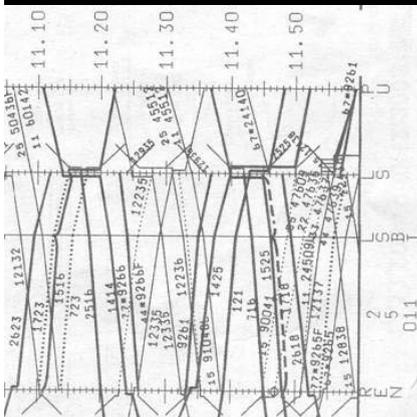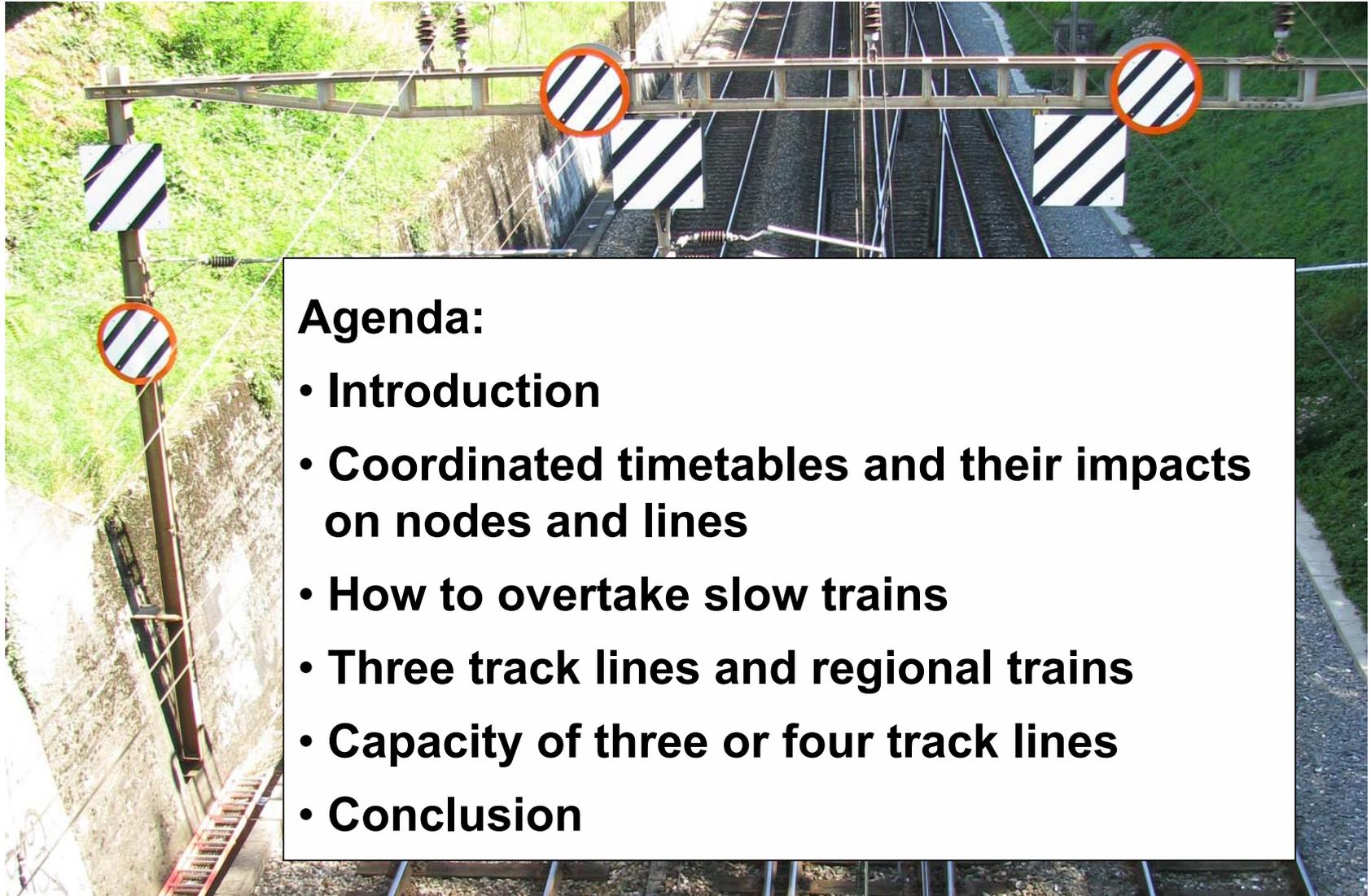# *Two, three, four tracks*
for railway busy lines

Agenda:

- **Introduction**

- **Coordinated timetables and their impacts on nodes and lines**

- **How to overtake slow trains**

- **Three track lines and regional trains**

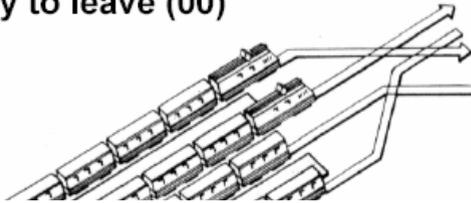- **Capacity of three or four track lines**

- **Conclusion**

Coordinated clockface timetables:
a subcategory of clockface timetables

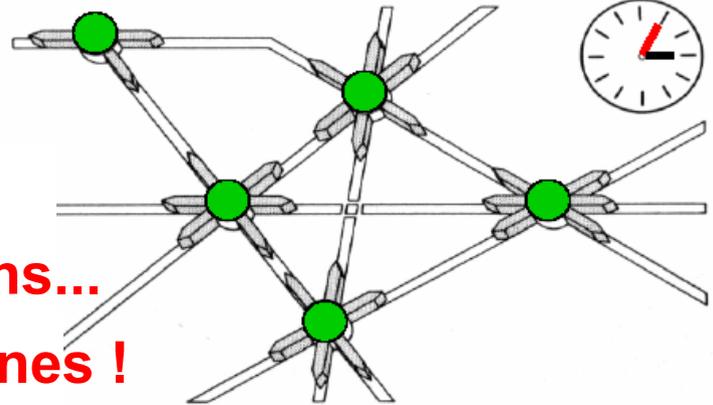| one or many categories of trains ...have regular time intervals on ...		
... one line	... a **sub-network or network** with ...	
	... more than one symmetry axis	... **one symmetry axis** and **trend to realise connecting nodes**
Clockface timetables		**Coordinated** clockface timetables

Trains ready to leave (00)

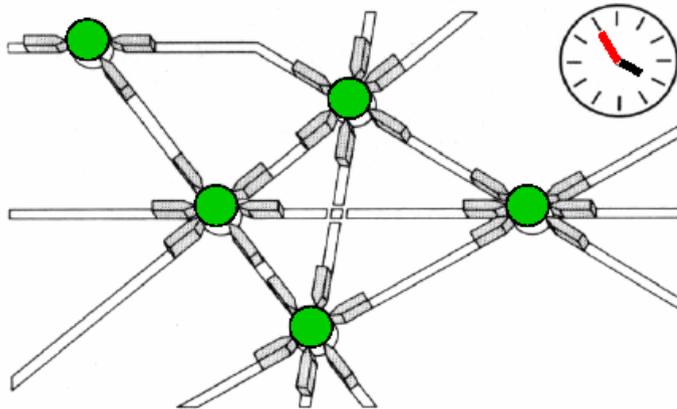**Departure from interchange stations (05)**

High concentration of trains
at specific moments in stations...

... but no information about lines !

Arrival at interchange stations (55)

Trains ready to leave (00)

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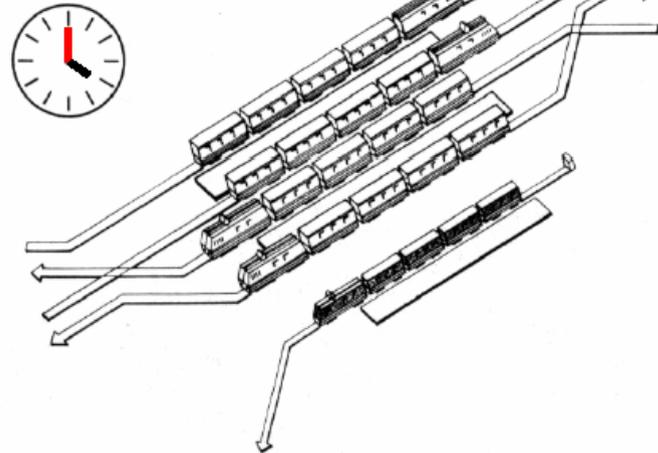
Trains ready to leave (00)
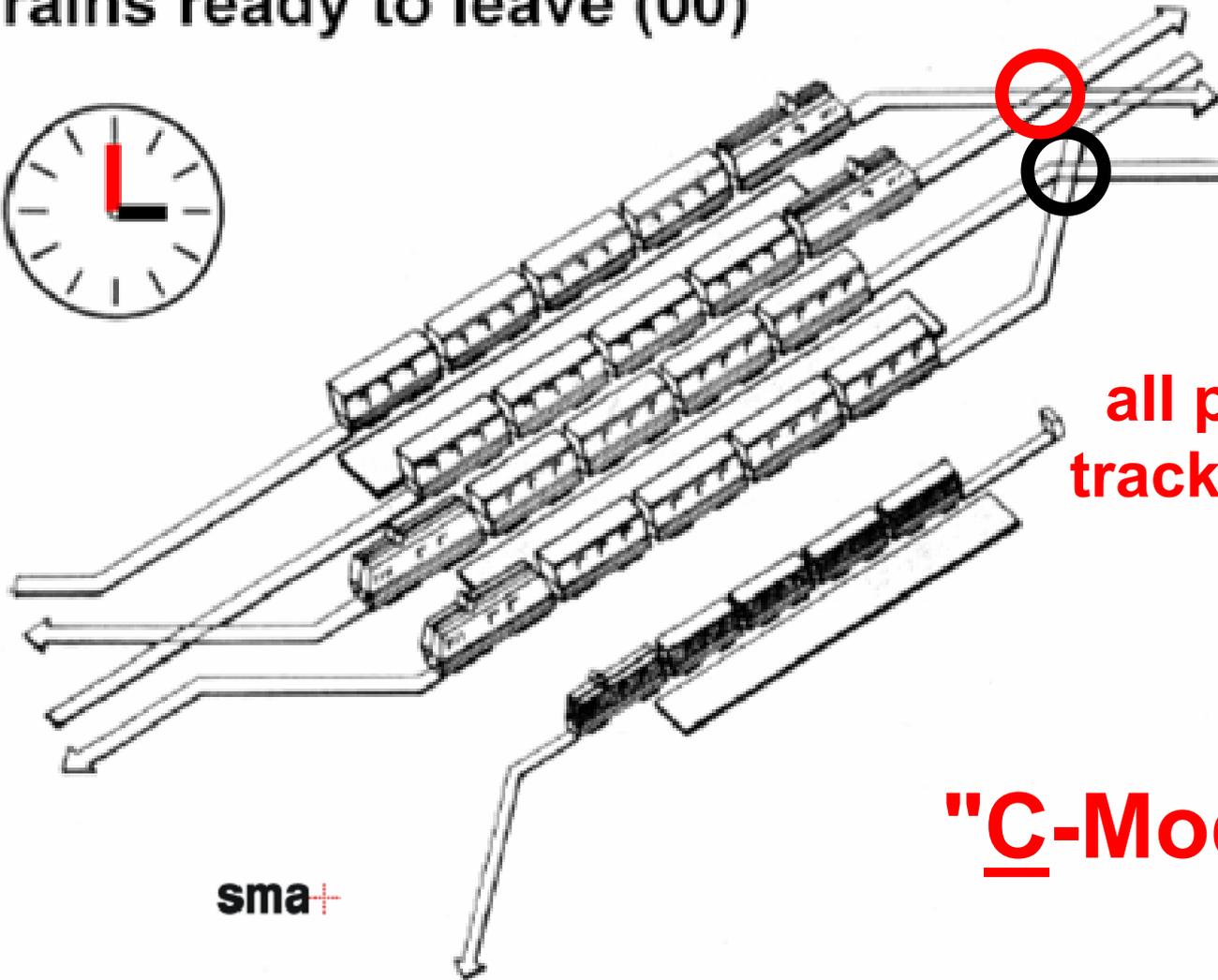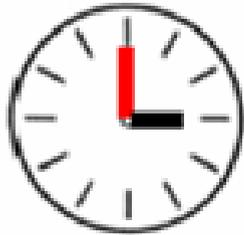
all plateform
track occupied

"C-Model"

sma

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6-7 Long Distance trains
TGV, **2*IC, ICN, 2*IR et RE**

Reservation/Occupation Lausanne 07'
Tuesday 7h-8h - 8 plateform tracks
4-6 Regio trains
2*RE
4*RER
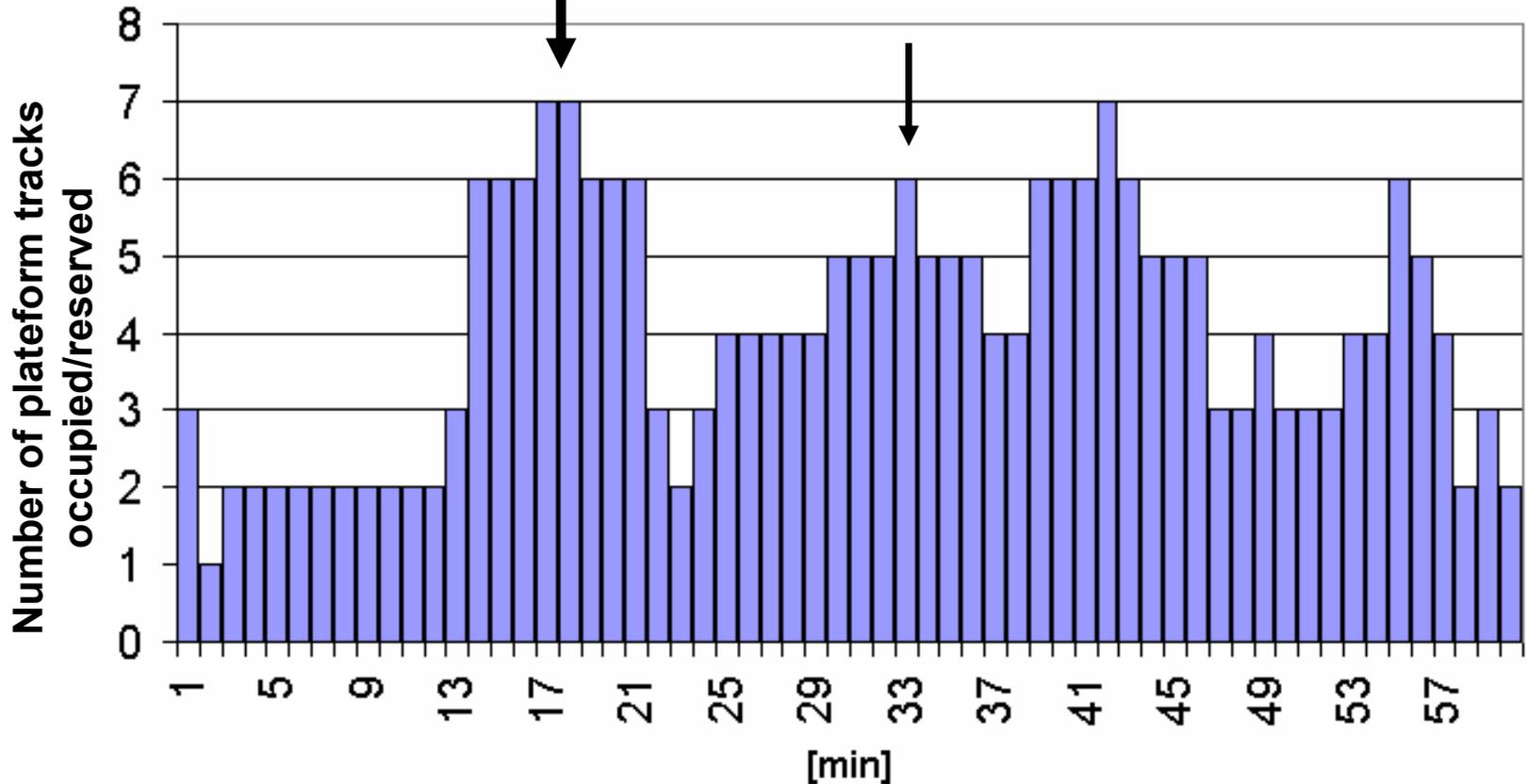
The "half interval shift"

2 advantages:
* *Stop & Go for diametrical lines*
* *time distribution*

1 disadvantage:
* *connection times*

"S-Model"
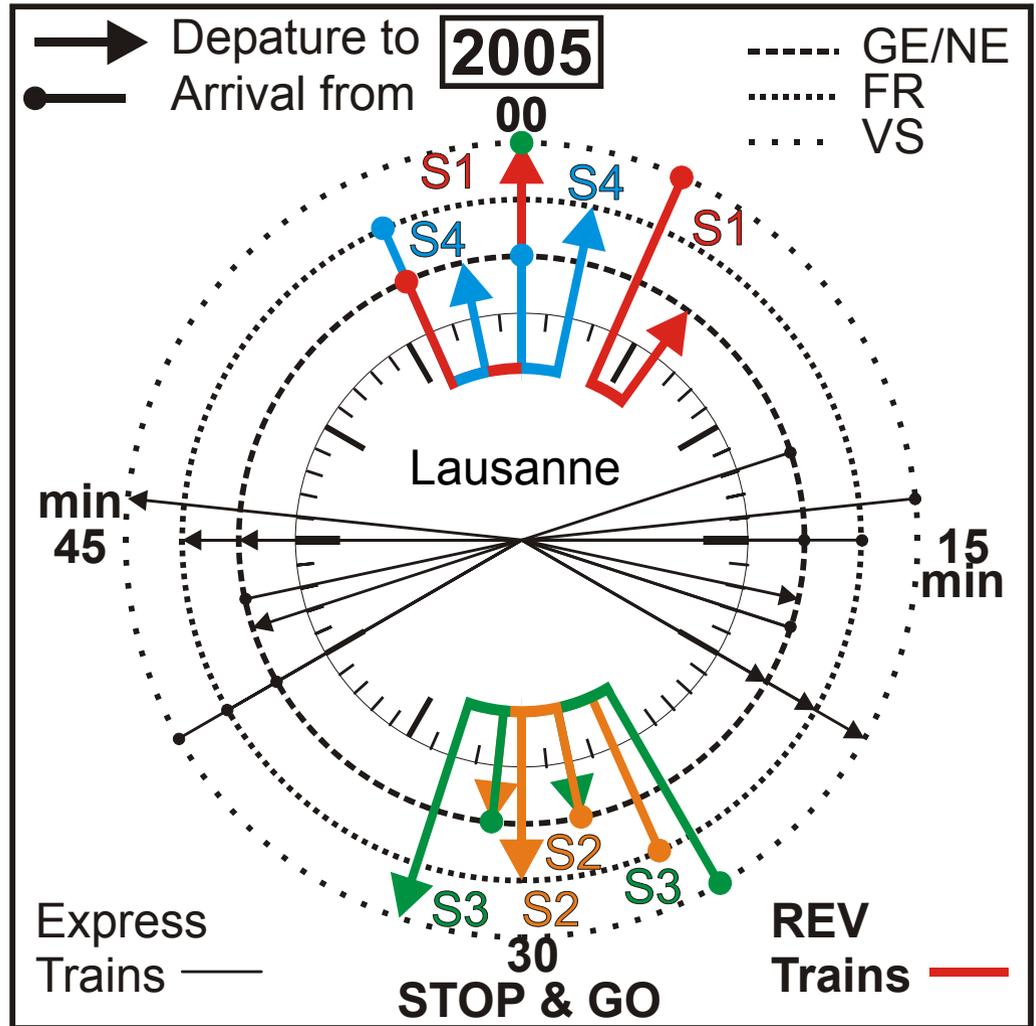
Impacts on nodes

Two, three, four tracks for railway busy lines

"C-Model" "S-Model"

major nodes (> ~8 platform tracks)

no connection

optimal connection

good connection

so-so connection

bad/no connection

small nodes (< ~5 platform tracks)

connection on the same plateform

connection time [min]

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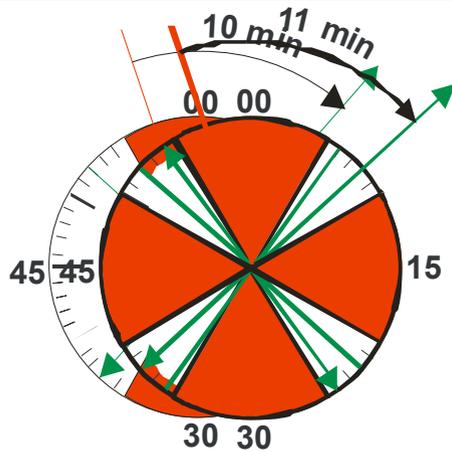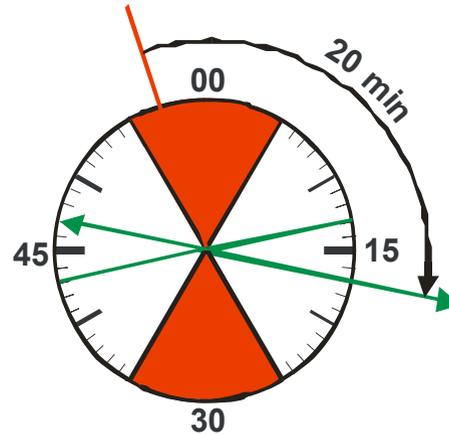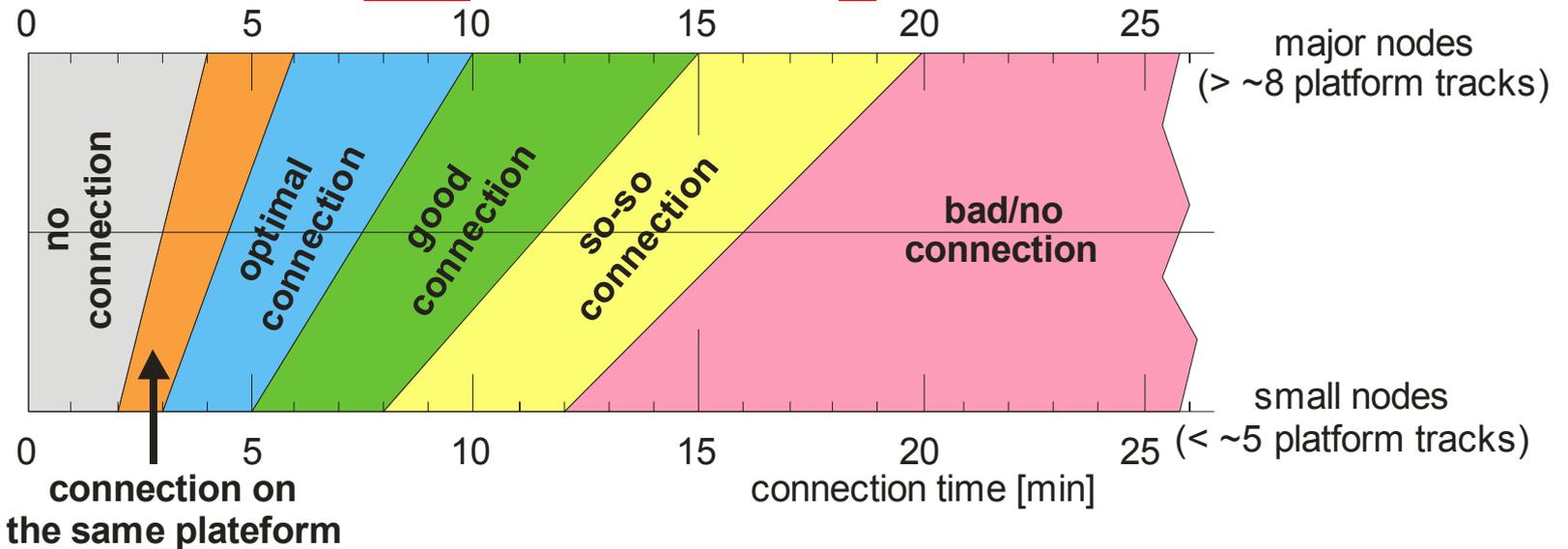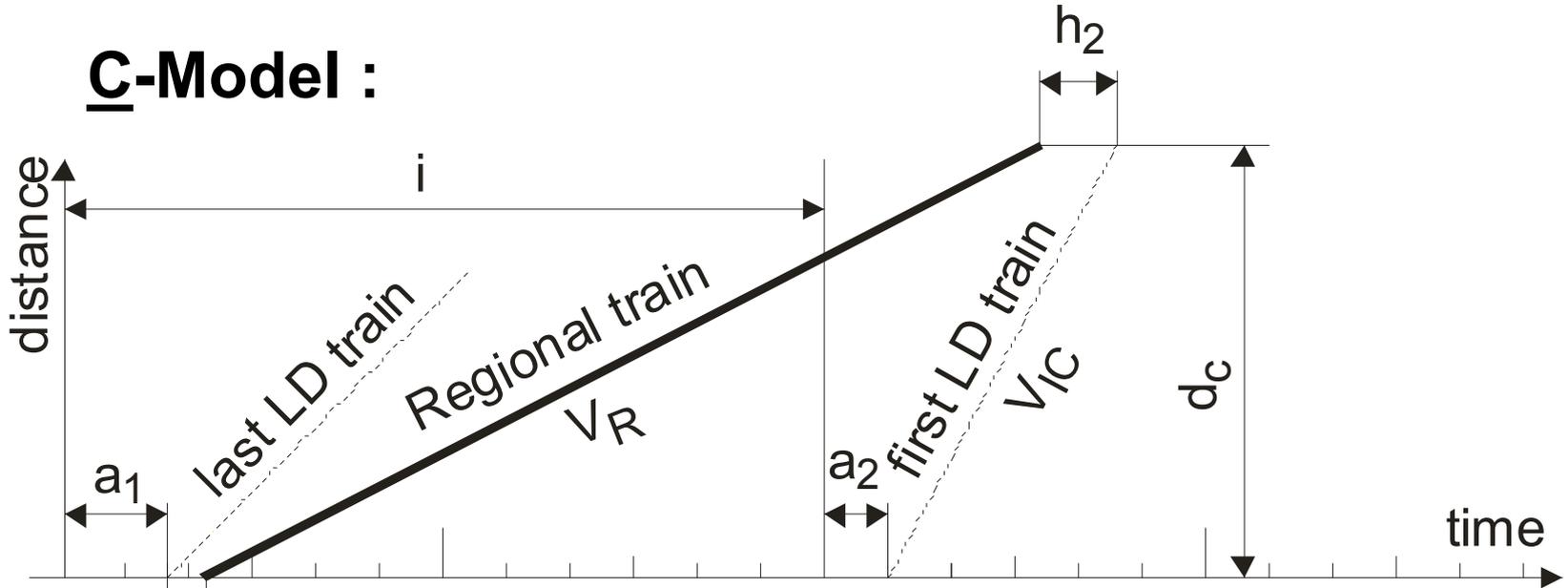
<u>C</u>-Model :

$$d_c = \frac{V_{IC} \cdot V_R}{V_{IC} - V_R} \cdot \frac{i - h_1 - h_2 - a_1 + a_2}{60}$$

with d_c in km, a_1, a_2, h_1, h_2 & i in min, V_R & V_{IC} in km/h

d_c = 95 km pour <u>i=60</u>, V_R=55 et V_{IC}=110, a_1=5, a_2=2, h_1=2, h_2=3

<u>S</u>-Model :
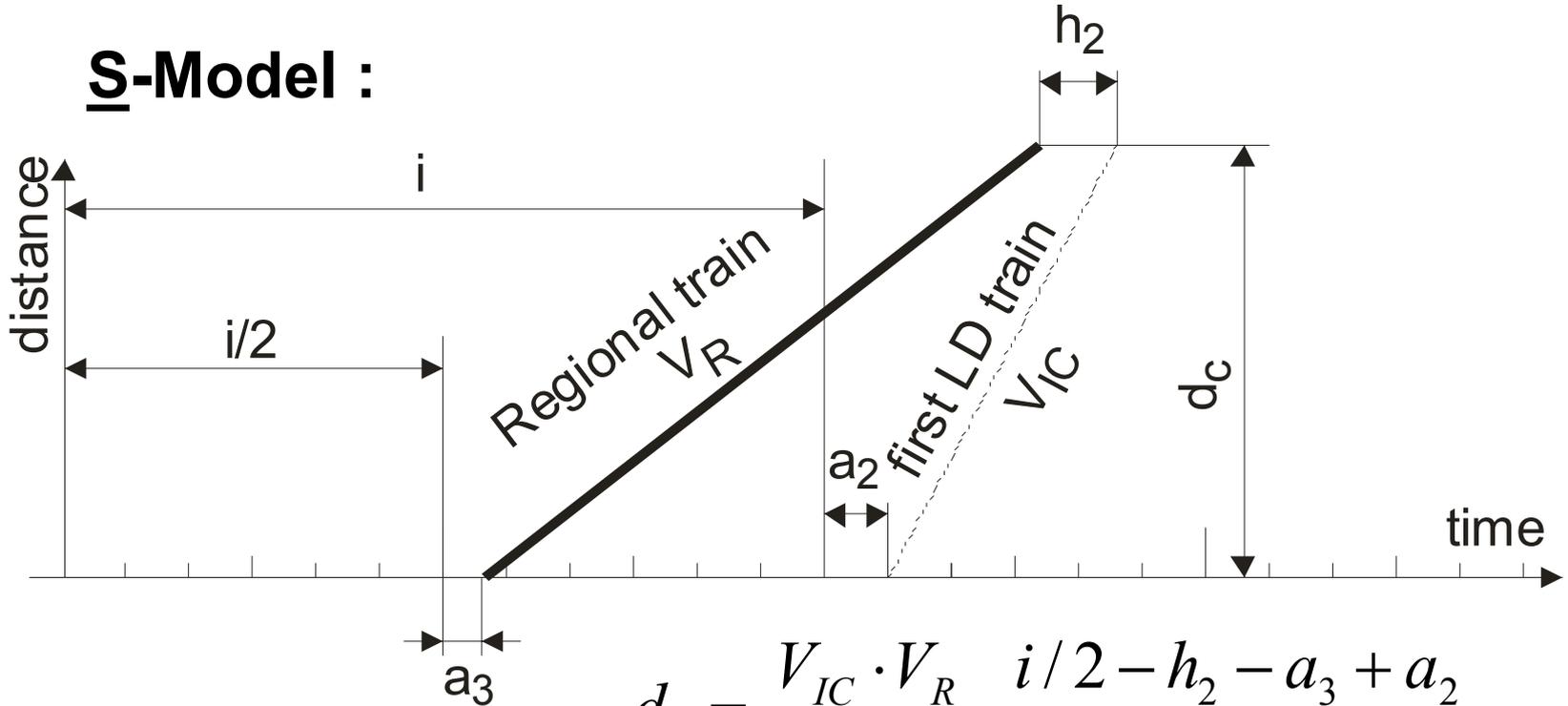
$$d_c = \frac{V_{IC} \cdot V_R}{V_{IC} - V_R} \cdot \frac{i/2 - h_2 - a_3 + a_2}{60}$$

with d_c in km, a_1, a_2, h_1, h_2 & i in min, V_R & V_{IC} in km/h

d_c = <u>22</u> km pour <u>i=30</u>, V_R=55 et V_{IC}=110, a_2=2, a_3=2, h_2=3

Distance

Passive overtaking

t_d

C

l_2

h_1

B

h_2

A

R-Train

LD-Train

time

Best case:

$$t_{lost} = h_1 + h_2 - t_d$$

Worst case:

$$t_{lost} = h_1 + h_2 + 60 \cdot \frac{V_{LDm} - V_{Rm}}{V_{LDm} \cdot V_{Rm}} l_2$$

Average:
(with h_1=3 min,
h_2=2 min,
t_d=0,5 min,
l_2=4 km,
V_{Rm}=70 km/h
V_{LDm}=120 km/h)

**5½ min lost
for R-train**

Active overtaking using one interstation
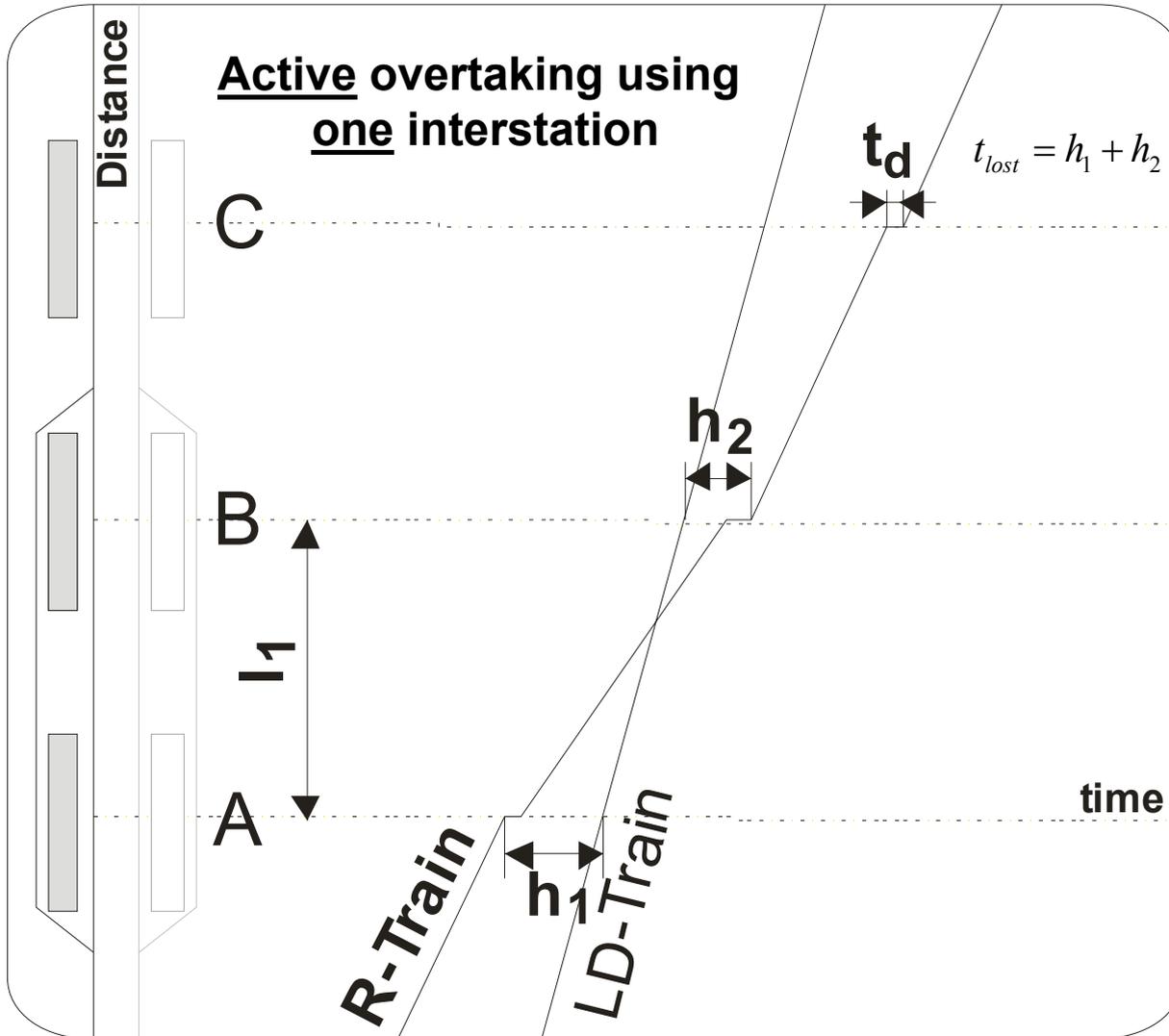
Best case:

$$t_{lost} = h_1 + h_2 - 2 \cdot t_d - 60 \cdot \frac{V_{LDm} - V_{Rm}}{V_{LDm} \cdot V_{Rm}} l_1$$

Worst case:

$$t_{lost} = h_1 + h_2 - t_d$$

Average:
(with h_1=3 min,
h_2=2 min,
t_d=0,5 min,
l_1=4 km,
V_{Rm}=70 km/h,
V_{LDm}=120 km/h)

3½ min lost for R-train

Active overtaking using two interstations

C

B

A

$l_1 + l_2$

$\geq h_2$

t_d

h_1

R-Train

LD-Train

time
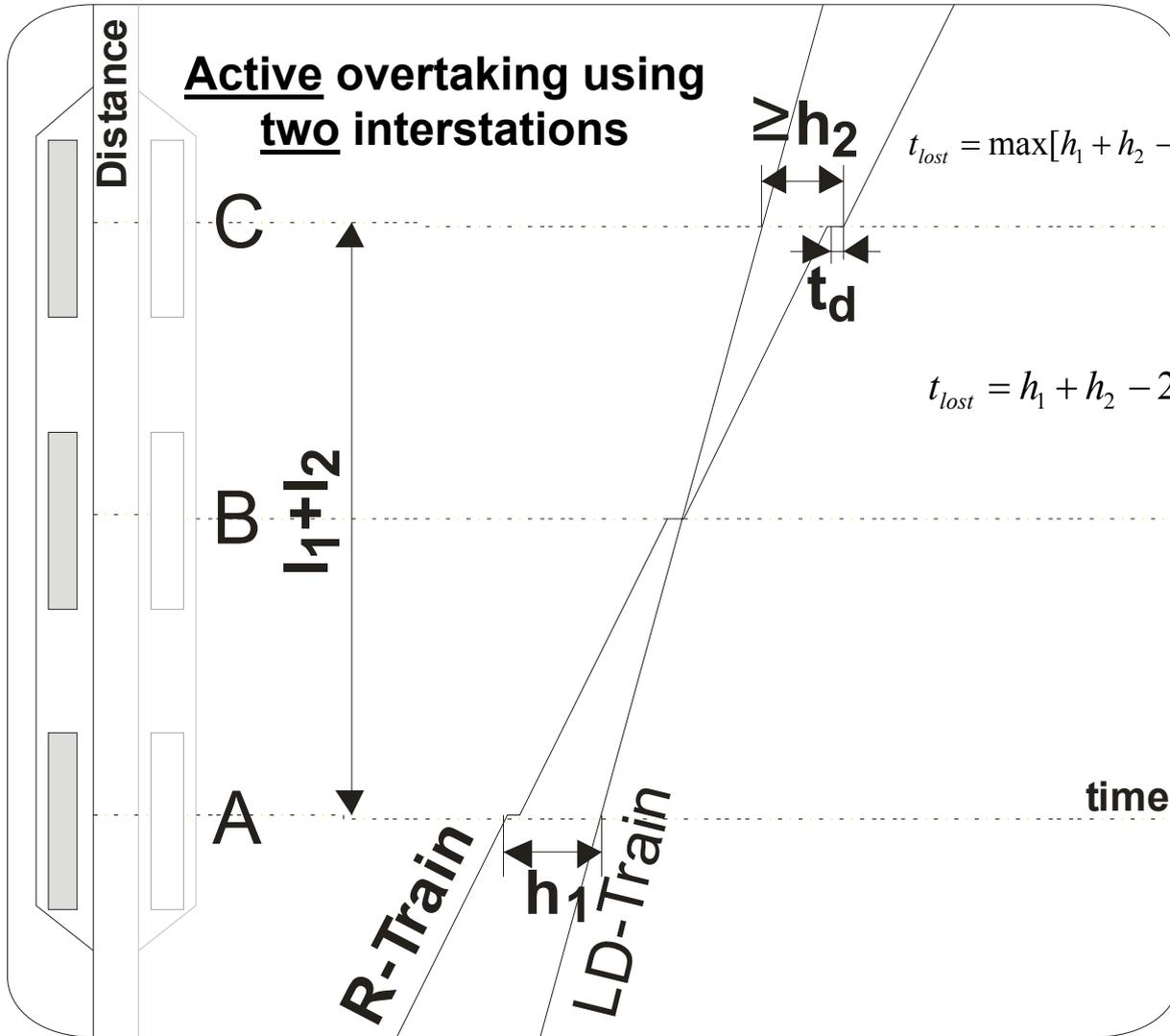
Best case:

$$t_{lost} = \max[h_1 + h_2 - 3 \cdot t_d - 60 \cdot \frac{V_{LDm} - V_{Rm}}{V_{LDm} \cdot V_{Rm}}(l_1 + l_2); 0]$$

Worst case:

$$t_{lost} = h_1 + h_2 - 2 \cdot t_d - 60 \cdot \frac{V_{LDm} - V_{Rm}}{V_{LDm} \cdot V_{Rm}} l_2$$

Average
(with h_1=3 min,
h_2=2 min,
t_d=0,5 min,
l_1, l_2= 4 km,
V_{Rm}=70 km/h
V_{LDm}=120 km/h)

1½ min lost for R-train
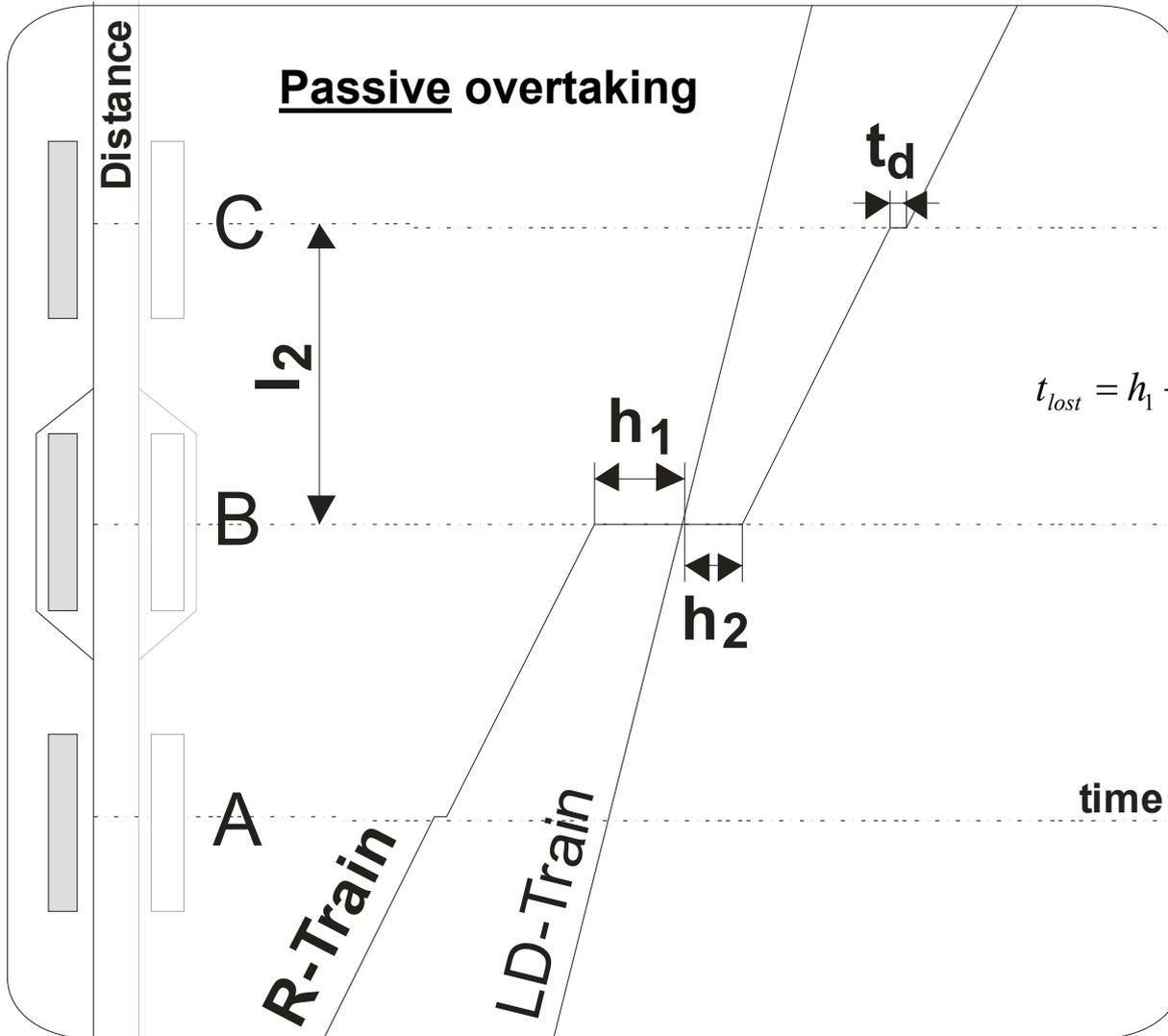
Distance

<u>S</u>-Model : IC + IR

$$d_{c\_IR} = \frac{V_{IR} \cdot V_R}{V_{IR} - V_R} \cdot \frac{i/2 - h_2 - a_3 + a_2 + h_3}{60}$$

with d_{c_IR} in km, a_1, a_2, h_1, h_2 & i in min, V_R & V_{IC} & km/h

d_{c_IR} = <u>35 km</u> pour <u>i=30</u>, V_R=55 et V_{IR}=90, a_2=2, a_3=2 , h_2=3 , h_3=3

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<u>S</u>-Model
30 minute intervals:
50 km line:

4-track sections

IC + R   :   8.5 km 4-tracks after 22 km:
**   (2.35 track equivalent)**

IC + IR + R :   8.5 km 4-tracks after 22
**   and after 35 km:**
**   (2.7 track equivalent)**

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30 min intervals : semi-flexible (3.03 tracks)

flexible   rigid   flexible

A   B   C   D   E   F   G   H   I   J   K

15 min intervals : rigid (3.1 tracks)

semi-flexible   rigid   semi-flexible   rigid   semi-flexible   rigid   semi-flexible   rigid   semi-flexible

A   B   C   D   E   F   G   H   I   J   K

15 min intervals : semi-flexible (3.25 tracks)

flexible   rigid   flexible

A   B   C   D   E   F   G   H   I   J   K

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Length of the line: 50 km

3-track line (about <u>10 passenger trains</u> per hour and direction):
- 30-min intervals on fast tracks: 2 IC, 2 IR, 2 M80, 2 RE
- 15-min intervals on the slow track: 4 R

3-track line (about <u>12 passenger trains</u> per hour and direction):
- 15-min intervals on fast tracks: 4 IC, 4 M120, 4 IR
  (without RE)
- 15-min intervals on the slow track: 4 R

4-track line (about <u>16 passenger trains</u> per hour and direction):
- 15-min intervals on fast tracks: 4 IC, 4 IR, 4 M120
- 15-min intervals on slow tracks: 4 RE, 4 M80, 4 R

Conclusions:

- **R-trains find no more place on double track, as soon as LD-train intervals are as low as 30 minutes and the S-model is used one main station**

- **3-track lines offer often no solution for RE trains when 15-minute intervals for IC and IR trains are planned**

- **4-track lines allow to keep the present categories of passenger and freight trains even if 15-minute intervals are planned**

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Thank you for your attention

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