paste values" of your final version as well as the **SMY** then delete all the controls not in contention. This will ensure that your design is not accidentally amended later but more importantly avoids searching through the entire spread sheet to find the recommended control.

1. INPUTTING DATA

1.1 Input Sequence and Colours

All data and tables are arranged with north at the top and from left to right in the following **sequence**:

- n, s, w, e – North, then south, then west and then east, or n/s, then w/e if combined.
- L, S, R – Left, then Straight and then Right.
- T – Through total, the combined L + S + R.
- AM, off, PM – Morning, off-peak and evening (Saturday and other times can be substituted).

In “hr” and “GEOM”, the **colours** used for data input cells are as follows:

- Yellow cells require user entry (enter, overwrite, or confirm as needed).
- Green cells are default values (overwrite if not correct).
- Blue cells are optional entry (not used by program).
- Dark red writing in a coloured cell indicates a calculation has been done by AutoJ (overwrite if actual values are known).
- Note: When cells are overwritten, the AutoJ calculation will be lost.
- The greyed block in the heading at the top right indicates the best control overall, together with the intersection V/C and delay of that control. This information is provided to assist the intersection designer to see whether a change improves or worsens the intersection performance without having to go to another sheet.

1.2 Input Requirements

The absolute minimum inputs required are a single hour traffic count and the number of lanes. Default values are provided for all other input data based on typical urban AM, PM, and off-peak hour variations.

Despite the defaults being available, users should always check these and overwrite if necessary.

When traffic signal timings will be implemented in the field it is extremely important to confirm or change the approach speeds, grades and to check the clearance distances as these affect the inter-green period. Incorrect inter-green times can be a serious safety hazard.

Any traffic count for any hour of the day or any day of the week can be input. Traffic volumes input can include heavy vehicles, pedestrians, pedal cycles, and U-turns.

If only one peak hour count is available, AutoJ will provide suggested values for missing peak and off-peak counts. This is particularly useful for traffic impact assessments and transportation modelling studies where only one hour's trip generation is obtainable. Improved accuracy will however be achieved by providing all available counts rather than relying on defaults.

(A list of all the data that can be input is given in Annexure A. Annexure A can also be used as a check list for the geometric and other data that should be collected on site.)

1.3 Input Order

Data can be entered in any order, but it is recommended that counts are entered first because AutoJ can then recommend the optimal number of lanes needed (see "GEOM").

2. INPUTS

2.1 The cover (CVR)

AutoJ opens on this page. This page identifies the intersection.

Before entering data, it is essential that "north" is identified first. All data, including street names and counts must be consistently entered in relation to this north direction. The north does not have to be true north, it can be any direction, but the road on the "north" approach must be identified and defined before proceeding.

Enter the intersection road names and "suburb, city and version". Any text entered here, for example "before development" or "after development", will appear on every page, so if any information must appear on every spreadsheet and on the printed pages enter that here.

It is good practice to include a location map with street names and surrounding area information.

The synopsis (which is likely to only be entered after completion of the analysis) is important to quickly identify to others what the study is about and what you recommend.

The intersection number / GPS co-ordinates / reference or other identification can also be entered, along with notes and observations.

2.2 The Intersection and Signal Layout Drawings (EX and NEW)

These allow for the designer to input existing and design drawings.

EX (Existing Layout)

The names of the streets on the north / south and west / east approaches from the cover (***CVR***) appear in the green / yellow box surrounding the layout drawing. If the streets on either side of the intersection have different road names, then overwrite here; or if a T-junction, delete the name of the non-existent approach. These street names will then be transferred to ***NEW, ADT, PK*** and ***GEOM*** spreadsheets.

The declaration information will also be transferred, including to the signal timing plans ("***+***" spreadsheets). If entered elsewhere than in ***EX,*** this data will not be copied automatically.

The appropriate logos can also be pasted but these will not be automatically transferred.

NEW (Proposed Layout)

The new layout will only be done after the intersection control has been decided and the signal, if any, is designed. This spreadsheet is placed here for convenience.

Declaration

If traffic signals are to be implemented in the field, the National Road Traffic Act, Regulation 287A, more fully described in the South African Road Traffic Signs Manual, volume 3, section 1.2 (4) requires the following declarations to be made by a **Professional Engineer or Professional Technologist** (Pr Eng or Pr Tech Eng):

"A responsible registered PROFESSIONAL ENGINEER or registered professional TECHNOLOGIST (engineering) of the road authority concerned SHALL approve every traffic signal installation at a signalised junction or pedestrian or pedal cyclist crossing, and sign a declaration containing the following:

*(a) scaled **drawing** of the layout of the junction or crossing, indicating lane markings and road layout.*

*(b) number, type, and location of **traffic signal faces**.*

*(c) number, type, and location of **pedestrian** and pedal cyclist facilities, including pedestrian push buttons.*

*(d) **phasing, time plan and offset** settings.*

*(e) **date of implementation** and*

*(f) **name**, signature and registration number of the engineer or technologist (engineering) who approved the signal, and date of signature."*

Requirements (a), (b) and (c) of the declaration must be provided on the ***NEW*** spreadsheet. Requirements (d) and (e) will be met by completing the signal time plan ("***+***" spread sheet) for the chosen control. The relevant print outs must be signed (f).

2.3 Traffic Counts (qtr, hr, ADT, PK)

There are four count related spread sheets (yellow tabs); the first two ***qtr*** and ***hr*** are where data is input, ***ADT*** and ***PK*** are for review and printing only. All volume input **must** be entered on the ***qtr*** and ***hr*** sheets, AutoJ will ignore any changes made on the ***ADT*** and ***PK*** sheets.

2.3.1 *qtr* *Quarter hour counts*

Use "***qtr"*** to input quarter hour counts. If the count is hourly, do not enter here; use "***hr"*** to enter these volumes.

The date and day of the count are important for future reference and should be entered. The source of count can also be entered. The peak hour factors (PHF) are displayed after data is input.

The sketch to the right of the heading indicates how each each movement is labelled, e.g. nR is vehicles from north proceeding Right, nP is Pedestrians who cross north-south using the crossing on the east side of the intersection.

If the counted movement is numbered rather than labelled, overwrite the label with a number here.

While provision is made for 14 hours of quarter hour counts from 5:00 to 19:00, it is not necessary to complete all the rows in the table, but a minimum of 4 quarter hour counts are needed.

The default peak hours, highlighted in green and orange on the left, are for reference only. The actual peak quarter hour and the peak hour are highlighted in red on the right of the table.

If cutting and pasting into "***qtr"***, make sure to **delete 0's**; i.e. uncounted rows and columns must be blank. If zeros are not deleted, it will be assumed 0 is a count to be included in the analysis.

The graph to the right is populated as soon as quarter hour counts are entered. The graph forms a useful visual check on the accuracy of the entries.

2.3.2 *hr* *Design Hour Volumes*

Base hour count (veh/hr)

This table is critical and must be populated with data for at least one hour and for exactly one hour per period. Up to three hourly counts can be entered, day or night, weekday, or weekend.

Base Count will have a date, period and time displayed. If this is not correct, overwrite with the correct data. This will then reflect throughout every sheet in AutoJ. Be aware that if the defaults are changed, the event table (in ***SET***) may also require changing.

If volumes have been entered in ***"qtr"***, the table will have data. AutoJ takes the maximum hourly volumes in ***qtr*** before and after 12:00 as the AM and PM peaks and shows the times those peaks begin. For off-peak it uses four times the average of the 9:00 to 15:30 quarter hour volumes. Users must check if these are as required and amend accordingly.

Heavy Vehicles including Buses.

Heavy vehicle percentages, not volume, must be entered. If the percentage of heavy vehicles is entered in the first "green" column, all the cells in the row will reflect that percentage; alternatively, the individual movement percentages can be entered.

The percentages of heavy vehicles can vary widely, with less than 1% on local streets to greater than 25% in industrial areas and commercial routes. If unknown, a figure of 3% heavy vehicles in peak hours and 7% in off-peak is a reasonable assumption (default is 0%).

The default weighting given to heavy vehicles is two (2), i.e. each heavy vehicle or bus is regarded as equivalent to two light vehicles. Users can amend this value if a lower or higher weighting should be given to heavy vehicles.

% growth base traffic

This cell allows the user to adjust an existing traffic count to cater for future growth (or decline). This is a useful facility for doing traffic impact assessments or for assessing how long a recommended control will stay optimal.

The default growth factor is 0%. To modify, enter the annual growth rate and the number of years, and compound growth will be calculated. Alternatively, simply insert the required percentage growth (which can be negative if shrinkage is applicable). All base count and heavy vehicle volumes will be multiplied by the growth factor, but the development and pedestrian volumes will not be adjusted.

Pedestrian, Cyclist and U-turn Counts (per hour)

The capacity of turning movements is significantly influenced by pedestrians (and cyclists) using pedestrian crossings, so the program is sensitive to these volumes. Enter these if available or guess them if pedestrians were noted on site. There is also provision to enter U-turns if these were counted.

The pedestrian crossing is labelled as per the adjacent main green signal, hence nP, for example, is the **two-way** pedestrian volume crossing with the north main green who will use the east side crosswalk. If crossing is banned, or crossing does not conflict with any vehicles (e.g. crossing on the opposite side to the leg of T-junction), it is important to leave the default of zero. Cyclist (pedal cycle) volumes are multiplied by 2.0 by the program (because bicycles plus the rider take more space) and added to the pedestrian volumes.

Development Traffic

When doing traffic impact assessments, it is necessary to account for traffic to and from the proposed new township or development. For the affected movements, enter the traffic volume per hour to be added (or subtracted). The program will add (or subtract) these values to the background count to get the design volume. If the development traffic is required to be analysed on its own, delete the background traffic volumes.

This table can also be used to add any other volumes, e.g. bus volumes for BRT studies, or to assess the effects of road closures.

Design Volume (equivalent vehicle units / hour)

The design evu/hr is used by AutoJ in all the calculations that follow. It is the sum of base volumes adjusted for heavy vehicles and any growth, plus development traffic and U-turns.

Average Daily Traffic

AutoJ uses the ADT figure to calculate peak and off-peak percentages of ADT in the ***PK*** and ***ADT*** spread sheets, but otherwise it is not used and can be ignored.

Peak and off-peak hour multipliers have been derived from many typical daily variation patterns in South Africa's large cities. It was found that the typical AM peak hour volume is 8.9% of ADT (standard deviation 1.1%), off-peak is 6.0% of ADT (std. dev. 0,6%) and PM peak is 8.7% of ADT (std. dev. 0.8%). To give approximately equal weighting to the three hourly volumes in the calculation of ADT, factors of 3.75 (AM), 5.55 (off) and 3.85 (PM) were derived. Hence 3.75 * 8.9 + 5.55 * 6.0 + 3.85 * 8.7 = 33.3% + 33.3% + 33.4% = 100%. The 12-hour (6:00 to 18:00) count was found to be 82% of ADT in typical urban conditions.

The average daily traffic is therefore estimated in one of two ways:

1. If 12 hours have been counted and entered in ***qtr***, these totals are used as 82% of ADT.

2. If 12 hours have not been counted, the peak multiplier method is used.

If the ADT is known, the above estimates are not required, and the known value should be overwritten in the green cell to the right of the ADT row.

Missing volumes

A procedure to estimate missing volumes is provided. This is useful when only one peak hour count is available (e.g. most transportation studies and some TIA's are done for only one peak period) or the off-peak volumes are missing. The program works by estimating the missing peak as a mirror image of the known peak and then estimating off-peak volumes from the peak values. This calculation is valid only for standard "peaks" on two-way streets in urban areas. Do not use if any of the approaches is a one-way or banned, i.e. not valid for freeway ramps for example.

To use, simply copy and "paste values" from this table into the evu/hr table above.

Weighting

The weighting option is to give the user the choice of favouring (or penalizing) one or more movements. By so doing, the program will multiply the movement design volume by the weighting. If the weighting is greater than 100%, the associated volume is increased; hence AutoJ will try to give more green time to that movement.

If the weighted movement does not affect a critical lane, i.e. the lane volume after weighting is still less than the critical lane volume, the weighting will have no effect as the critical lane will dictate the required green time.

This facility can be used to favour public transport routes and bus rapid transit routes or to favour main roads over side roads by more than the volume differences would otherwise dictate. Because the weighting distorts the optimal timing, it is suggested it is used sparingly and with caution.

Downstream Blockage

Capacity is greatly reduced if downstream conditions result in queues blocking back to or through the intersection being designed. AutoJ will attempt to compensate for this by giving additional green time to the unaffected movements if the user weights them accordingly, rather than waste green time on movements that cannot move.

This is a crude method as any additional green time is still unlikely to be effectively used. Hence it is rather recommended that shorter cycle times are used to reduce the number of vehicles stored in the intersection (with short cycles, motorists are less likely to move into the blocked intersection and unaffected movements get many more opportunities to clear).

2.3.3 *ADT* and *PK* *Traffic Count Graphical Display (for viewing, checking, printing)*

Graphical presentations of ***ADT*** and hourly ***PK*** design evu (equivalent vehicle units) volumes are provided for easy viewing, checking, and printing purposes. No user input is required, and any user overwriting will be ignored.

The ***ADT*** summary is particularly useful for checking count consistency. Check for balanced flows. The design value evu includes growth, heavy vehicles, and development traffic, while quarter hour veh/hr is the actual count, so the design may exceed the count value.

The ***PK*** sheet gives all the hourly volumes including pedestrians and cyclists, the hours as a percentage of ADT, %HV, the PHF and the directional split.

AutoJ takes the count information for all calculations from the ***hr*** "D*esign Volume"* table. If there is a need to amend volumes after viewing ***ADT*** and ***PK***, these should be changed in the ***qtr*** or ***hr*** sheet and not in the ***ADT*** or ***PK*** summary.

2.4 Geometry (GEOM)

Every intersection is unique, so it is important that the user provides accurate information of the lane numbers, lane markings and related data describing the intersection. Data needs to be entered for each approach individually. If an approach does not exist (T-junction or one-way), AutoJ will know that from the traffic count and user should ignore, but not delete, any default geometric data.

The **number of lanes of each road marking type** is the most important input requirement. Everything is affected by this. If the count has been entered, AutoJ calculates the approximate minimum number of lanes required for each movement and this is shown in red. The suggestion will disappear as soon as the actual number of lanes is added. The number of lanes need not be an integer; a point will be accepted (see Note 4).

On each approach enter the number of lanes of each of the following lane types:

- *Left slip:* slip lanes are separated from the adjacent lane by a physical dividing island and are not controlled by the traffic signal. If the slip road flows freely into its own exclusive lane when exiting into the crossroad, the "slip must yield?" question must be answered no (n), otherwise if controlled by a yield sign and having to take gaps on exiting, leave the default yes (y). (Slip roads should never be signal controlled as this is misleading and dangerous. If signal control is necessary, the left lanes should go through the normal intersection and not be physically separated. If a signal-controlled slip road does exist however, analyse it as a separate unrelated intersection.)

- *Left only*: motorists in these lanes must turn left.
- *Straight-Left*: motorists in this lane can go left or straight.
- *Straight only*: motorists in these lanes must go straight through.
- *Left-Straight-Right*: a usually unpainted lane allowing motorists to turn in any direction. For a T-junction, this lane type must be used to allow turning both left and right from the same lane.
- *Straight-Right*: motorists in this lane can go straight or right. This marking can be used at priority junctions, or T-junctions, or signalized approaches without a flash. If a green flash exists, use the shared straight-right with caution because motorists wanting to turn right on the flash may be blocked by straight through traffic and may drive dangerously as a result.
- *Right only*: exclusive right turn lanes are required at most signalized intersections, and especially when a right turn flash is operating.
- AutoJ needs to know if *"rt. turns in gaps allowed?"* at a traffic signal; yes (y) is usual (permissive), but if <u>protected only</u>, change to no (n). If no, the program will provide additional right turn flash green time to compensate for vehicles not being able to take gaps, but will ignore if there is not a flash.
- *No. lanes if roundabout:* – AutoJ determines the number of roundabout lanes from the number of standard intersection lanes. By default, this is set to a maximum of two for a roundabout and one for a mini-circle. If a roundabout has more than two lanes, users must override the default number of lanes. If there is a slip road, it is assumed this will not go through the roundabout and is dealt with as not part of the roundabout.
- *Exit lanes* are automatically calculated from the opposite approach and turning lane numbers. The number is used by AutoJ to calculate clearance distances and should be amended if incorrect.

Note 1: In the event of conflicting lanes (for example a left lane and left turn slip), AutoJ will warn of a *"lane clash".* Lane choice **must** be corrected.

Note 2: If a movement has a volume greater than zero and no lane is specified, the program will warn that a lane for that movement **must** be provided. The warning "*NOTE, add or amend lanes*" will remain until this is corrected. Do not proceed until this and "lane clash" is cleared as wrong results will be produced.

Note 3: When selecting the number of lanes and lane markings, the performance on the top right of the spreadsheet can be watched. A lower V/C and/or delay indicates a better lane configuration.

Note 4: Although lane widths have limited effect on capacity, very wide or very narrow lanes can result in capacity increases or decreases. If the user wishes to adjust for lane width, the following is recommended:

lane width (m)	2.5 – 2.8	2.8 – 3.1	**3.1 – 3.8**	3.8 – 4.2	4.2 – 4.5	4.5 +
no. of lanes	0.8	0.9	**1.0**	1.1	1.2	1.3

Note 5: AutoJ uses lane and volume input to estimate all other input data and calculations. The default data needs to be checked and corrected by the user.

The following items need checking:

- *"Median (m)"* width, M, is used in the clearance, gap acceptance and pedestrian calculations, default is 0.0 m (no median).
- The *clearance distance "(m) to clear", c,* is the distance from the stop line to the extension of the kerb line on the far side of the intersection. AutoJ estimates this from the number of side street lanes and median width, but this estimate is approximate, so the actual distance should be entered. This distance influences inter-green timing and right turning capacity.
- The *pedestrian crossing distance,* P, is estimated by AutoJ from the total number of lanes that a pedestrian must cross. The minimum green times are calculated from these crossing distances. If the main road is wide, the minimum green times for the crossroad can be very long to allow pedestrians to cross the full distance (not staged). If there is a median (staged), the distance to the median is calculated by default which will substantially reduce the crossing time required. Users should therefore be careful to check these distances. Delete this distance and the width only if pedestrians are prohibited from using the crossing.
- *Pedestrian crossing width, W,* is needed to calculate the pedestrian carrying capacity of the crossing. Default is 3.0m.
- If *pedestrian heads, H,* are provided (yes (y) is default), the program will display pedestrian crossing green man and flashing red man times in the timing diagrams. If no (n) AutoJ will still calculate a minimum crossing time for pedestrians (who will cross on the green disc for vehicles) but green and flashing red man times will not be shown in the timing diagram. Pedestrian heads always restrict pedestrians to less crossing time than they would otherwise have, so use only when crossings are long or multiple stages are present.
- *Turn lane length (m).* Enter the actual auxiliary lane lengths (full lane plus half the taper) for left and right turning lanes. By default, these lanes are set at 50m (straight through lanes come from the previous intersection and are assumed to be unlimited in length as they are not "auxiliary"). If the lane is too short, the recommended lane length for a random variation in arrivals will appear in white on red to warn the user. When the turning lane is too short, turning traffic will on occasions spill over into the adjacent lane and block straight through traffic, alternatively turning vehicles will be blocked

by straight through traffic and not able to enter the lane. AutoJ adjusts for this by adding the overflow volume to the adjacent straight lane and thereby gives more green time to that approach.

- The *approach speed, V,* (use speed limit if not known) influences inter-green phasing. The default value is 60 km/h. For safety, this value **must** be correct.
- The *grade, G,* entered must be 0% for flat, positive % for uphill, negative % for downhill. The capacity and inter-green phasing are both sensitive to grade, so the best possible estimate of the true grade **must** be provided if the signal timings on down hills will be implemented on site. As a guide:
  - -2% to +2% is relatively flat.
  - +/- 2% to +/- 5% is a gentle incline.
  - +/- 5% to +/- 8% is quite steep.
  - greater than 8% is very steep (and quite rare, intersections are not recommended on such steep slopes).

2.5 Time Settings (SET)

The event table, cycle times, minimum green, yellow, and all-red times, local conditions, and co-ordination (synchronization) effects are entered in the ***SET*** (Time Settings) sheet. The fixed data table at the bottom provides all the pre-set data needed to make these calculations and should not be changed by users.

AutoJ rounds all time calculations to the nearest 0.1 seconds. Electronic controllers should be able to be set to this accuracy. Humans however seem to prefer rounding to the nearest second, or sometimes half second, perhaps because it is easier to picture and makes mental arithmetic easier. Users have the choice to manually round down or round up numbers as they wish, but the combined yellow and all-red time must never be rounded down by more than 0.2 seconds. The rounding done in ***SET*** is reflected in all the signal time plans.

Event Table

The event table reflects the duration of each program by specifying both the start and end times. The times set here will be reflected in the timing diagrams and form the instructions to the signal installer. If other than the default AM, off and PM event times are designed for, these must be changed in ***hr*** *(cells A9, A10 and A11)* before amending here.

Offset and Co-ordination Efficiency

The table of co-ordination efficiency provides for how well or badly the signals are synchronized. The delay calculation is sensitive to this factor.

The default is 50% which allows for random arrivals, but the factor can range from 100% for a perfectly co-ordinated signal system to the worst case of 0%, where all vehicles arrive during the red signal and delay is maximized. More information is provided in the definitions above.

Pre-calculated offsets must be entered in the signal timing plan ("***+***") sheets. AutoJ does not calculate offsets (**AutoSynch**, available for free on request, does this).

Local Driving Habits

An option to adjust for local driving habits is offered. In most cities and metropolitan areas in South Africa, drivers are aggressive, follow closely, take small gaps and generally maximize capacity. The saturation flow in these conditions is set at 2 000 vehicles per hour per lane. This is the City "C" option.

In towns "T" drivers are generally more relaxed and take longer to take a gap. They also follow less closely. If the T option is selected, 1 800 vehicles per hour per lane is the saturation flow with all other gap acceptance and headway adjustments made accordingly.

In villages and rural areas "V", a further adjustment to 1 600 vehicles per hour per lane applies.

Cycle Time

Cycle times are generally set in the 60 to 90 second range, although cycle times as short as 40 seconds and as long as 120 seconds (or even more) can be justified on occasions. Traditionally cycle times are set in 10 second intervals, but most controllers can be set in 5 second intervals if needed.

When cycle times are changed, observe the V/C and delay values alongside. These values are put here to help the user choose a cycle time that optimizes the performance of the intersection. It may however be necessary to use a non-optimal cycle time when dictated by co-ordination requirements. In a co-ordinated system, the cycle time is usually set based on the busiest intersection.

Shorter cycle times reduce delay, while longer cycle times can increase capacity. Short cycle times assist turning traffic as the number of opportunities to turn during inter-green is increased. Short cycle times can even mean that right turn flashes are not required. Longer cycle times are often justified on busy main road with minor side road intersections.

The capacity enhancement of longer cycle times is often overestimated. The improvement in capacity is due to a smaller percentage of "lost time", but this is marginal and is only realized if there is an "infinite" queue. In practice, long gaps in traffic and underutilized lanes are often the result of too long cycle times. Some vehicles may start to skip red lights if cycle times are long.

Minimum Green and Inter-green

There are four inter-green situations to be considered. The first and most common is when a green stage is followed by a cross street green stage (e.g. 2 stage signal), the second is when a green disc stage is followed by a lagging right turn flashing arrow, the third is a when a leading green flashing arrow is followed by a green disc and the fourth is when a lagging green flashing arrow is followed by a cross road green. The minimum values for each situation must be specified by the user, or the default accepted.

AutoJ calculates the **minimum green** time for through movements as the greater of the pedestrian crossing time or RTSM policy. For turning movements, it uses RTSM only. The SADC Road Traffic Signs Manual (RTSM) specifies 11 seconds preferred with an absolute minimum of 7 seconds for green disc movements, and 7 seconds with an absolute minimum of 4 seconds for green flashing arrow movements.

Leading green arrow flashes require longer flash times than lagging green arrows as they must allow for start-up delay, including time for motorists to observe the flash and to react, as well as time to proceed from the stop line into the intersection. Also, with a leading green there will be more vehicles waiting to turn as they have arrived during the red period. Lagging greens can be shorter as motorists can take gaps while the light is green and those not taking gaps are in the intersection waiting for the light to change and not back at the stop line. Therefore, while 7 seconds is appropriate for leading green flashes, lagging green arrow movements require a shorter minimum of 4 seconds (3 seconds is enough, but not allowed in RTSM).

The **yellow** time interval is calculated using the formula in the RTSM, with a minimum yellow time of 3.0 seconds for all movements. Users can choose to amend the calculated yellow times or round off to eliminate the decimal point. For safety reasons make sure the approach speeds and grades are correct in ***GEOM*** as these are used to calculate the yellow interval.

The **all-red** interval is also calculated using the RTSM formula. While users can change this time, rounding down is not recommended. A minimum all-red of 2.0 seconds is normal except for flashes. After the termination of a leading green flash, the all-red interval can be reduced to 1.0 second.

Currently the RTSM does require the minimum 2.0 seconds all-red in addition to the yellow after the through and before the lagging flash, but this is a mistake that should be rectified. A no all-red (0.0 secs) here is best and safest, because with a lagging green flash the first turning vehicle in the intersection will wait for the opposing traffic to slow and stop before proceeding and does not depend on the signal to provide a clearance interval. But if an all-red is provided in this situation, the green flash does not start immediately and vehicles waiting to turn behind the vehicles in the intersection will be unsure of whether it will be displayed or not. They therefore hesitate and often brake unnecessarily. For that reason, many authorities do not apply the 2.0 sec rule.

Level of Service Colour Code

The LoS colour coding which is used in every one of the data sheets is described here. It is based on Highway capacity manual recommendations.

Fixed data

Data under this heading is considered "fixed" and should not be amended. AutoJ has been designed using these values and changing them may have unintended consequences. Expert users may wish to consult the Technical Manual for detailed explanations and derivations of values and how to experiment with different values if required.

Minimum greens, reaction times, deceleration rates and walking speeds are taken from the RTSM. They are used to calculate the minimum allowable green, yellow, and all-red times for all phases and phase combinations.

2.6 Calculations

The **conflicting volume, capacity, saturation flows, critical gaps and signal timing calculations** are hidden. They can be viewed using "unhide".

The saturation flow for light vehicles in "perfect" conditions has been set at 2 000 vehicles per hour ("practical saturation" is 0.975 of this, or 1 950 vph). This figure is then adjusted for many factors, including turning traffic, shared lanes, multiple lanes, heavy vehicles, pedestrians, and grade. The capacity is calculated by multiplying the adjusted saturation flow by the effective green time.

Gap taking is calculated for priority controls but also for right turning in gaps when signalized. A right turn friction factor is also provided to allow for the reduction in capacity when more than one turning lane is introduced.

The Technical Manual (Intersection Traffic Engineering) describes the functioning of these factors.

3. RESULTS

3.1 Summary (*SMY*)

The summary ***SMY*** is the engine room of AutoJ. This is where the performance of the 26 standard intersection control devices is contrasted and compared, and the optimum control is chosen.

Detailed measures of effectiveness of the 5 priority and 21 signal staging options are provided in the 48 spreadsheets that follow. At the end of that, there is a mid-block pedestrian signal option.

3.2 Level of Service

AutoJ colour-codes the Level of Service to provide an immediate and visual picture of vehicle and pedestrian performance (see ***SET*** for colour coding), based the following Highway Capacity Manual thresholds:

Table 3.1: HCM 2000 Vehicle Level of Service thresholds

Level of Service	Volume to Capacity (V/C) ratio	Average delay, seconds per vehicle, priority intersections	Average delay, seconds per vehicle, signalized intersections
A	< 0.5	< 10	< 10
B	< 0.8	< 15	< 20
C	< 0.9	< 25	< 35
D	< 0.95	< 35	< 55
E	<0.99	< 50	< 80
F	more than 0.99	more than 50	more than 80

Table 3.2: Pedestrian Level of Service thresholds

Level of Service	Pedestrian Volume to Capacity (V/C) ratio	Pedestrian volumes (peds / min / m)
A	< 0.1	< 7
B	< 0.3	< 23
C	< 0.4	< 33
D	< 0.6	< 49
E	<0.97	< 82
F	more than 0.97	more than 82

Because there are different delay ranges for priority controls and traffic signals, it will happen that priority controls have a worse LOS than traffic signals for the same delay. It can also happen that different levels of service are given depending on whether V/C or delay is the criterion.

HCM 2000 recommends **delay** Level of Service is used for intersections, but AutoJ extends this to use a combination of delay, V/C and queue. This is done by using a performance index to determine overall control efficiency throughout the day and not just delay in a single hour.

3.3 Performance Index

Unlike most programs which use only a single measure of effectiveness (MoE) in a single hour, the AutoJ Performance Index is made up of seven (three delay, three V/C and one Queue). The user can decide to use a single measure or any combination of all the measures.

The performance index is then calculated by checking each control type against the best control performance for that measure, weighted as required, and expressed as a percentage of 100% optimal.

The performance index is designed for a typical intersection in an urban area where AM, PM and off-peak counts are available. It is however equally accurate if other periods are used.

Each of the MoE's can be weighted by the user. By default, the V/C ratios receive 60% of the weighting, while delay and queue get 25% and 15% respectively. The reason V/C receives a higher weighting is that this is usually the reason the intersection requires attention. If the aim is to increase capacity of a particular overloaded movement, even if it is to the detriment of delay to the rest of the traffic movements, then V/C might be the only factor considered.

In general, signals will reduce V/C but increase delay when compared to priority intersections. If a user wishes to prioritize delay, a higher weighting to delay (and queue) can be given which will therefore favour a priority control or simple (two-stage) signal option. If V/C is weighted higher, three or four stage signals will often be preferred as right turn movements generally have the lowest capacity which is helped by the right turning flashes.

The best overall intersection control is given at the bottom of the table and highlighted in dark green. Any ICD not quite optimum but with an MOE within 10% of the optimum value is highlighted in light green.

The colour coded Level of Service provides an immediate visual assessment of which control device or signal staging is better than another. A more detailed analysis may be needed however, and this is provided in the spreadsheets that follow the Summary.

3.4 Individual Intersection Control Device Analysis

For each of the ICD options, for each of three time periods, for each movement, and for each intersection, the following information is provided:

- the evu design volume;
- the number of lanes;
- the control type or for signals the cycle time and g/c (green to cycle time) ratio;
- the volume to capacity (V/C) ratio;
- the level of service based on V/C;
- the average delay, in seconds per vehicle;
- the level of service based on average delay;
- the queue length, which equals the total delay in vehicle-hours per hour.

For traffic signals, the following is provided in addition (+ sheets):

- a staging diagram;
- the optimal fixed timing (for VA, see below);
- the pedestrian green man and flashing red man times (with a warning if too short);
- a signal timing diagram.

In practice, not all the ICD’s are likely to be examined by the user, only the relevant ones.

After inspection, users can revert to the input information, e.g. cycle times or lane types, or input signal timings manually, and immediately see the result of any changes.

3.5 Non-optimal Control

It is recognized that the user may not always be interested in the “optimal” ICD, or even in the optimal signal timing and staging. This could be because the user requirement is to:

- simulate an existing control;
- research a particular timing or staging;
- optimize the staging sequence that exists on site;
- not change ICD or staging for cost reasons;
- not change because the staging has been put in for a particular reason;
- not change because the difference between the current and optimal is small;
- not change because in future a different control will be needed.

The choices provided give the user the means to explore all these options.

3.6 Vehicle actuated (VA) control

Vehicle actuation requires setting minimum and maximum green times. This can be calculated in AutoJ by inputting first the lowest and then the highest expected volumes. The minimum and maximum cycle times should correspondingly be entered in ***SET.***

For the lowest volume AutoJ will provide the minimum VA settings, and for the highest, the maximum VA setting, with the difference being the green extension required. These values can then be entered in the appropriate spreadsheet.

Be aware that AutoJ uses the value in the “green” column (and ignores the “gr ext”) when calculating V/C and delay.

QED.

ANNEXURE A: INPUT DATA

All possible user inputs are listed here, with key entries highlighted in red.

AutoJ tab	Input
CVR	**North**
	Road names
	Suburb / Town / version
	Location map
	Synopsis
	Existing and proposed control type
	Number / GPS / date
	Description of what was done / recommended
EX, NEW	Existing layout (EX). Check the road names in the green box border, change here if not correct.
	Proposed new lane and road marking layout (NEW)
	Proposed Traffic Signal Layout Design (SIG)
	Logo, job no., name, position, registration, and signature of designer
qtr	Count date / day
	Done by
	¼ hour count per movement
hr	**Base hour count**
	Pedestrian and pedal cycle volumes
	U-turns
	Heavy vehicles including bus percentages, weighting
	Annual growth % and number of years, % growth base traffic
	Development traffic
	Design volume (derived from above)
	Weighting of movements
	Missing volumes
	ADT
ADT	*no input required*
PK	*no input required*
GEOM	Approach speed
	Approach grade
	Right turn in gaps
	Slip exit condition
	Auxiliary lane length
	No. of lanes of each type
	No. of roundabout lanes
	No. exit lanes
	Island width
	Clearance distance
	Pedestrian crossing distance, crossing width and heads
SET	Event table
	Cycle times
	Local Driving Habits
	Co-ordination efficiency
	Minimum greens, yellows and all-reds
	Fixed data