Domain Glossary

Software Applications Development

Traffic-signal terms used across the test project

Submitted by:
Bence Lakos - Ingenimind Kft, Independent Test Project Designer
Benjamin Frost, Independent Test Project Validator

Contents

Geometry of an intersection **2**
The signal program (control structure) **2**
Demand and sensing **3**
Optimization — Webster's method **4**
Performance and grading **4**
Mathematical notation **5**
Operators and symbols 5
Inclusive and exclusive bounds (interval notation) 6
Symbols used in the formulas 6

This glossary explains the traffic-engineering vocabulary used in the GreenWave test project (Session 1 and its simulator) — in plain language, with no prior domain knowledge assumed. Where it helps, an entry notes how the term appears in the simulator.

The 10-second picture. An *intersection* is described by a *signal program* (its lanes, movements, and phases). *Detectors* report how many vehicles arrive on each movement — a stream of *detector frames*. From that demand, a controller computes the *cycle* and *green split* — how long each *phase* stays green — using *Webster's method*. Quality is judged by the average *control delay* per vehicle, graded as a *Level of Service* (A–F).

Geometry of an intersection

Intersection — Where two or more roads cross and traffic is controlled by signals. The whole GreenWave model describes a single intersection.

Approach (leg) — One incoming road, named by the direction traffic comes **from** — North, East, South, West. Vehicles on the North approach travel southbound into the intersection. Each approach has one or more lanes.

Lane — A single file of traffic within an approach. A lane is marked for one or more *movements* (e.g. a left-turn lane, or a shared through/right lane). *In the simulator:* you set how many lanes an approach has and "which lane can go where".

Movement — A permitted path through the intersection from an approach, classified by turn type — **Through**, **Left**, or **Right**. For example "North-Through" or "East-Left". Movements, not lanes, are what the signal actually controls.

Saturation flow (rate) — The maximum number of vehicles a movement could discharge in one hour of continuous green, in vehicles/hour (vph). A rough rule of thumb is ~1800 vph per lane. It represents capacity — how fast a queue can clear once the light is green. *In the simulator:* saturation flow is 1800 × (lanes serving the movement).

© WorldSkills International

The signal program (control structure)

Signal program — The complete, static configuration of an intersection's signals: its movements, its phases, the conflict rules, the lost time, and the legal cycle-length range. It is the "rules of the intersection" the controller works within — it does **not** contain live traffic data.

Phase — A group of movements that are allowed to be green **at the same time** because they don't conflict — e.g. "North + South through traffic" is one phase, "North + South left turns" is another. A signal cycles through its phases one at a time. Giving a phase more green time favours the movements in it.

Conflict — A pair of movements that must **never** be green together because their paths cross dangerously (e.g. a left turn against opposing through traffic). A valid phase may not contain both members of a conflict pair.

Cycle (cycle length) — One complete run through all phases, measured in seconds. A 90-second cycle means every movement gets its turn once every 90 s. Shorter cycles cut waiting but waste time on switching; longer cycles serve heavy traffic better but make everyone wait longer.

Lost time — The seconds in each phase that can't be used for moving traffic — the all-red / amber clearance while the intersection empties between phases, plus start-up delay. The **total** lost time in a cycle is the per-phase lost time ℓ multiplied by the number of phases n:

$$L = n \cdot \ell$$

Here ℓ is the per-phase lost time and L the total that appears in the formulas below.

Green time — The seconds a particular phase shows green.

Green split — How the available green time in a cycle is divided among the phases. The whole point of optimization is to choose a good split.

Effective green — The green time in a cycle that is actually usable for discharging traffic — the whole cycle length C minus the total lost time L. The green split then divides this G among the phases. The whole formula:

$$G = C - L$$

Minimum / maximum green — The shortest and longest a phase may stay green. Minimum green prevents the signal from switching too fast (and gives pedestrians time to cross); maximum green stops one phase from starving the others. The optimizer clamps each phase's green to these bounds.

Pedestrian phase / crossing — A signalised pedestrian crosswalk and the time it is served. In GreenWave, pedestrians cross concurrently with the parallel through phase. A pedestrian phase carries a *walk time* — the seconds pedestrians get to start crossing — and a valid signal program gives every pedestrian phase a positive walk time.

© WorldSkills International

Demand and sensing

Demand — How much traffic wants to use each movement, expressed as a flow in vph. High demand on a movement needs more green.

Arrival flow — The rate at which vehicles arrive on a movement, in vph — the measured demand. Symbol q.

Detector — A sensor in or above the road (an inductive loop, camera, or radar) that senses vehicles near the stop line. It is the intersection's "eyes". *In the simulator:* drawn as a blue zone per lane, its reading being the lane's standing-queue count.

Detector frame — One time-stamped snapshot of what the detectors report — the arrival flow (vph) for each movement at that moment. A sequence of frames is a short history of demand that the demand calculator averages. Think of it as one "reading" from the sensors.

Optimization — Webster's method

Flow ratio (demand ratio) — For a movement, the fraction of a green period it needs — its arrival flow q divided by its saturation flow s. A movement with $y = 0.3$ needs green for about 30% of the time it could be served. The whole formula:

$$y = \frac{q}{s}$$

Critical movement / critical ratio — Within a phase, the movement with the highest flow ratio — the one that sets how much green the whole phase needs. The phase's critical ratio y_i is the largest flow ratio over the movements m in that phase:

$$y_i = \max_{m \in phase\ i} \frac{q_m}{s_m}$$

Webster's method — The classic recipe for the best **fixed-time** plan — two formulas. First, the **optimal cycle length**: it grows as the intersection gets busier, i.e. as the sum of critical ratios $Y = \sum y_i$ approaches 1, given the total lost time L:

$$C_0 = \frac{1.5L + 5}{1 - Y}$$

Second, the **green split**: each phase receives a share of the usable green $C - L$ in proportion to its critical ratio y_i:

$$g_i = \frac{y_i}{Y} \cdot (C - L)$$

Webster minimises average delay for steady demand, but it is computed once and then repeated — it does not react to live conditions.

Phase allocation (plan) — The output of optimization — the chosen cycle length and the green time for each phase.

© WorldSkills International

Mathematical notation

Several entries use compact notation. This section decodes every symbol and convention that appears in the formulas, so none of them is a mystery.

Operators and symbols

Sum (Σ) — The capital Greek letter sigma means "add up a series of values." $\sum_{i=1}^{n} x_i$ reads *"the sum of x_i for i from 1 to n"* — i.e. $x_1 + x_2 + \cdots + x_n$. When the index runs over a **set** instead of a range, e.g. $\sum_{m \in phase\ i}$, it means *"add over every movement m in phase i."*

Floor (⌊ ⌋, written `floor` in the optimizer) — Round the value **down** to the next whole number — drop the fractional part. For example ⌊26.667⌋ = 26. The optimizer floors each phase's raw green before sharing out the leftover seconds.

Maximum (max) — The largest value in a set. $max_{m \in phase\ i}(q_m / s_m)$ is the biggest movement ratio among the phase's movements.

Multiplication ($\cdot$) — A raised dot means "times": $n \cdot \ell$ is n times ℓ. Multiplication is also *implied* when two symbols sit side by side — $1.5L$ means 1.5 times L.

Division (a/b) — A slash, or a horizontal bar in a fraction, means "divided by": G/n is G divided by n.

Subscript (x_i) — A small index below a symbol says *which* one is meant — y_i is "the critical ratio of phase i", q_m is "the arrival flow of movement m." A subscript is a label, never multiplication.

Member of ($\in$) — "$m \in phase\ i$" reads *"movement m is in phase i."*

Implies ($\Rightarrow$) — "therefore / which gives." "$Y \geq 1 \Rightarrow$ use MaxCycle" reads *"if Y is at least 1, then use MaxCycle."*

Comparisons ($<$, $\leq$, $>$, $\geq$) — less-than, at-most (≤), greater-than, at-least (≥). "$x \geq 1$" means x is 1 or more.

Inclusive and exclusive bounds (interval notation)

A range is written with two brackets, and the **bracket style** says whether each endpoint is allowed.

Closed — $[a, b]$ — Square brackets **include** the endpoints — every value from a to b, with a and b themselves allowed. "Clamp the cycle to $[MinCycle, MaxCycle]$" means the result may equal MinCycle or MaxCycle.

Clamp — "clamp x to $[l, h]$" means: if $x < l$ use l; if $x > h$ use h; otherwise keep x unchanged. The optimizer clamps the cycle length and each phase's green this way.

© WorldSkills International

Symbols used in the formulas

Symbol	Meaning
C, C_0	realized cycle length; Webster's optimal cycle length (seconds)
L, ℓ	total lost time per cycle; per-phase lost time (seconds)
G	total effective (usable) green per cycle, $G = C - L$ (seconds)
n	number of phases
q, s	a movement's arrival flow and its saturation flow (vph)
y_i, Y	phase i's critical flow ratio; the sum of all phases' critical ratios
g_i, R	phase i's green time; the leftover seconds after flooring
d	average control delay per vehicle (seconds)

The tool that visualises all of these concepts is described in the Simulator document.

© WorldSkills International