## International Practice on Road Traffic Signal Control

# Country Report Germany and Austria

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# The Book Chapter „Germany and Austria“

**authored by Axel Wolfermann, Bernhard Friedrich and Martin Fellendorf**

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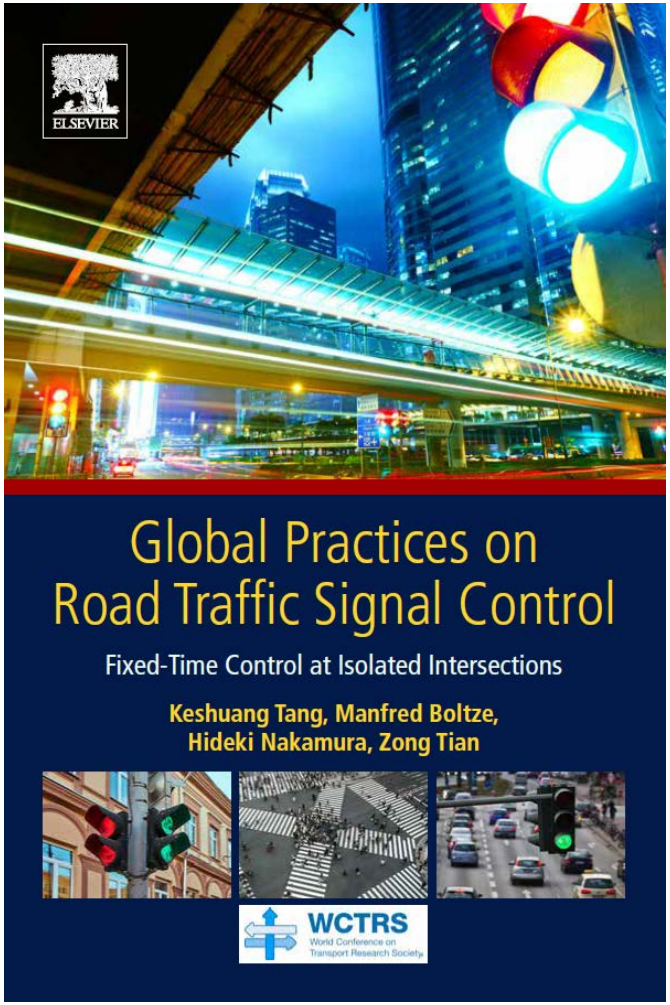
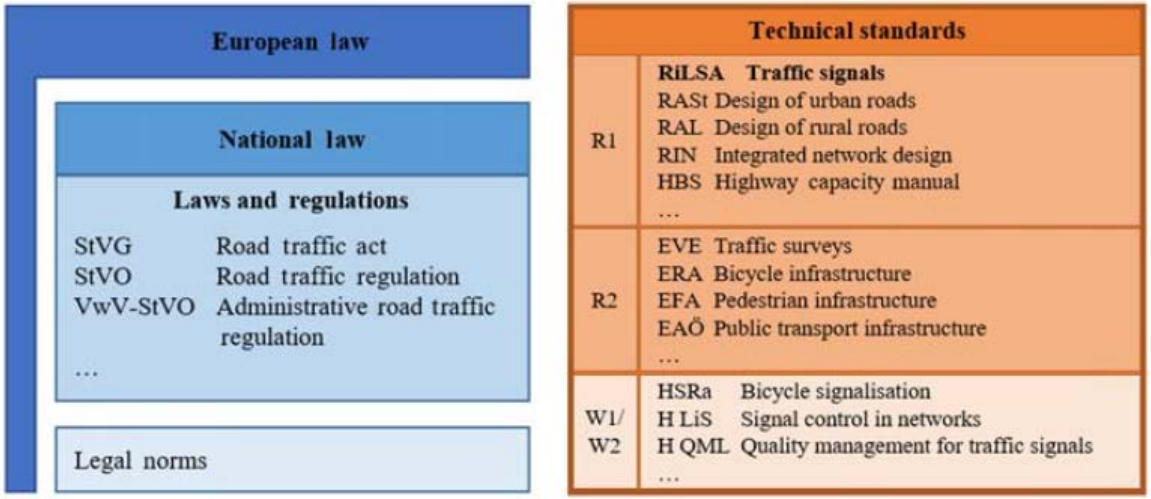




| | | | |
|---|---|---|---|
| **4** | **Germany and Austria** | | **37** |
| | *Axel Wolfermann, Bernhard Friedrich and Martin Fellendorf* | | |
| 4.1 | Background and fundamentals | | 37 |
| | 4.1.1 | History of traffic signal control in Germany | 37 |
| | 4.1.2 | Signals and traffic rules | 37 |
| | 4.1.3 | Guidelines and legal regulations | 41 |
| | 4.1.4 | Quality management | 43 |
| 4.2 | Control strategy | | 45 |
| | 4.2.1 | Signal control and other intersection types | 45 |
| | 4.2.2 | Fixed-time control, actuation and coordination | 46 |
| | 4.2.3 | Special constellations | 48 |
| 4.3 | Intersection layout | | 48 |
| | 4.3.1 | General | 48 |
| | 4.3.2 | Vehicle lanes | 49 |
| | 4.3.3 | Bicycle traffic at urban intersections | 50 |
| | 4.3.4 | Public transport | 52 |
| | 4.3.5 | Pedestrians and accessibility | 52 |
| 4.4 | Signal timing procedure | | 53 |
| | 4.4.1 | Overview and input data | 53 |
| | 4.4.2 | Intergreen times | 54 |
| | 4.4.3 | Signal phasing | 57 |
| | 4.4.4 | Cycle length and green times | 57 |
| | 4.4.5 | Signal timing plan | 59 |
| | 4.4.6 | Quality check | 59 |
| 4.5 | Example | | 59 |
| | 4.5.1 | Intersection layout and signal groups | 59 |
| | 4.5.2 | Intergreen times | 61 |
| | 4.5.3 | Stage sequence, cycle time, and green split | 61 |
| | 4.5.4 | Signal timing plan | 64 |
| | 4.5.5 | Quality | 64 |
| Bibliography | | | 66 |

# Traffic Signal Standards






**Legal Framework for Traffic Signal Control in Germany**
(Wolfermann et al. 2019, Figure 4.4)

- German Technical Standards for Road Transport, such as RiLSA for Traffic Signals, are edited by the German Road and Transport Research Association (FGSV).
- The Austrian Research Association for Roads, Railways and Transport (FSV) has a similar role, editing RVS 05.04.31 (Deployment Criteria, 1998), RVS 05.04.32 (Planning of Traffic Signals, 1998), and others.


**The German Traffic Signal Control Standard**
(Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Richtlinien für Lichtsignalanlagen RiLSA. Köln 2015)

## Germany and Austria

# Traffic Signal Standards – RiLSA Translations

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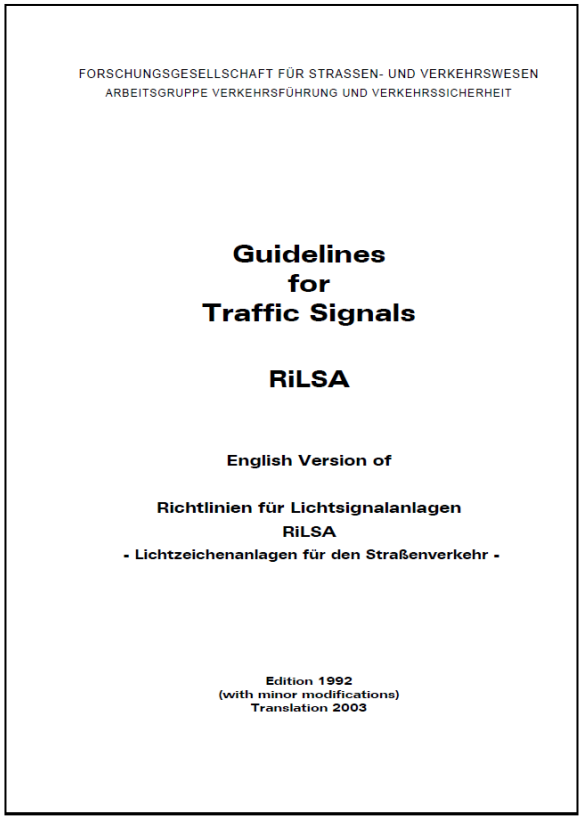
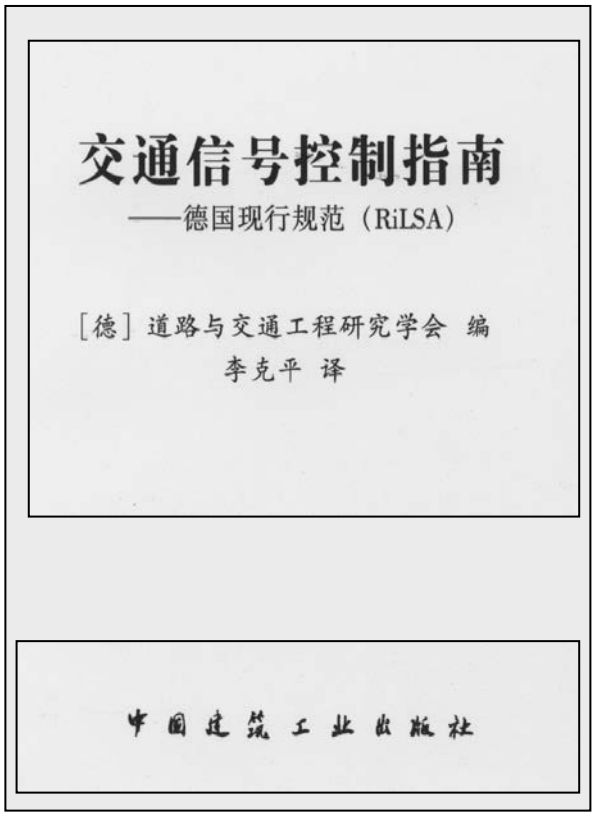



**English 2003**




**Chinese 2005**


**Vietnamese 2007**



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# Important Control Principles

- **Right-hand traffic.**
- **Standard speed limit** within built-up areas: 50 km/h.
- Maximum speed limit at signalized intersections: 70 km/h.
- Typically **three vertically aligned discs** of 200 mm diameter (300 mm at 70 km/h).
- Signals for vehicles located at the **near side of the intersection**.
- Signal heads next to or above the relevant lane. (Each vehicular signal head repeated.)
- Standard vehicular **signal sequence**: RED, RED AND YELLOW, GREEN, YELLOW, RED.
- Austria: FLASHING GREEN of 4 seconds follows each GREEN signal.
- **Arrow signals indicate protected turns.**
- **Group-based control.**

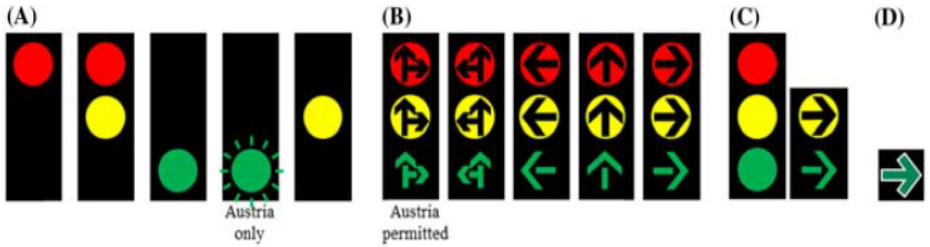


**Figure 4.2** Signal heads. (A) Vehicular signal sequence (in Austria 4 s flashing *green* before *yellow* ). (B) Signal heads with arrow symbols (protected turning; in Austria through/right signal, right movement is permitted). (C) Permitted-protected right turn signals. (D) Static *green* arrow for right-turn on red. (Wolfermann et al. 2019)

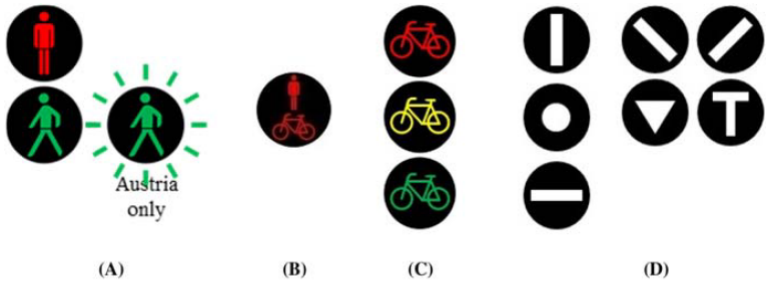


**Figure 4.3** Pedestrian, cyclist, and public transport signal heads. (A) Pedestrian signals; in Austria *green* is also followed by 4 s *green* flashing. (B) Combined pedestrian/cyclist signal. (C) Bicycle signals. (D) Signals for public transport on separate lanes. (Wolfermann et al. 2019)

# Intersection Layout

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- **Intersection geometry** determines intergreen times and may influence saturation flow rates.
- **Compact layout** to increase visibility and to reduce intergreen time.
- **Centre islands for pedestrians** influencing their minimum green times, intergreen times and possible signal groups.
- **Bicycle facilities** and bike signalization.
- Trams and buses may have separate lanes and **special public transport signals**.

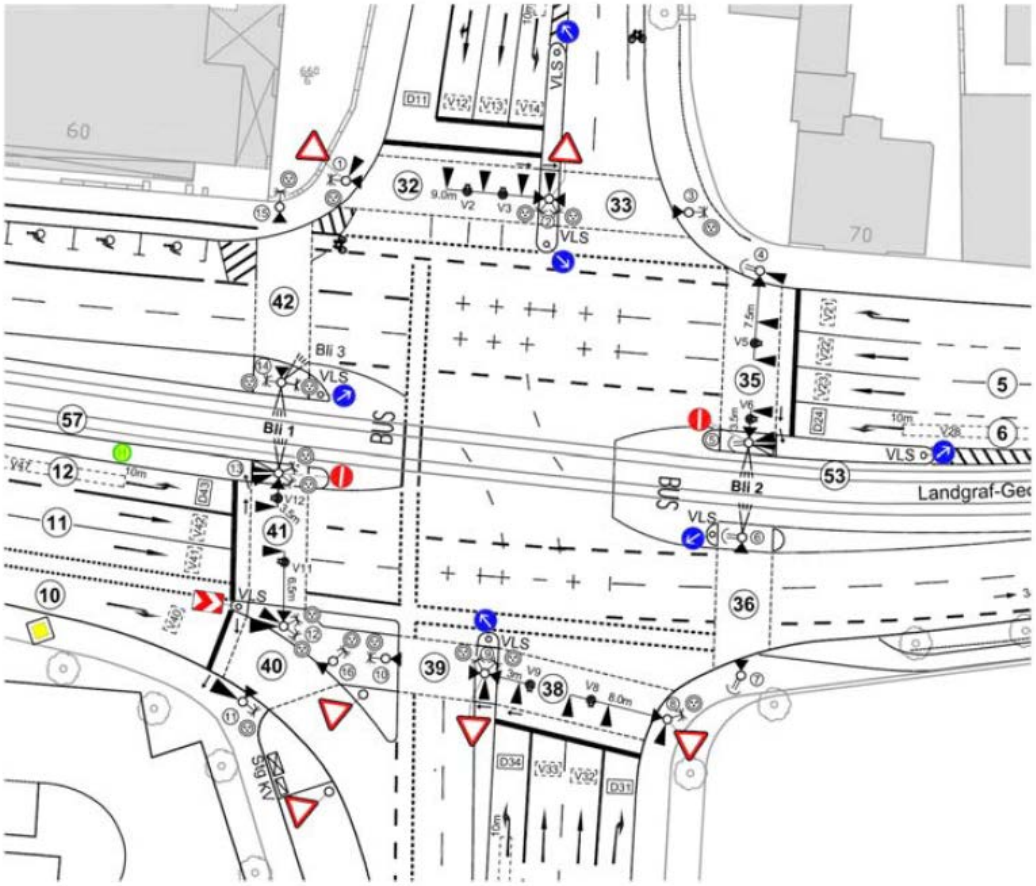


**Figure 4.7** Complex urban intersection with detectors and public transport lanes.
*Source*: Wissenschaftsstadt Darmstadt. (Wolfermann et al. 2019)



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# Saturation Flow Rate

$$s = \frac{3600}{h}$$

$$h = f_{HV} f_1 f_2 1.8\ s$$

$$f_{HV} = \frac{V_{car} + 1.75 V_{LorryBus} + 2.5 V_{TracTrail}}{V_{car} + V_{LorryBus} + V_{TracTrail}}$$

$$f_1 = \max(f_{lw}, f_r, f_g)$$

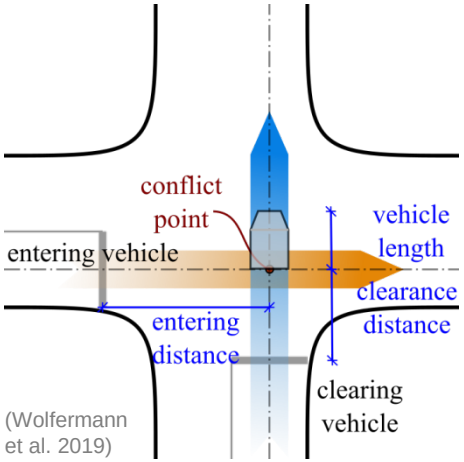
$$f_2 = \min(1, f_g)$$

where $s$ = saturation flow rate (vehicles/h); $h$ = time headway (s/vehicles); $f$ = modification factor ($HV$: heavy vehicles, $lw$: lane width, $r$: turning radius, $g$: approach grade); $V$ = vehicle volume (vehicle/h) (car: light vehicles, Lorry/Bus: heavy vehicles without tractor-trailer; TracTrail: tractor-trailers and similar).

(Wolfermann et al. 2019)

- **Basic headway** of 1,8 s (i.e. 2000 veh/h).
- **Adjusted by factors** for vehicle mix, turning radius (if r<20m), lane width (if w<3,0m) and grade (if >2% or <-2%).
- If more than one factor (lane width, radius, grade) is applicable, only the maximum factor is applied.
- The German Highway Capacity Manual HBS (FGSV 2015) provides linear diagrams to determine these factors.

# Intergreen Times




(Wolfermann et al. 2019)

$$t_{ig} = t_{cr} + t_{cl} - t_e$$

$$t_{cl} = \frac{l_{veh} + l_{cl}}{v_{cl}} \qquad t_e = \frac{l_e}{v_e}$$

$t_{ig}$ = intergreen time (s)
$t_{cr}$ = crossing time (s)
$t_{cl}$ / $t_e$ = clearance / entering time (s)
$l_{cl}$ / $l_e$ = clearance / entering distance (m)
$v_{cl}$ / $v_e$ = clearance / entering speed (m/s)
$l_{veh}$ = vehicle length (m)

- **Definition of Intergreen time:** The time between the end of GREEN for one traffic stream and the beginning of GREEN for another traffic stream which is not compatible with the first stream.
- **Detailed analysis** of conflicts during stage transition.

**Table 5.2 Intergreen matrix for example intersection**

| Clearing signal groups \ Entering signal groups | K1 | K2 | K3 | K4 | K5 | K6 | K7 | K8 | F1 | F2 | F3 | F4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| K1 | | - | 3 | 4 | - | 6 | 5 | 4 | 4 | - | - | 8 |
| K2 | - | | 5 | 5 | 5 | - | 4 | 3 | 5 | - | 7 | - |
| K3 | 6 | 4 | | - | 4 | 6 | - | 7 | 8 | 4 | - | - |
| K4 | 5 | 4 | - | | 5 | 7 | 4 | - | - | 5 | - | 8 |
| K5 | - | 7 | 5 | 4 | | - | 3 | 4 | - | 8 | 4 | - |
| K6 | 5 | - | 4 | 3 | - | | 5 | 6 | 7 | - | 5 | - |
| K7 | 4 | 6 | - | 7 | 6 | 4 | | - | - | - | 8 | 4 |
| K8 | 5 | 8 | 4 | - | 5 | 4 | - | | - | 8 | - | 5 |
| F1 | 18 | 18 | 15 | - | - | 15 | - | - | | - | - | - |
| F2 | - | - | 13 | 13 | 10 | - | - | 10 | - | | - | - |
| F3 | - | 15 | - | - | 18 | 18 | 15 | - | - | - | | - |
| F4 | 10 | - | - | 10 | - | - | 13 | 13 | - | - | - | |

(Wolfermann et al. 2019)

**Table 4.1** Parameters for intergreen calculations according to RiLSA (FGSV, 2015)

| Clearing movement | Crossing time | Vehicle length | Clearance speed |
|---|---|---|---|
| Through car | 3 s | 6 m | 10 m/s |
| Turning car | 2 s | 6 m | 5 or 7 m/s (depending on radius) |
| Public transport (without stopping) | 3 or 5 or 7 s (depending on $v_{max}$) | 15 m (tram) | $v_{max}$ (in m/s) |
| Public transport (with stop in front of intersection) | 0 s | 15 m (tram) | Accelerated movement |
| Bike | 1 s | 0 m | 4 m/s |
| Pedestrian | 0 s | 0 m | 1–1.5 m/s |

(Wolfermann et al. 2019)

# Signal Phasing

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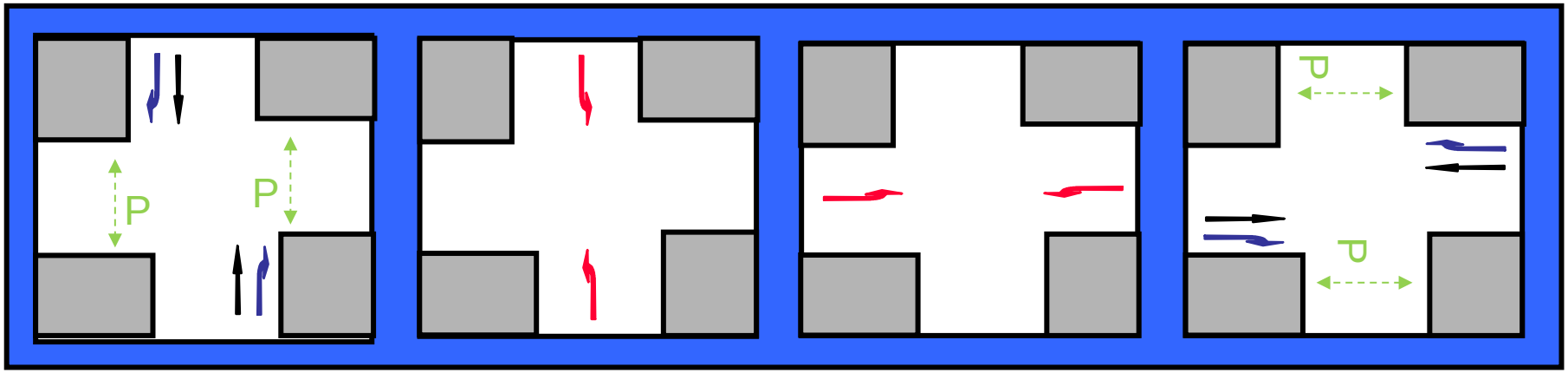
- **Group-based control.**
- Movements belonging to different signal groups must have a separate lane.
- The combination of signal groups to stages is based on minimum critical traffic demand (sum of flow ratios).
- **Stage sequence** is influenced by the sum of intergreen times (to reduce cycle time).
- **Many specific regulations.** Example: If pedestrians receive GREEN in the same stage as permitted turning vehicles, they have to receive a head start in a way that the first pedestrian enters the street before the first entering vehicle arrives at the pedestrian crossing.




**Typical four-stage program with protected left-turns as separate stages**



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# Cycle Time and GREEN Times

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- Cycle time is calculated **based on motorized vehicle demand** (equation below).
- With respect to delay for non-motorized traffic, **cycle time is limited to 30 – 90 s**, as an exception, up to 120 s may be applied.
- Delay for pedestrians and cyclists should not exceed 85 s, also due to acceptance.
- **Minimum GREEN time is 5 s.**
- In addition, minimum GREEN time for pedestrians must ensure that they can cross at least half of the carriageway during GREEN (standard pedestrian speed: 1,2 m/s).
- Many specific regulations exist to consider the **needs of impaired people**.

$$C = \frac{\sum_i t_{ig,i} + \sum_j t_{g,\min,j}}{1 - \sum_k \frac{q_k}{s_k}} = \frac{\sum_i t_{ig,i} + \sum_j t_{g,\min,j}}{1 - \sum_k b_k}$$

where $C$ = cycle time (s); $q_k$ = relevant vehicle demand (vehicles/h) of stage $k$; $t_{ig}$ = intergreen time (s); $s_k$ = relevant saturation flow rate (vehicles/h) of stage $k$; $t_{g,\min}$ = green times independent of cycle time (s); $b_k$ = maximum flow rate of stage $k$.

(Wolfermann et al. 2019)

# Quality Criteria and Quality Management

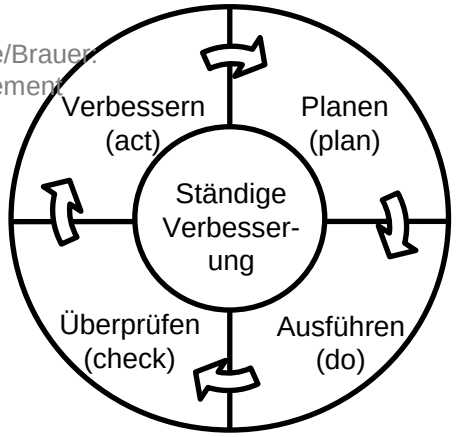
**Quality check** according th the German Highway Capacity Manual HBS (FGSV 2015):

- average delay for motor vehicles
- maximum waiting times of pedestrians and cyclists
- Delay for public transport, if applicable
- Queue length, if relevant for adjacent intersections of other facilities (e.g. railway crossings)
- Coordination with adjacent intersections, if applicable (performance index)

Calculation of average vehicle delay considers **effective GREEN time** (signaled GREEN time plus 1 s).

RiLSA: Separate chapter on **Quality Management** for traffic signals during planning, implementation and operation (since 2010 edition).

**PDCA-Cycle**
Source: Kamiske/Brauer: Qualitätsmanagement von A bis Z. München/Wien, 2006




| LOS | Motorized Vehicles<br>Average Delay [s] | Public Transport (on separate lanes) Average Delay [s] | Pedestrians and Cyclists Maximum Delay [s] |
|---|---|---|---|
| A | ≤ 20 | ≤ 5 | ≤ 30 |
| B | ≤ 35 | ≤ 15 | ≤ 40 |
| C | ≤ 50 | ≤ 25 | ≤ 55 |
| D | ≤ 70 | ≤ 40 | ≤ 70 |
| E | > 70 | ≤ 60 | ≤ 85 |
| F | -[3)] | > 60 | > 85[4)] |

**LOS Definitions for Different Road User Groups**
Source: German Highway Capacity Manual HBS (FGSV 2015)

# Conclusions

- Quite high standard of road traffic signal control.
- Detailed guidelines.
- Mostly similar regulations in Germany and Austria with only a few major differences (e.g. flashing GREEN).
- Group-based control with very detailed calculation of intergreen times.
- Strict limitation of cycle time to a maximum of 90 s (in exceptional situations 120 s).
- Comprehensive consideration of pedestrians, cyclists, and public transport.
- Evaluation of traffic signal control programs mostly based on delay.
- A broader consideration of other criteria is desirable, but not covered by guidelines, so far.

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