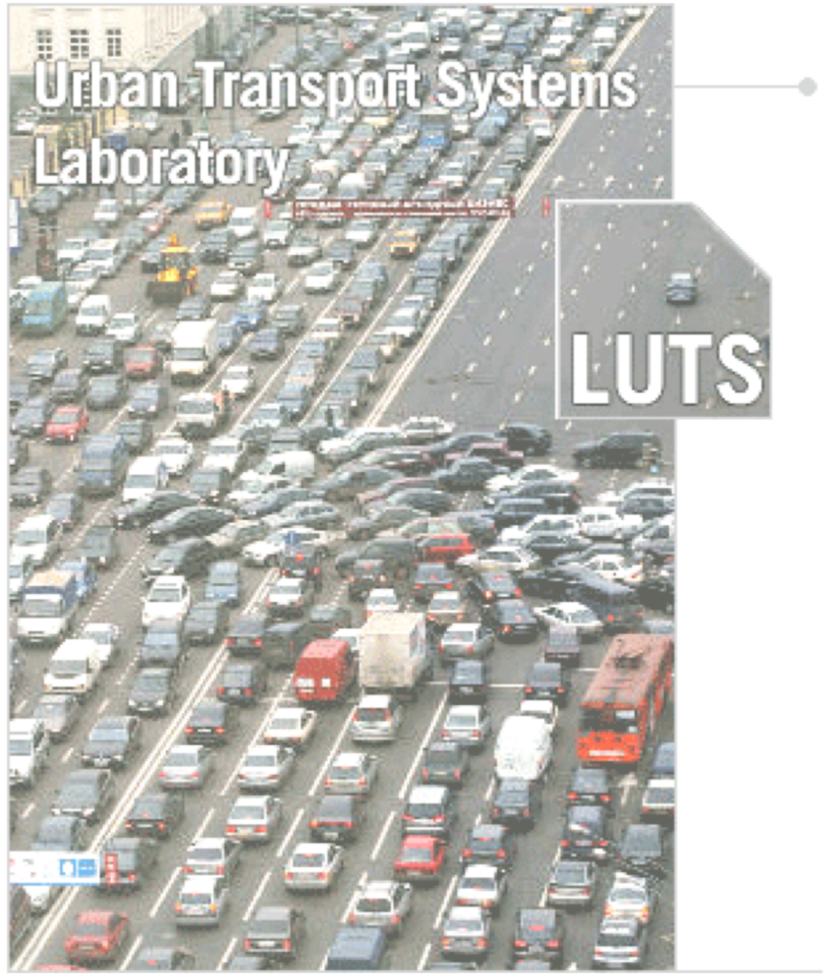
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



Input – Output Diagrams

Intro to traffic flow modeling and ITS

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Welcome

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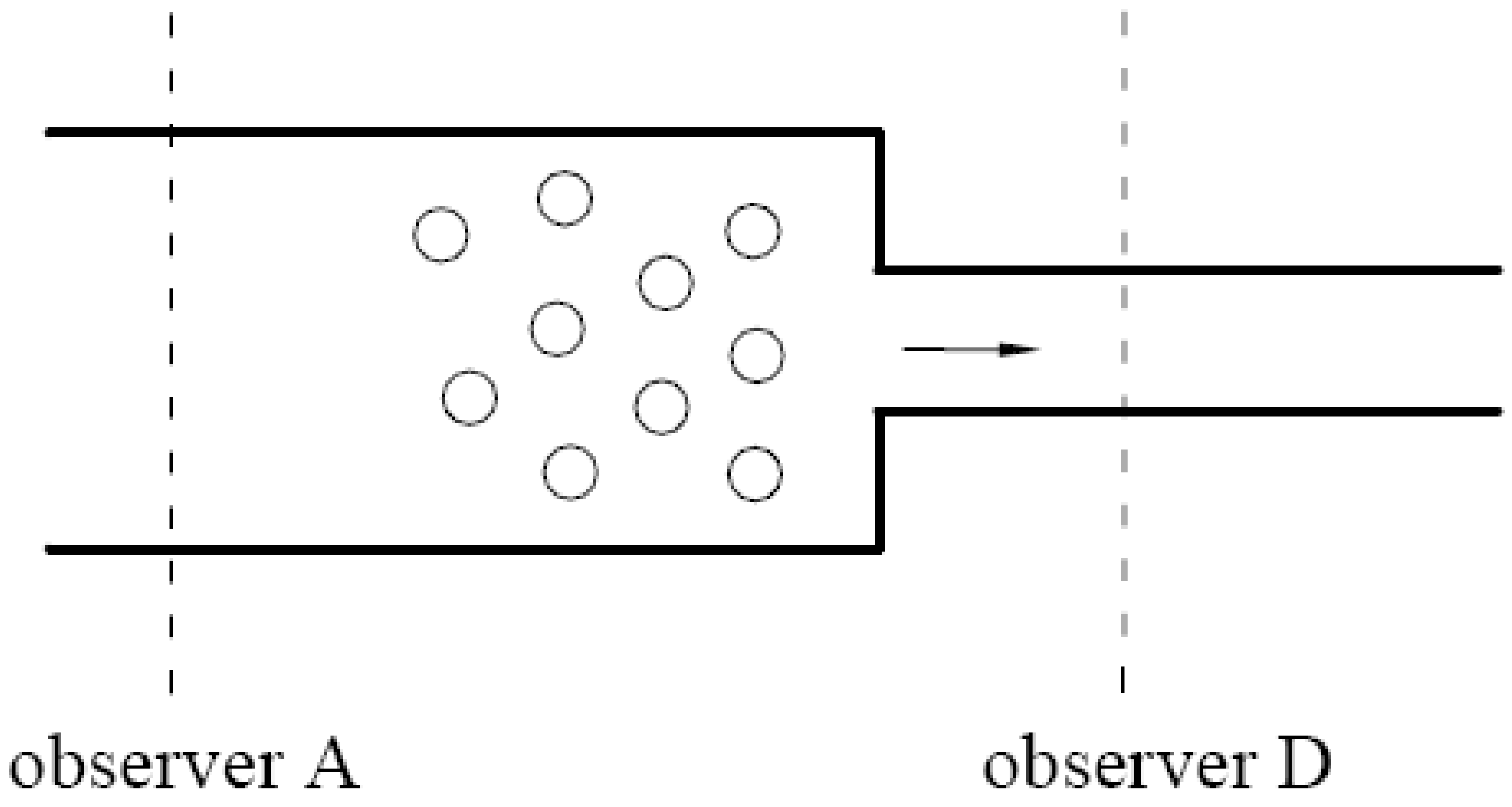
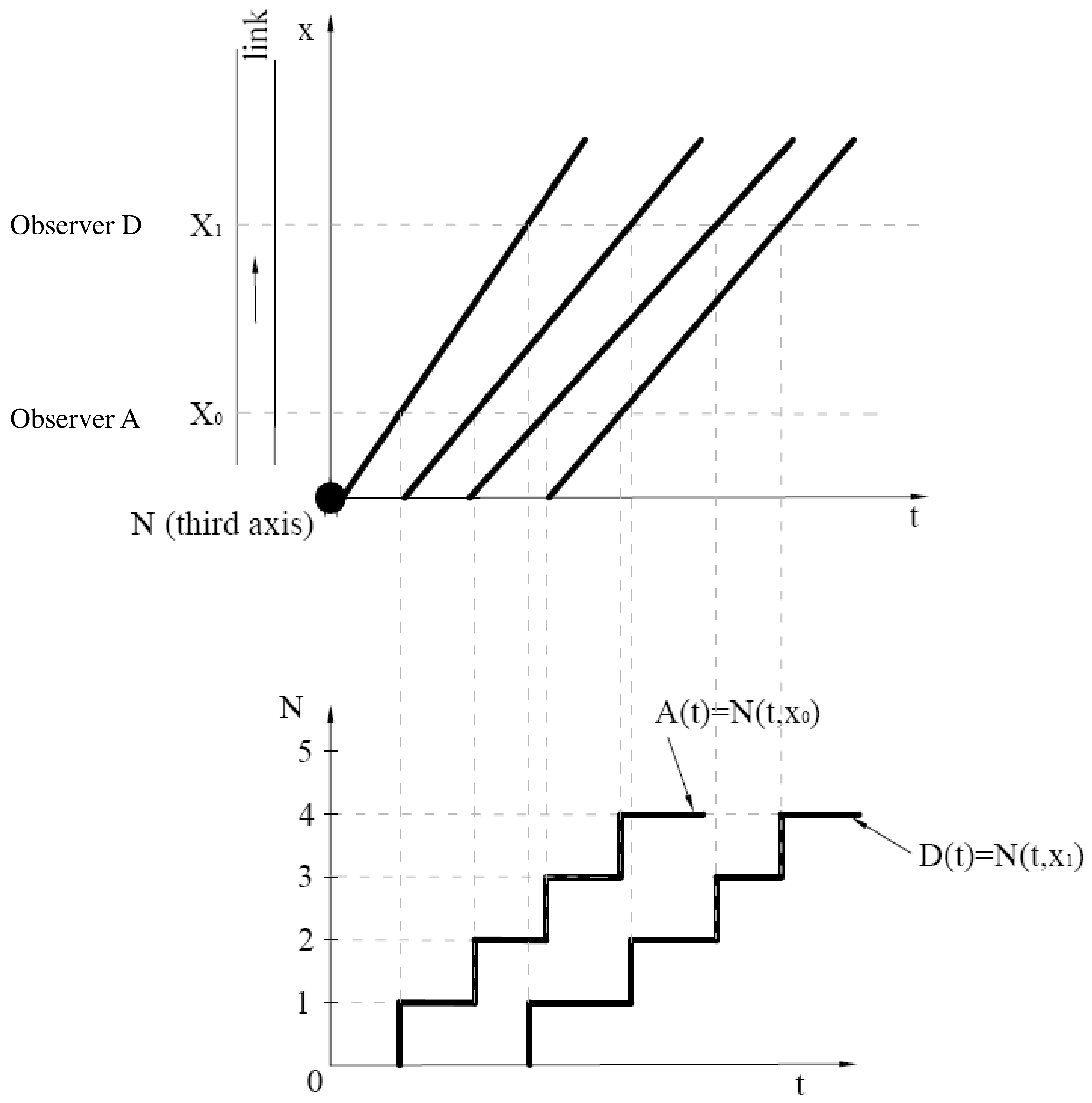
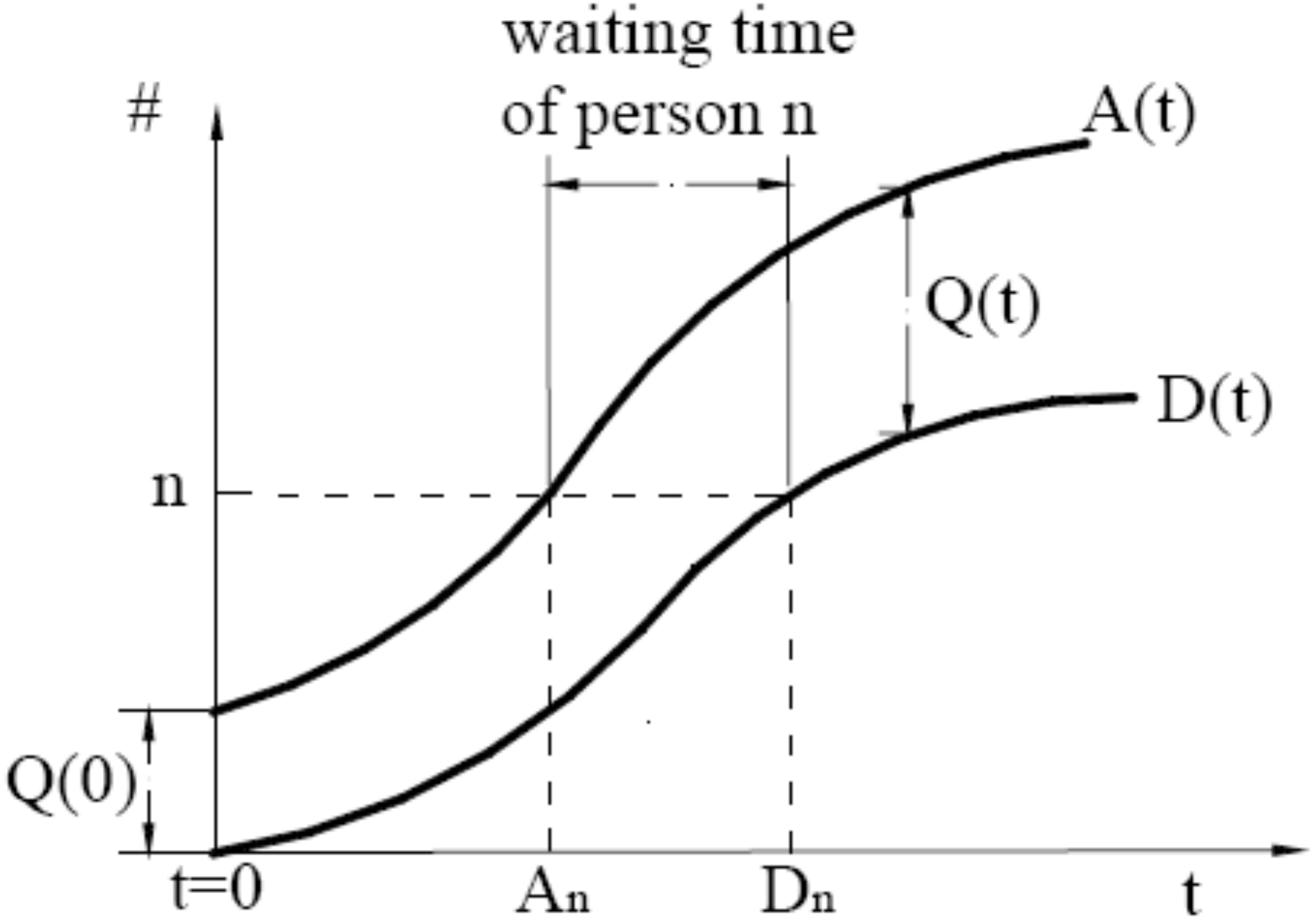
A queueing system



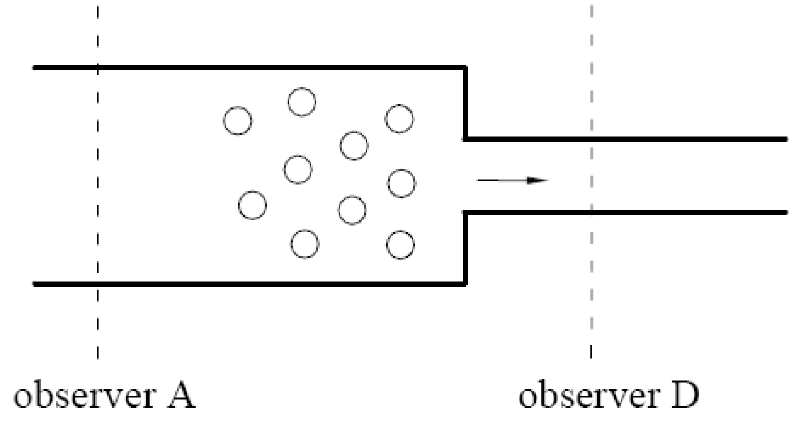
Cumulative curves vs. Time-Space



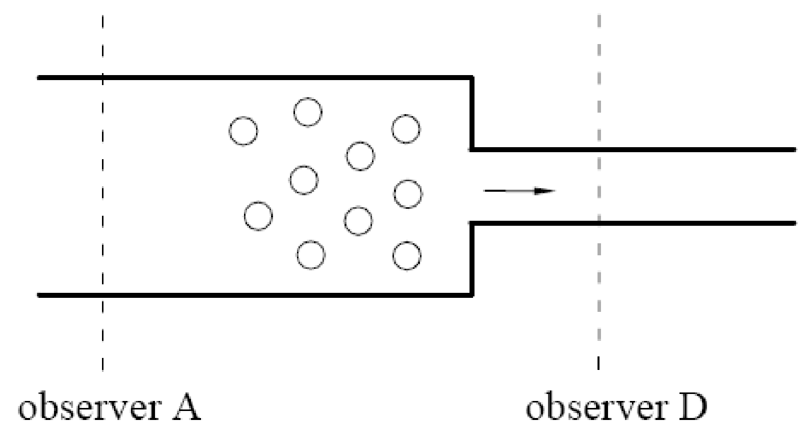
Input-Output Diagrams

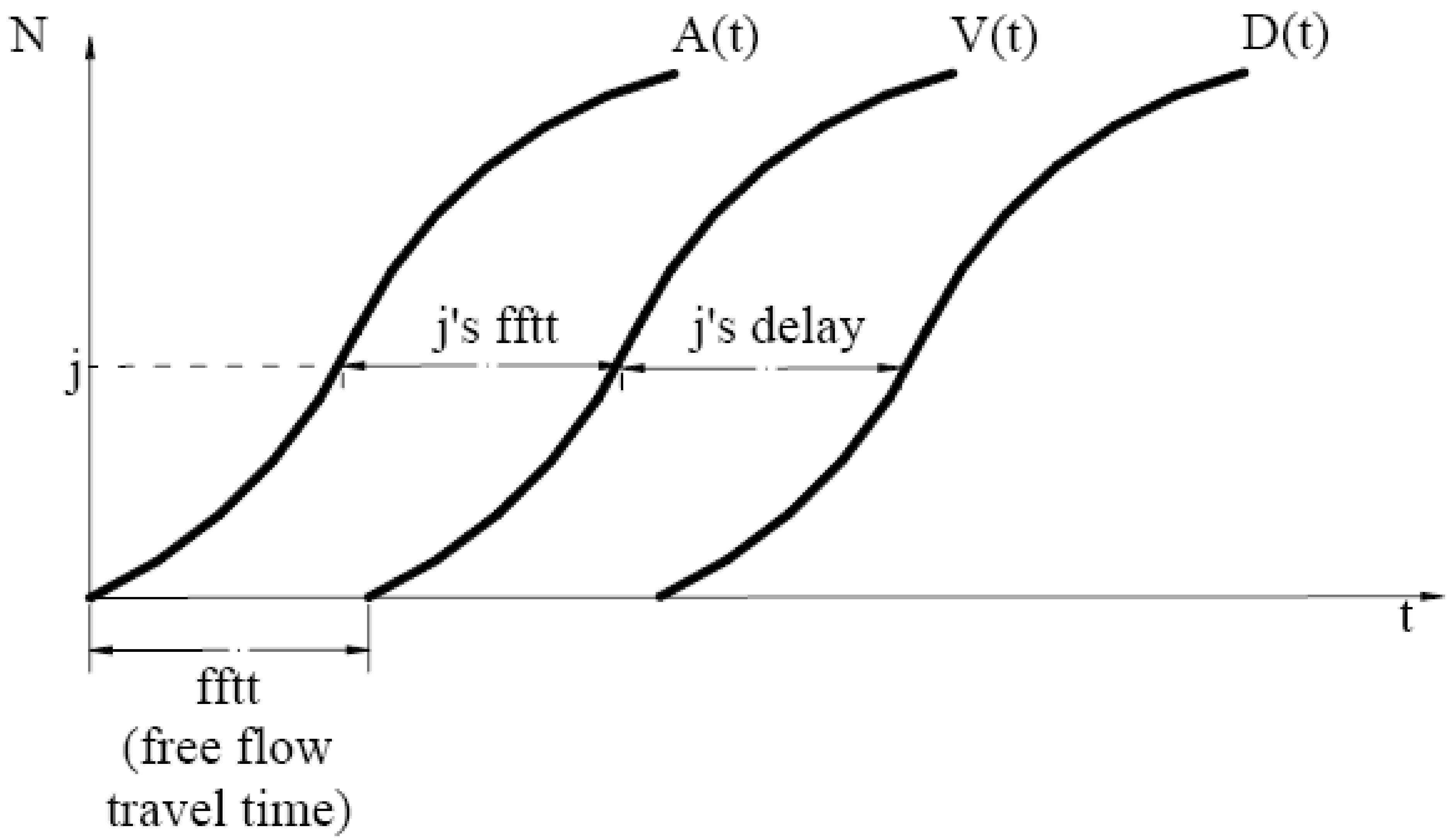


- $Q(0)$ = number of customers in queue at time 0
- $Q(t)$ = number of customers in queue at time t
- A_n = time of arrival of the n[th] customer
- D_n = time of departure of the n[th] customer



A(t), V (t) and D (t) curves

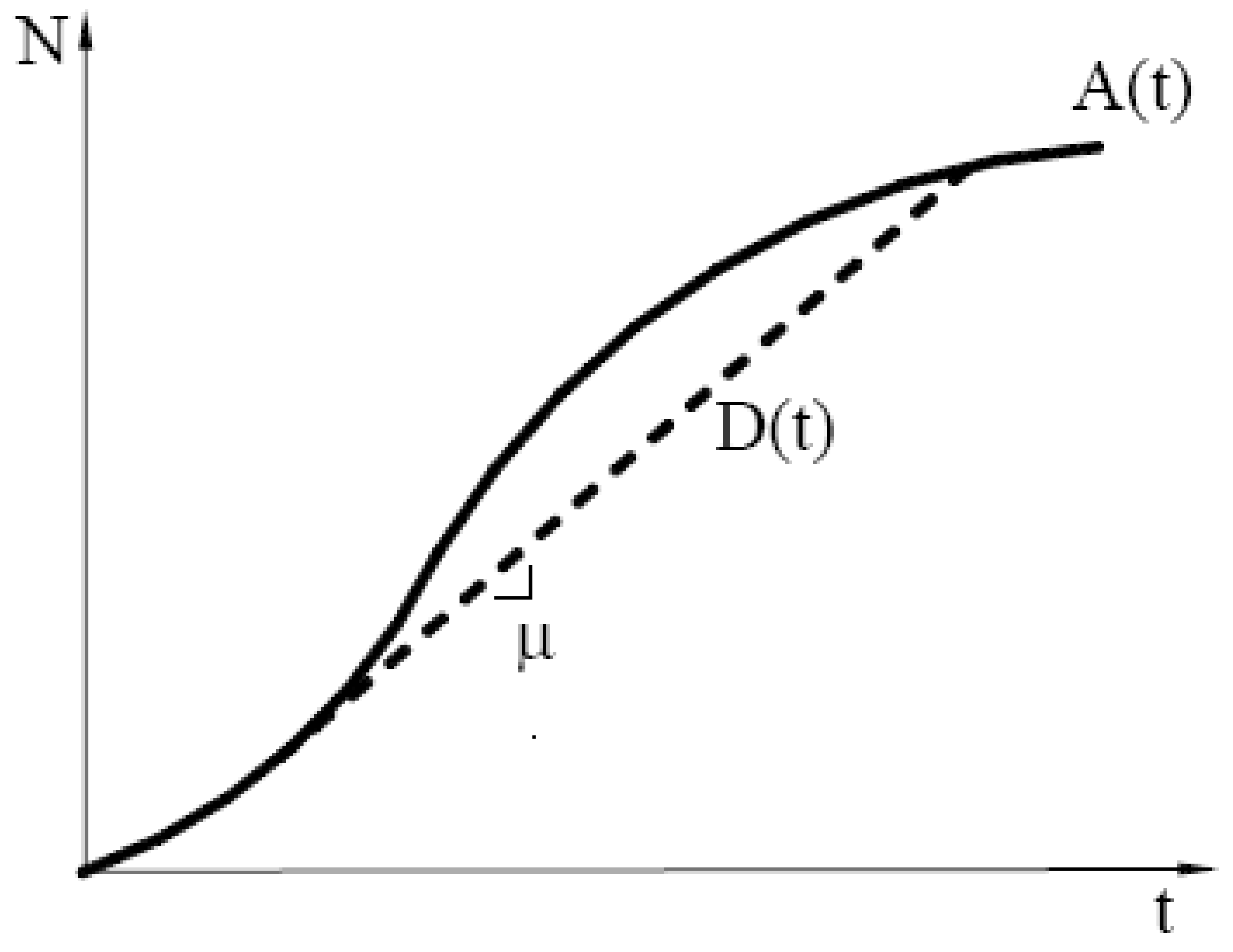




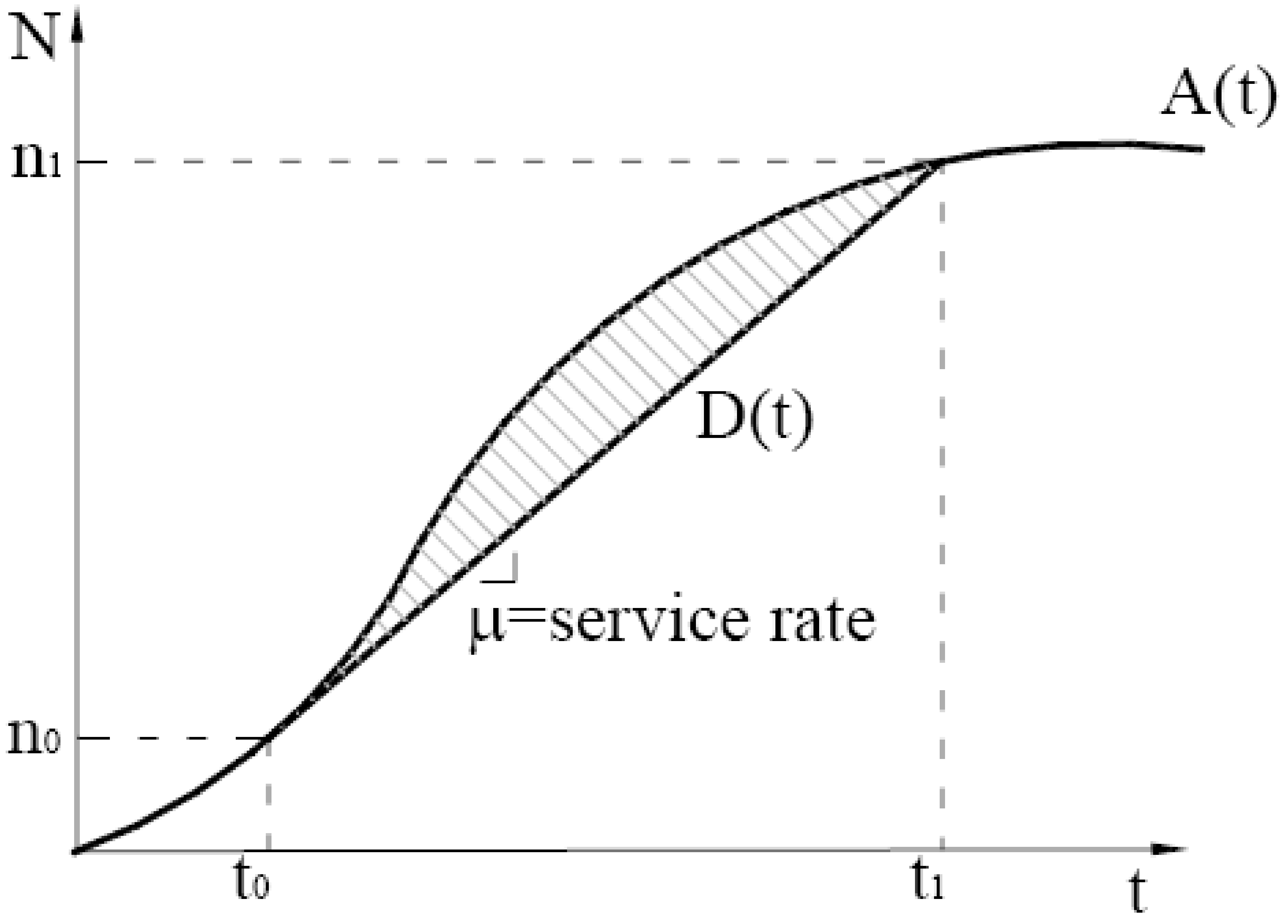
- $V(t)$ represents virtual departures: the time you would have departed the downstream end if there was no queue.
- If L ~ small $\Rightarrow$ $A(t) \approx V(t)$
- If L ~ large $\Rightarrow$ $A(t) \neq V(t)$

Construct I-O curves

- Given $A(t)$, L, v_f and μ (capacity or service rate)



Little's Formula

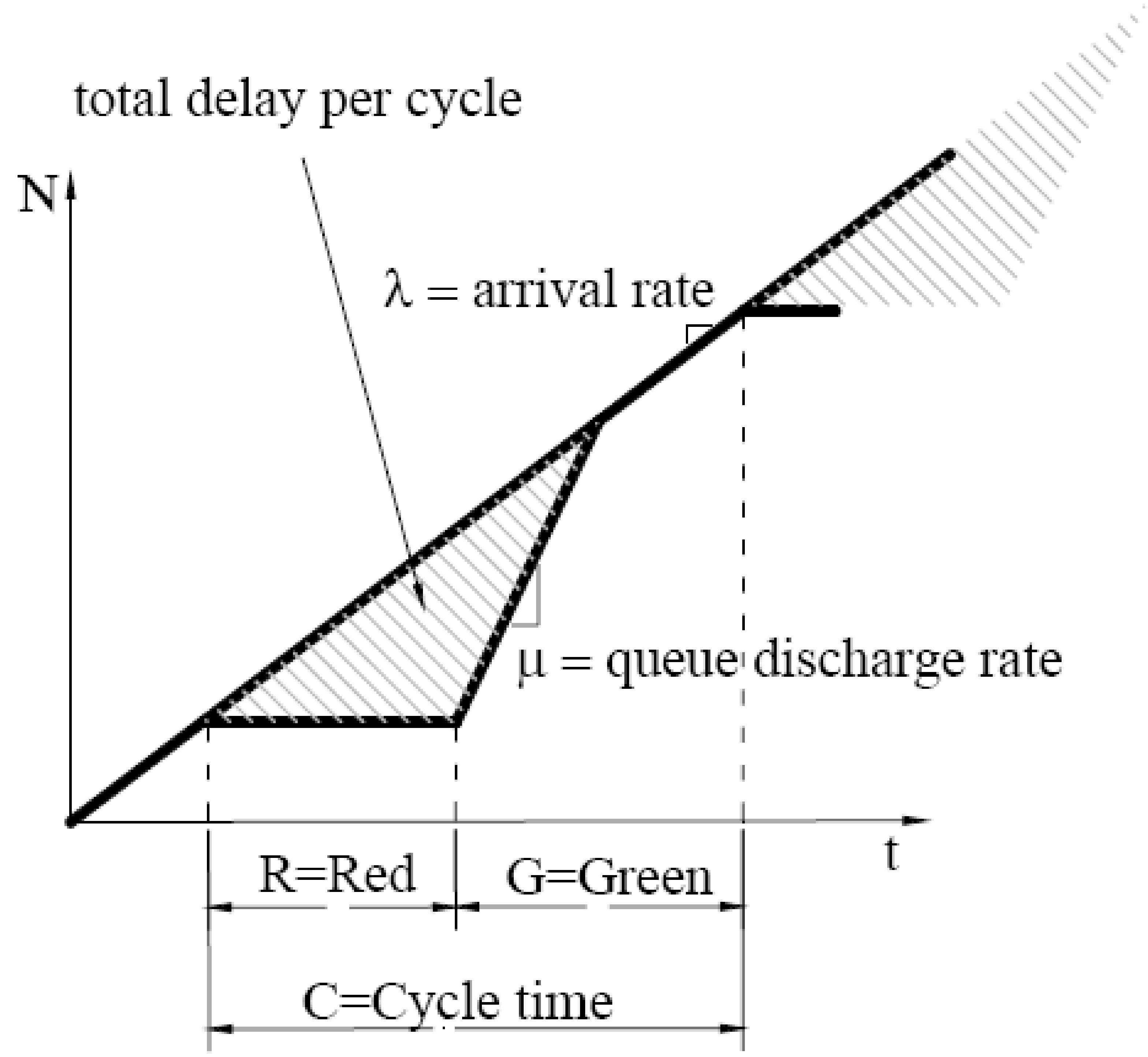


$\bar{w}$:average waiting time

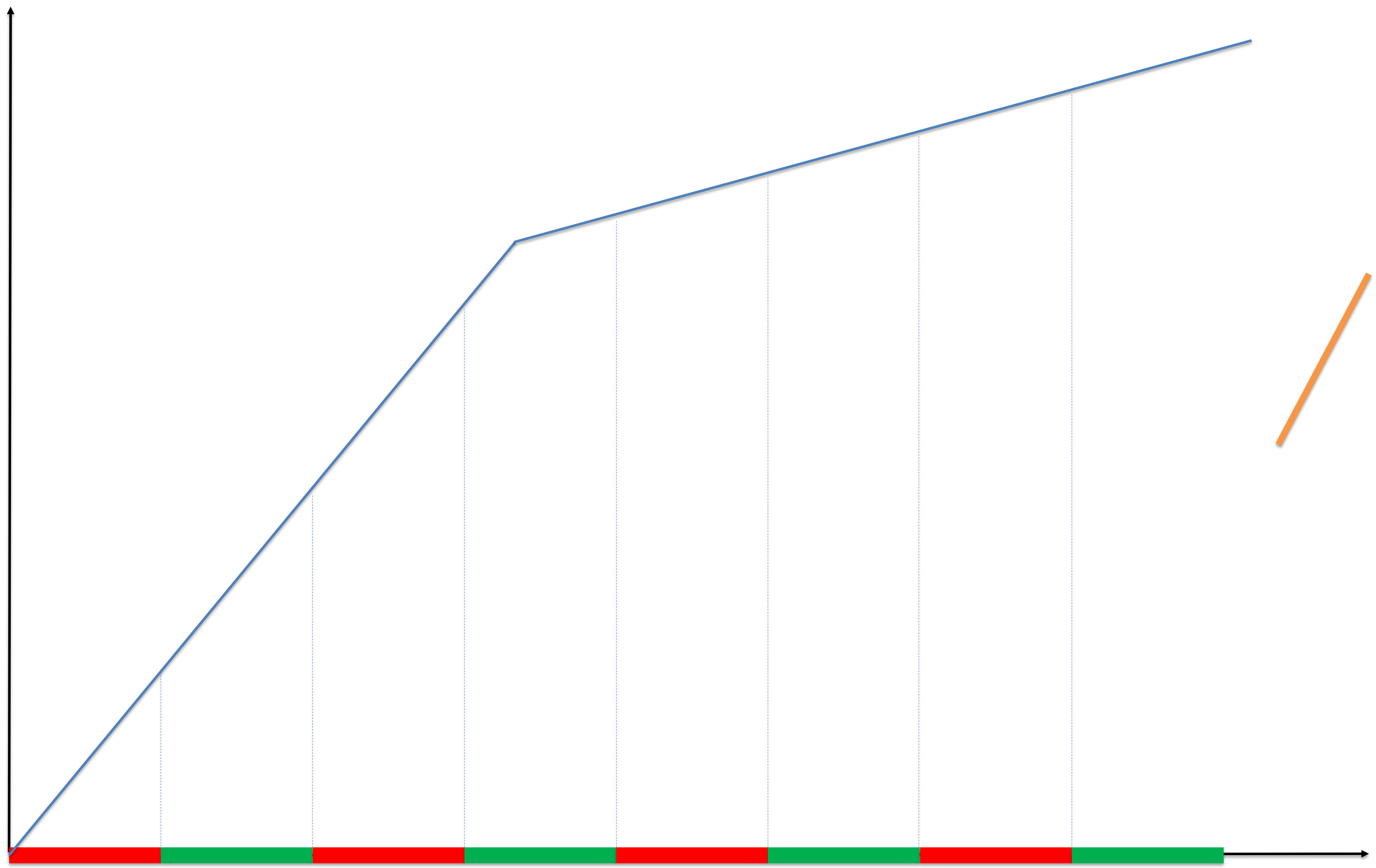
$\bar{Q}$:average queue length

λ :average arrival time

I-O curves (Example of a traffic signal)

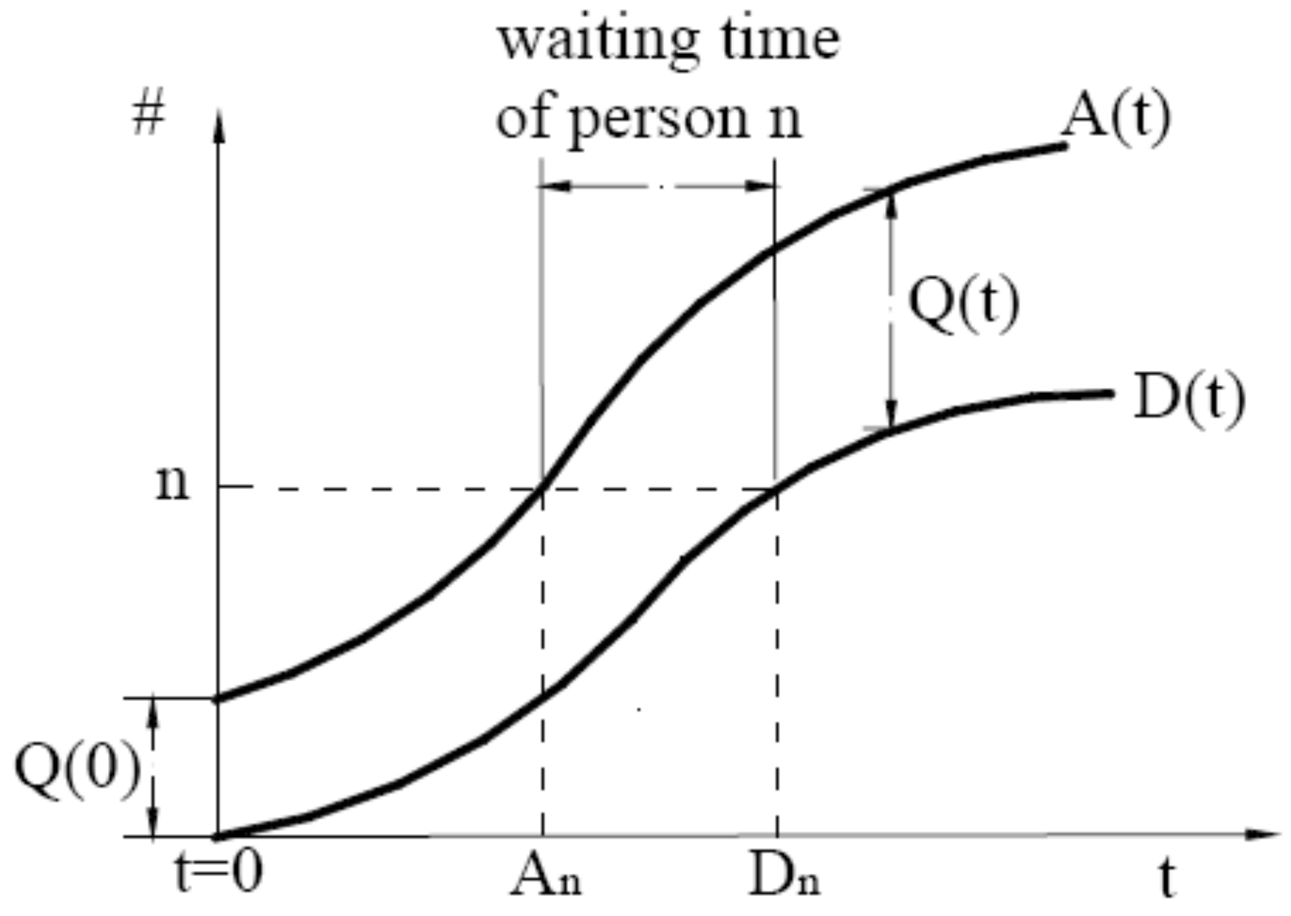


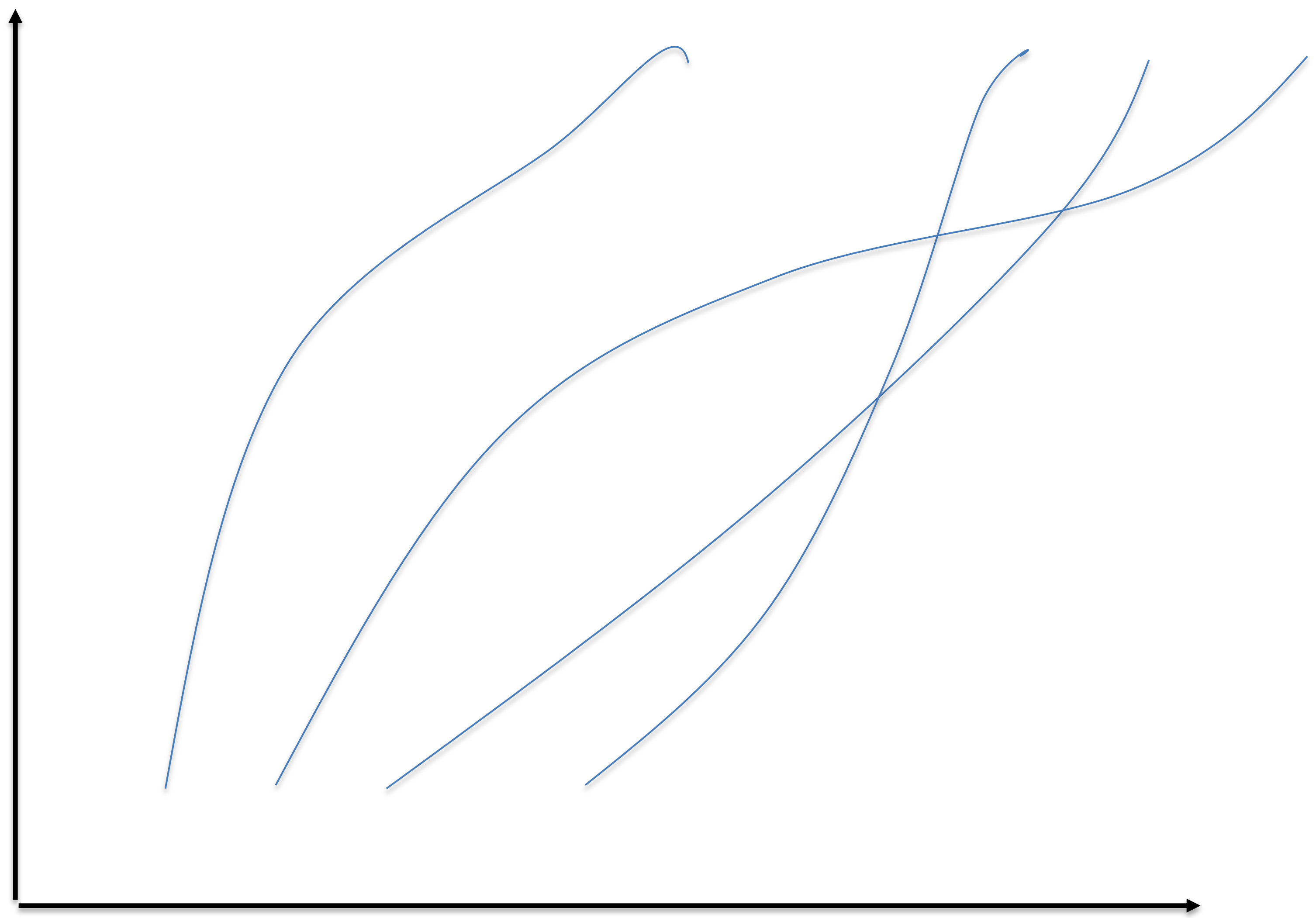
An oversaturated traffic signal



Discussion (I) - FIFO

- Violation of First in – First out (FIFO) Principle
  - Problematic for individual vehicle delay
  - Indifferent for estimation of aggregated variables (e.g. delays or accumulations)





Discussion (II) - Noise

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- Effect of measurement errors and noise
  - Theory of random walk

$$Y_t = Y_{t-1} + \varepsilon_t, Y_0 = 0 \qquad \varepsilon_t \sim N(0, \sigma^2)$$

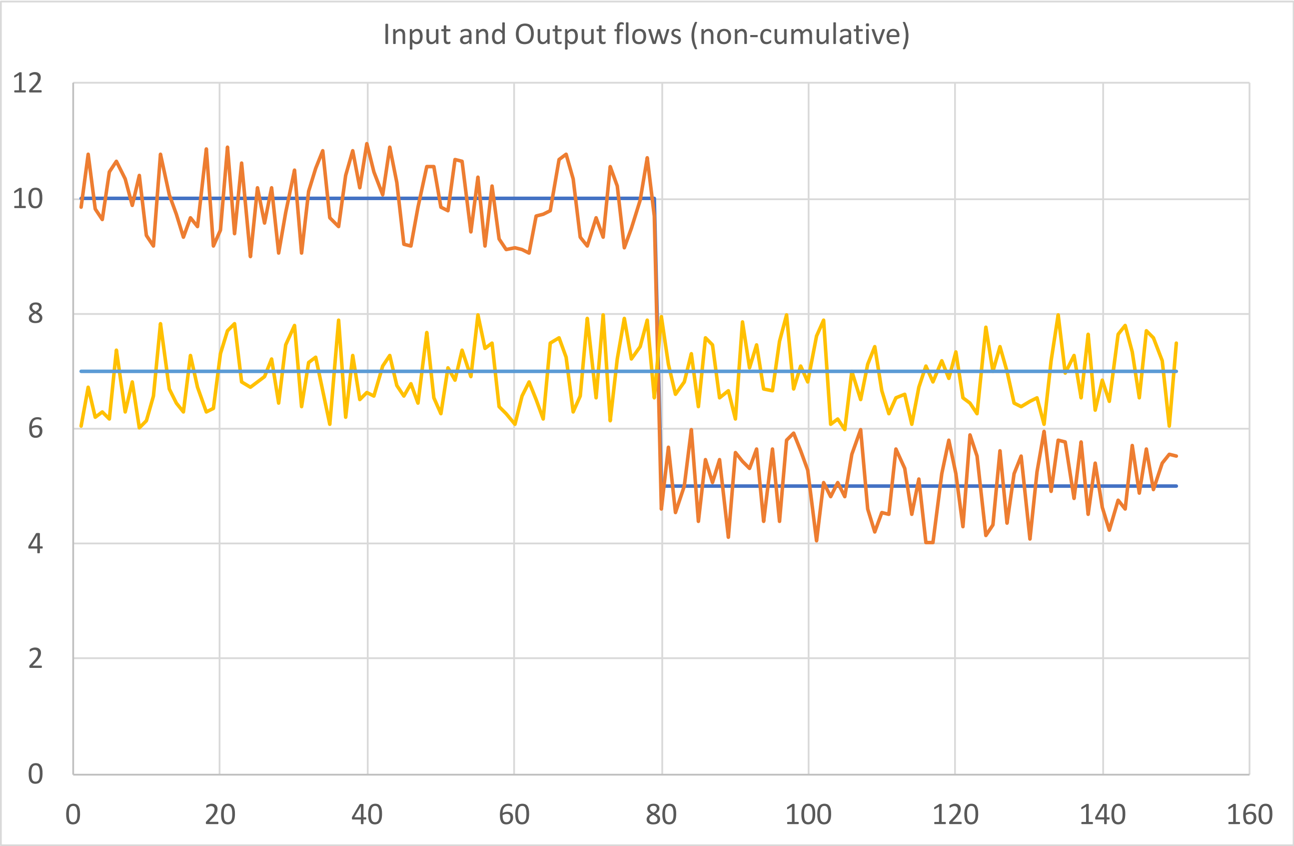
$$E(Y_t) = E(Y_{t-1}) + E(\varepsilon_t) = \cdots =$$
$$= E(Y_0) + E(\varepsilon_1) + \mathrm{E}(\varepsilon_2) + \cdots = 0$$

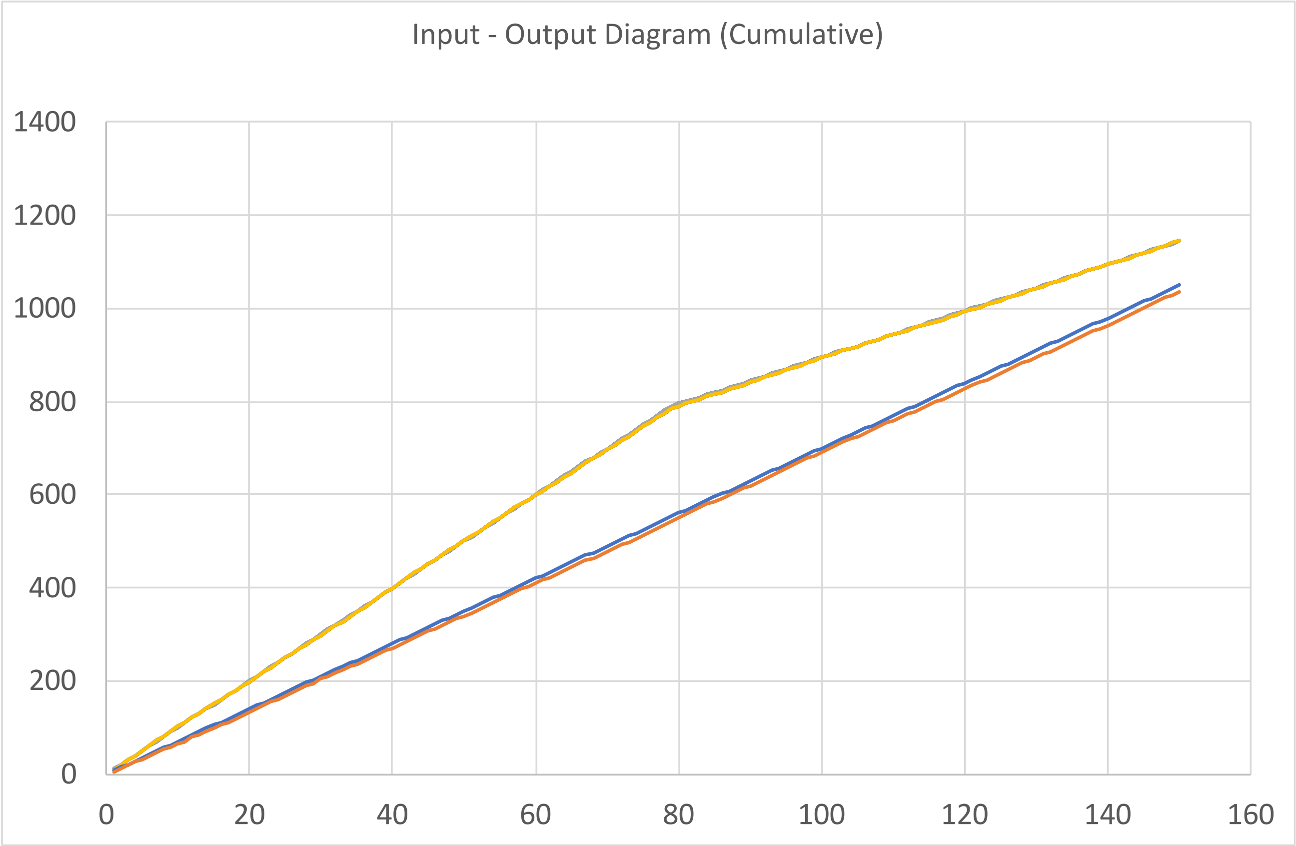
$$Var(Y_t) = Var(Y_{t-1}) + Var(\varepsilon_t) = \cdots =$$
$$= Var(Y_0) + Var(\varepsilon_1) + Var(\varepsilon_2) + \cdots = t\sigma^2$$

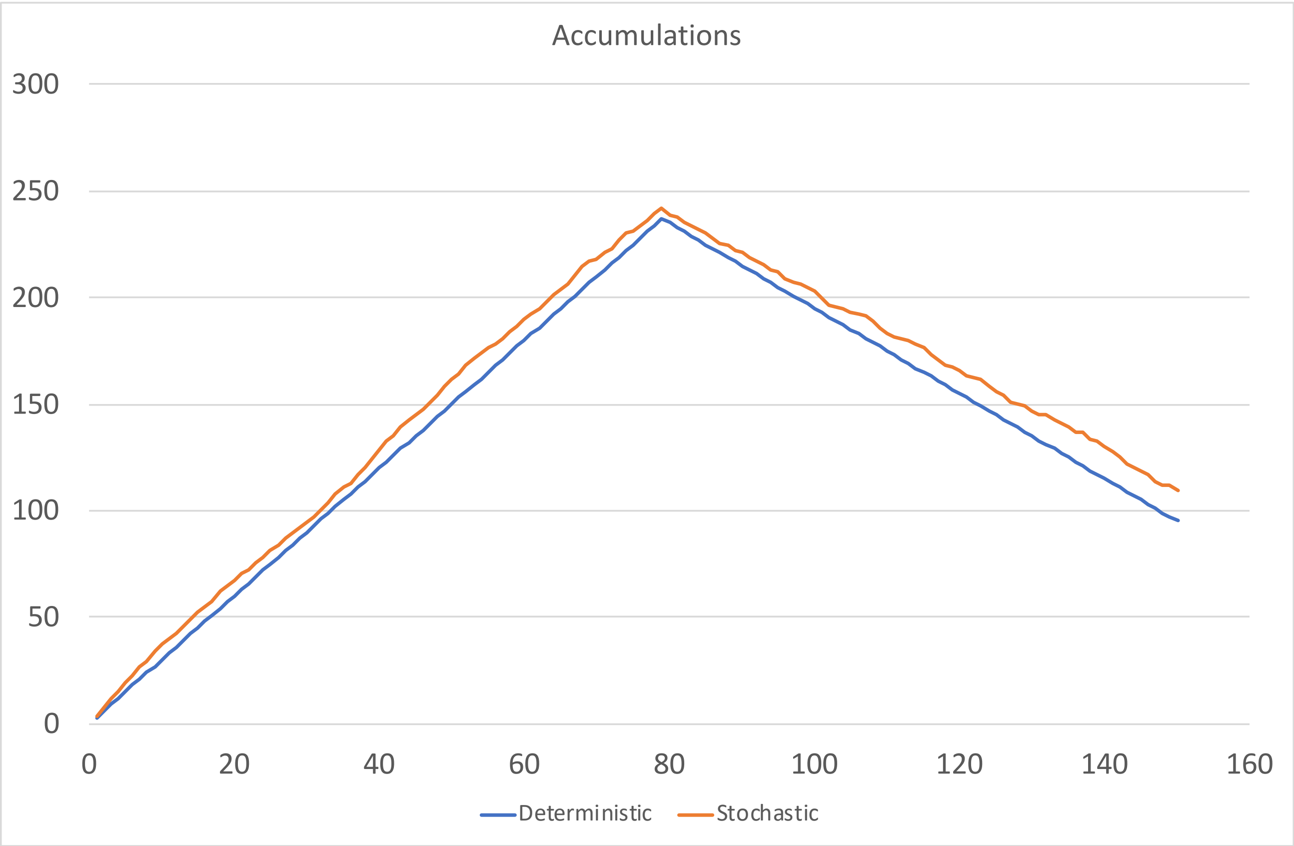
Y_t: Position of a walker at time *t*

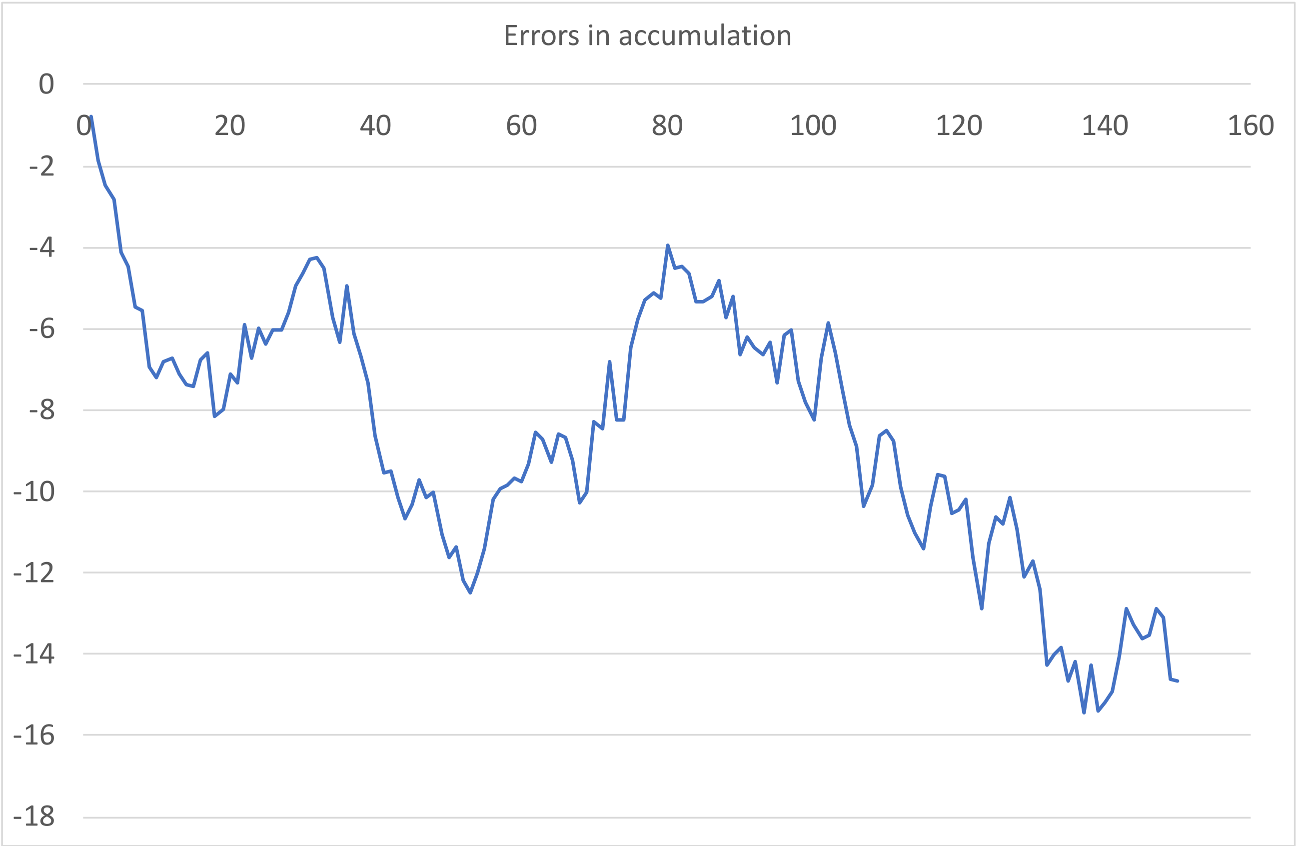
ε_t: Random noise

- An example (Errors increase with time)









Input/Output Diagram - Summary