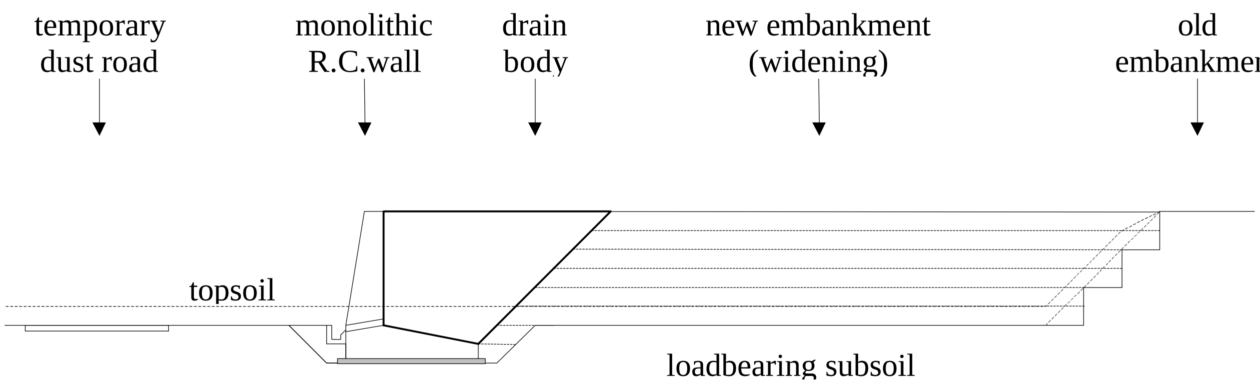
BASICS OF SCHEDULING

(planning – accomplishment – management)



Activity				Work day																					
ID	**Name**	**Time**	**Resource**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Topsoil removal	2 d	1 bulldr																						
2	Step embankment	4 d	10 labr																						
3	Levelling	1 d	1 grader																						
4	Ditch excavation	2 d	1 excr																						
5	Blinding	3 d	5 labr																						
6	Formwork	3 d	2 carpr																						
7	Reinforcement	5 d	4 rodm																						

$$T = \boldsymbol{f}\,(\,\S,\ \$,\ l,\ m,\ p,\ \ldots\,)$$

§	**: law & regulation**
$	**: financing**
l	**: location**
m	**: technology**
p	**: time period**

PRE-TENDER REPORT

(Site Survey)

Systematic audit of all facts and factors at the site that may have great influence on accomplishment

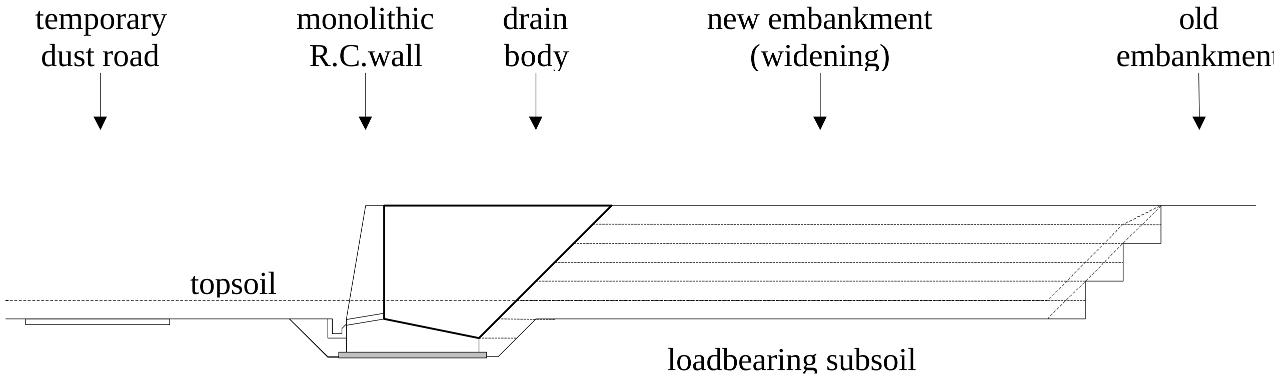
Nature:	Geology and Topography
	Flora and Fauna (Environm.Prot.)
	Watershed (Permanent, Seasonal)
	Weather Conditions (Extremities)
	:
Human:	Nearby Municipalities, Agriculture
	Local Laws and Regulations
	Local Authorities (Permits, …)
	Local Customs (Holidays, …)
	Education (Communication, …)
	Location, Accessing the Site
	:
Resource:	Local Manufacturers and Suppliers
	Local Labour Capacities
	Local Mines, Pits, Deposits
	Concurrents Local Projects
	Transport Capacities
	Accomodation Capacities
	:

WORK BREAK-DOWN STRUCTURE (WBS)

- Decision Actuality / Circumstances
- Decision Level / Responsibility
- Time-span / Term
- Function / Delivery
- Structure / Unit
- Technology / Contracting
- Measurability / Controlling
- Division / Management
- :
- Experience / Database

typical/frequent, quantified, qualified, …, accurately identified items with reference codes, structured

WORK BREAK-DOWN STRUCTURE (WBS)



01 Preparing the site
- 01-01 Cutting bushes and trees
- 01-03 Pre-liminary earthworks
  - 01-03-02 Demolishing and depositing top soil
  - 01-03-06 Stepping old embankment
  - 01-03-09 Levelling the ground
- 01-08 Constructing temporary access road
- 01-18 Constructing temporary supply lines

03 Mass earthworks
- 03-03 Excavating foundation ditch
- 03-05 Refilling ditch by wall
- 03-06 Constructing embankment
- 03-07 Constructing filter body
- 03-09 Levelling the ground

07 Concrete works
- 07-01 Blinding
- 07-04 Concreting foundation slab
- 07-06 Concreting wall
- 07-32 Constructing dewatering channels

11 Wood works
- 11-04 Formworking foundation slab
  - 11-04-02 Preparing formwork sheets
  - 11-04-05 Assembling and supporting
  - 11-04-11 Removing formwork
  - 11-04-12 Repairing formwork sheets
- 11-06 Formworking wall
  - 11-06-02 Preparing formwork sheets
  - 11-06-04 Assembling and supporting internal formwork
  - 11-06-06 Assembling external formwork
  - 11-06-09 Scaffolding and supporting external formwork
  - 11-06-11 Removing formwork
  - 11-06-12 Repairing formwork sheets

17 Steel works
- 17-02 Pre-fabricating reinforcement
  - 17-02-01 Cutting and bending
  - 17-02-03 Transporting
  - 17-02-05 Pre-assembling
- 17-04 Assembling foundation slab reinforcement
- 17-06 Assembling wall reinforcement

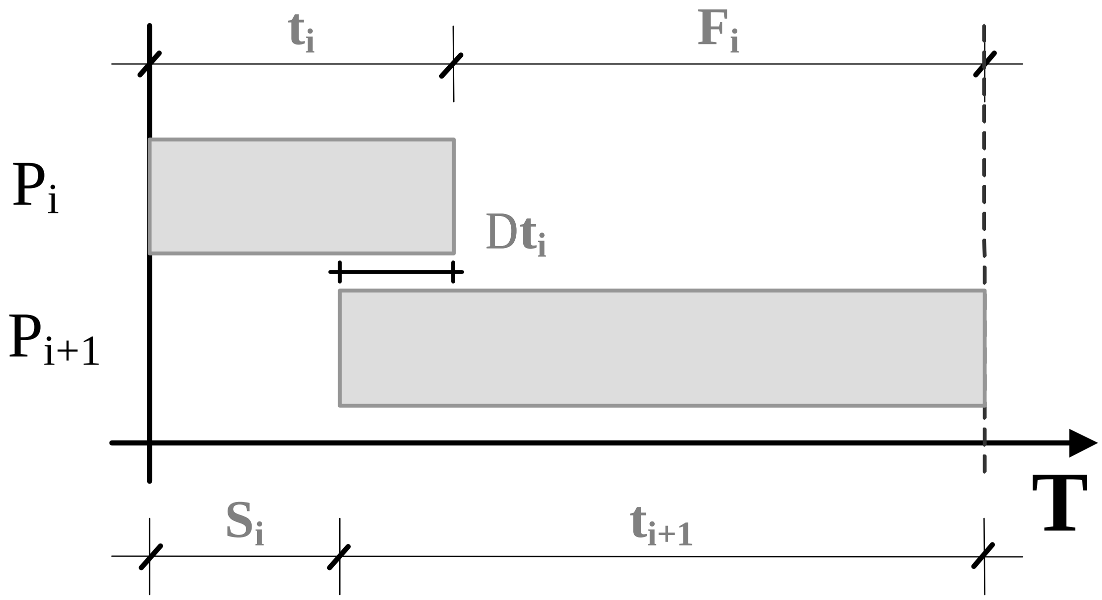
By Complexity: (responsible)

Production process (head of div.)
Building process (site engineer)
Technology process (engineer)
Activity (foremen, groupleaders)

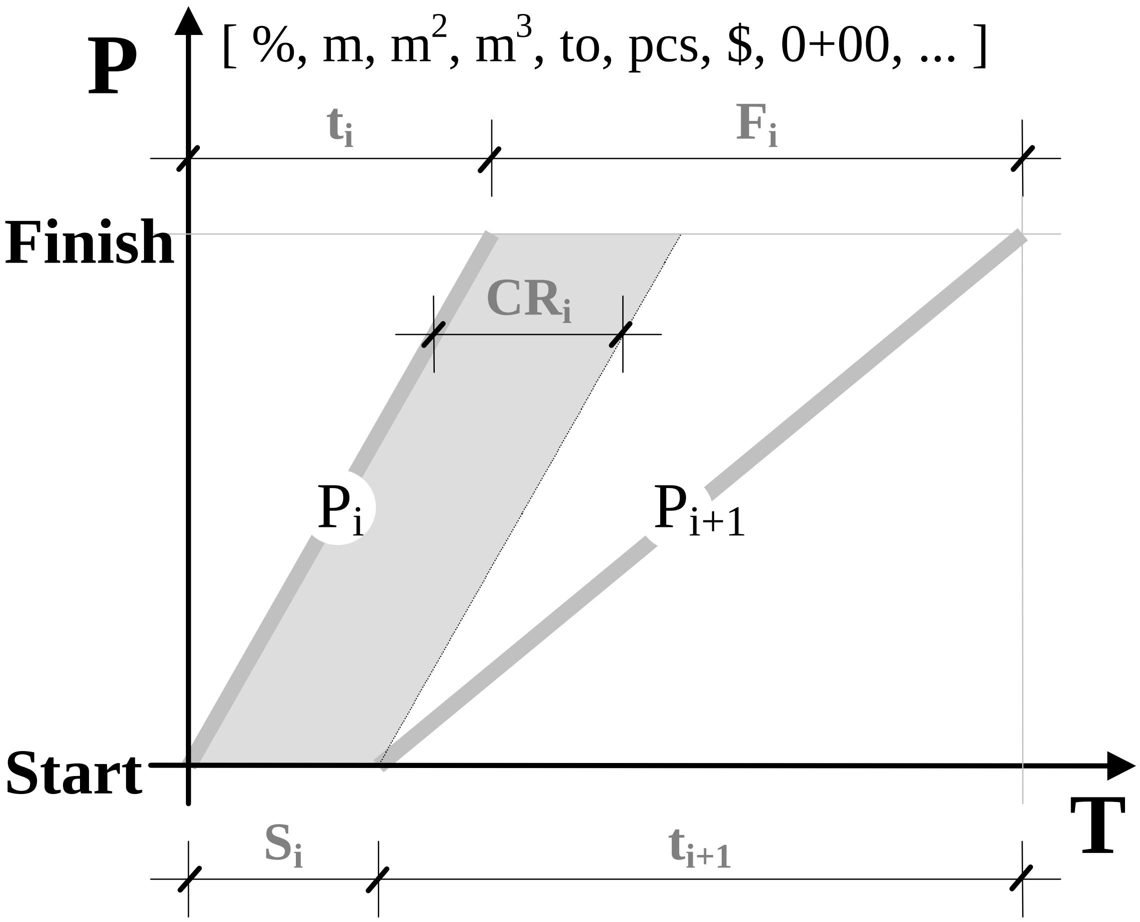
Motion (engineer + foremen)

Graphical Representations

1D – Bar Chart – Gantt Chart



2D – Linear Schedule – Cyclogram



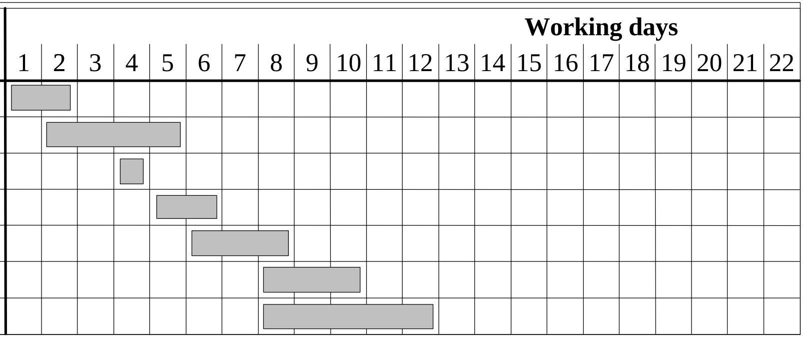
SCHEDULE REPRESENTATIONS

a-numeric – Tabular - Timetable

Activity		Schedule			Resource			Remark
ID	Name	Time	Start	Finish	Crew	Machine	Cost	
1	Demolish top soil	2d	02.03.1998	04.03.1998		1 bullr	£250	Depo. on site
2	Stepping old slope	4d	03.03.1998	06.03.1998	10 labr		£900	h = 1m
3	Levelling ground	1d	05.03.1998	05.03.1998		1 gradr	£200	
4	Excavating ditch	2d	06.03.1998	09.03.1998	3 labr	1 excr	£430	15% by labr
5	Blinding	3d	09.03.1998	11.03.1998	5 labr		£530	
6	Formworking	3d	11.03.1998	13.03.1998	2 carpr		£850	
7	Reinforcement	5d	11.03.1998	17.03.1998	4 steelfr		£1410	prefabr. 35%

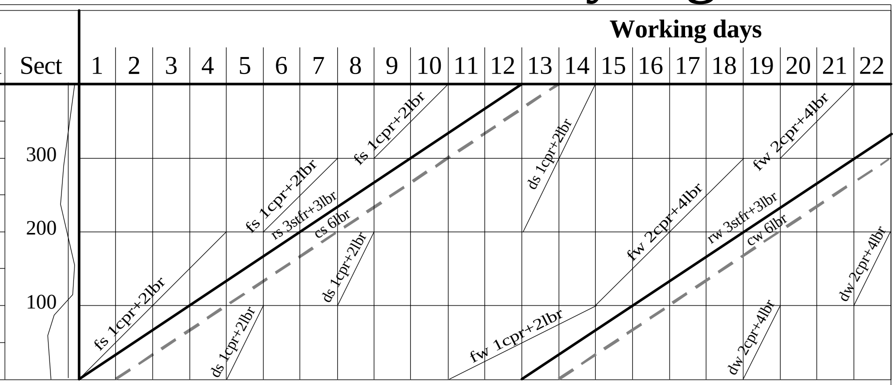
1Dimensonal – Bar Chart – Gantt Chart

Activity			
ID	Name	Time	Crew
1	Demolish top soil	2d	1 bullr
2	Stepping old slope	4d	10 labr
3	Levelling ground	1d	1 gradr
4	Excavating ditch	2d	1 excr
5	Blinding	3d	5 labr
6	Formworking	3d	2 carpr
7	Reinforcement	5d	4 steelfr



2Dimensional – Linear Schedule - Cyclogram

Activity			
ID	Name	Time	Ini
1	Formworking slab	8d	**fs**
2	Reinforcing slab	12d	**rs**
3	Concreting slab	12d	**cs**
4	Demolishing formw.	4d	**ds**
5	Formworking wall	8d	**fw**
6	Reinforcing wall	12d	**rw**
7	Concreting wall	12d	**cw**
8	Demolishing formw.	4d	**dw**



RESOURCES

anything and everything
that is needed … and … bounded

M a t e r i a l

- Construction material (earth, wood, metal, concrete, …)
- Auxiliary structures (formwork, timber, scaffold, …)
- Fuel (gas, petrol, electricity, …)

H u m a n

- Management (leadership, know-how, authority, …)
- Skilled workers (mason, steel-fitter, carpenter, plumber, …)
- Labourers (unskilled, universal, trained workers, …)

E q u i p m e n t

- Heavy equipment (excavator, bulldozer, crane, truck, …)
- Auxiliary machinery (mixer, floater, finisher, pump, …)
- Power tools (cutter, drill, welding set, pin vibrator, …)

T i m e

A r e a

M o n e y

S T A N D A R D S

Ways of establishing Standards

- Statistical analysis (bulk processing)
- Technical analysis (estimates)
- Hystorical analogies (comparision)
- Measuring performance (timing)

Basic types of Standards

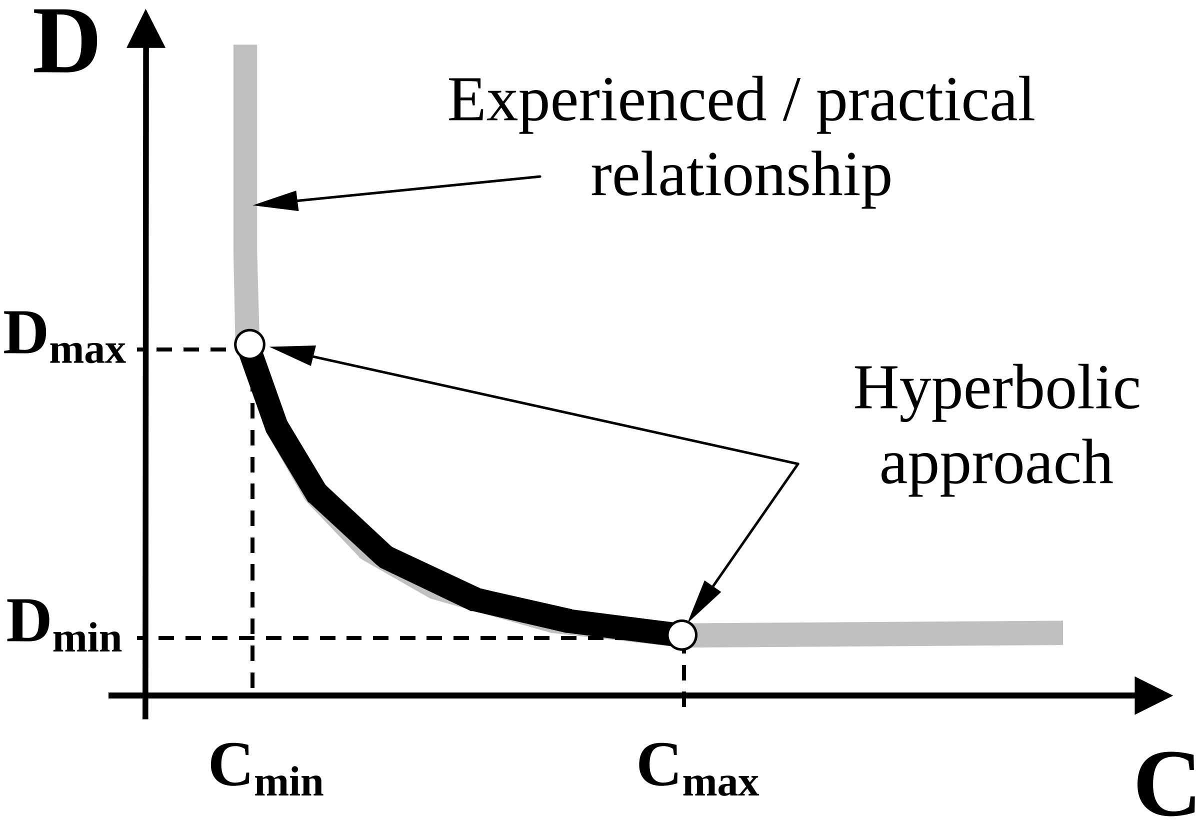
- Performance standard [time/unit] (h/m^3,h/to,..)
- Standard output [unit/time] (m^3/h,to/h,pcs/h,..)
- Material standard [volume/unit] (m^3/pc,..)
- Storage standard [volume/area] (pcs/m^2,..)
- Cost standard [cash/unit] ($/pcs,$/to,$/m²,..)

Adjusting Standards

$l<1$: Location factor (disadvantageous access)
(*position of equipment can not be optimal*)
$t<1$: Time efficiency factor (too much time loss)
(*much time to spend for technical breaks*)
… : … (…)
$r<1$: Resource factor (unfavorable material)
(*gluey or hard soil, sensitive structure*)

$$N_{eff} = N_{stnd} \cdot l \cdot t \cdot \ldots \cdot r$$

CAPACITY / DURATION



V : volume [unit] *(of product)*

n : performance [time/unit] *(for a unit resource – labour)*
N : output [unit/time] *(for a unit resource – equipment)*

W : work [time] *(for a unit resource)*

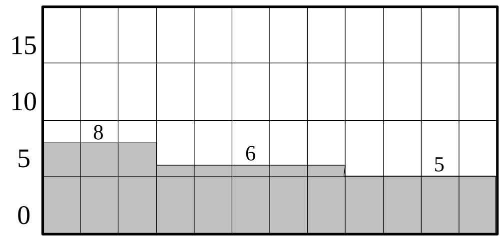
C : capacity [unit] *(allocated resource units)*
D : duration [time] *(for resource units allocated)*

$$W = \frac{V}{N} \qquad W = V \times n \qquad D = \frac{W}{C}$$

TIMING RELATIVE

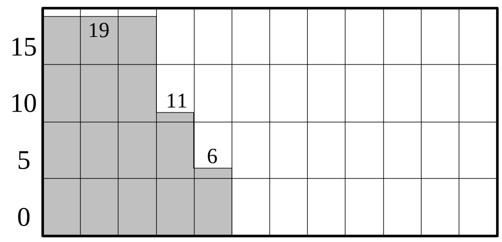
Consecutive Link

Activity				**Schedule**											
ID	Name	Time	Crew	1	2	3	4	5	6	7	8	9	10	11	12
1	Excavate ditch	3d	8 labr		8										
2	Formworking	5d	6 carpr						6						
3	Reinforcement	4d	5 steelfr											5	



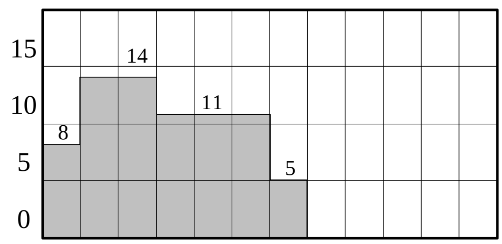
Parallel Link

Activity				**Schedule**											
ID	Name	Time	Crew	1	2	3	4	5	6	7	8	9	10	11	12
1	Excavate ditch	3d	8 labr		8										
2	Formworking	5d	6 carpr			6									
3	Reinforcement	4d	5 steelfr		5										

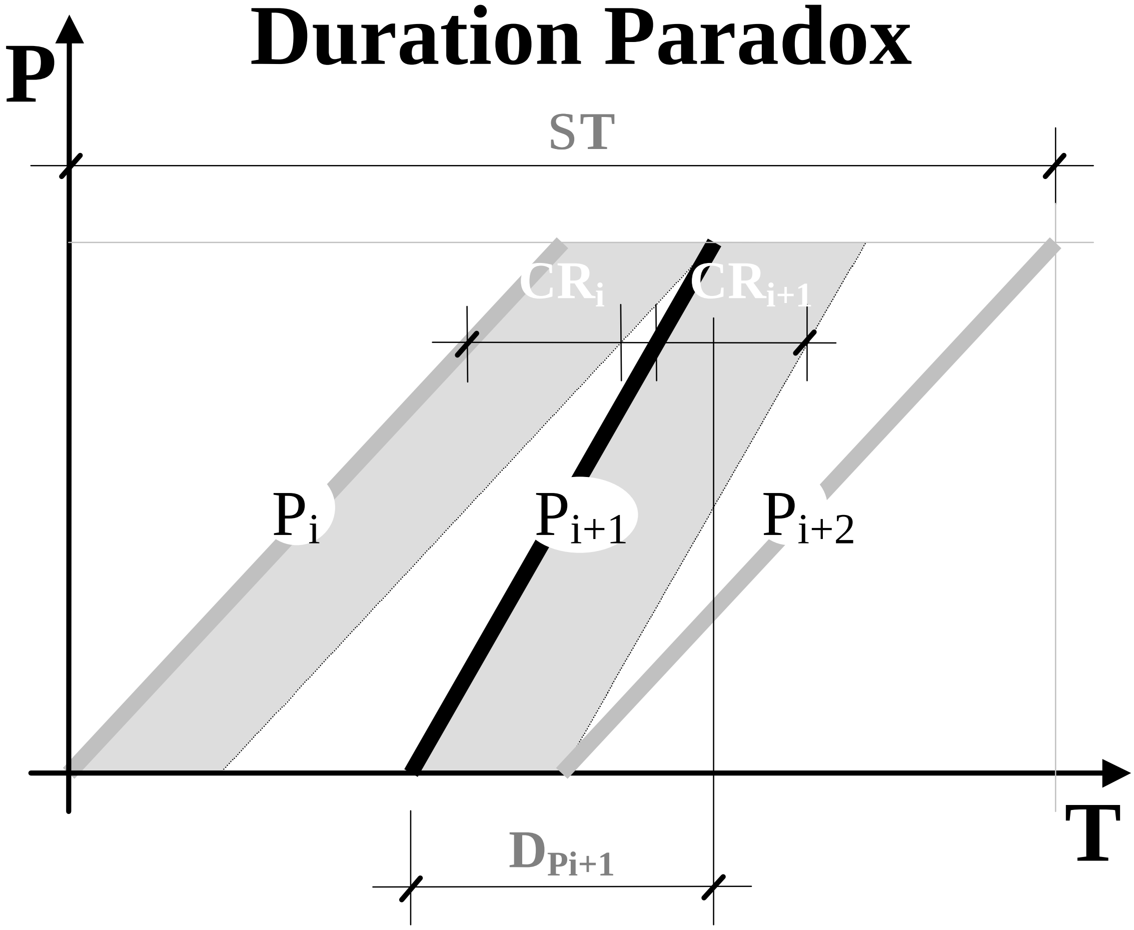


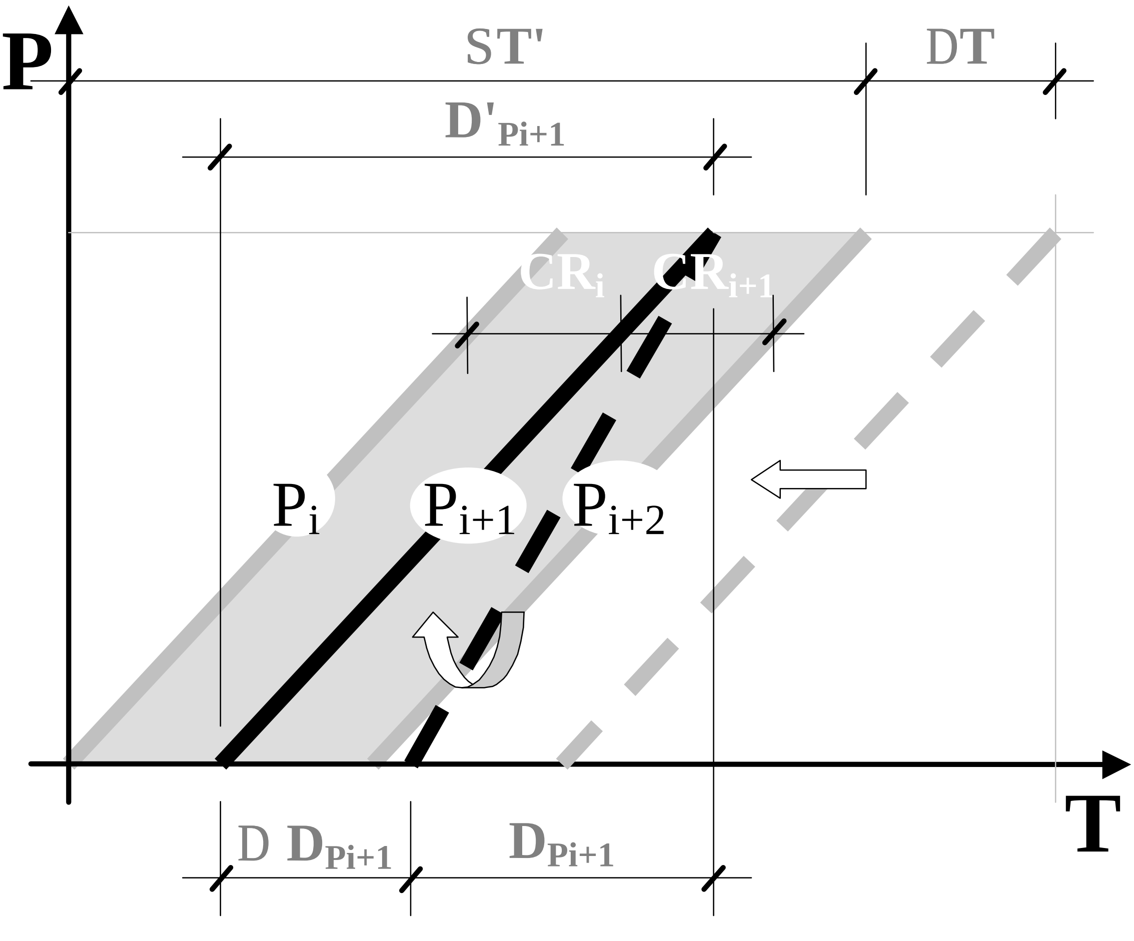
Overlapped Link

Activity				**Schedule**											
ID	Name	Time	Crew	1	2	3	4	5	6	7	8	9	10	11	12
1	Excavate ditch	3d	8 labr		8										
2	Formworking	5d	6 carpr				6								
3	Reinforcement	4d	5 steelfr					5							



Duration Paradox

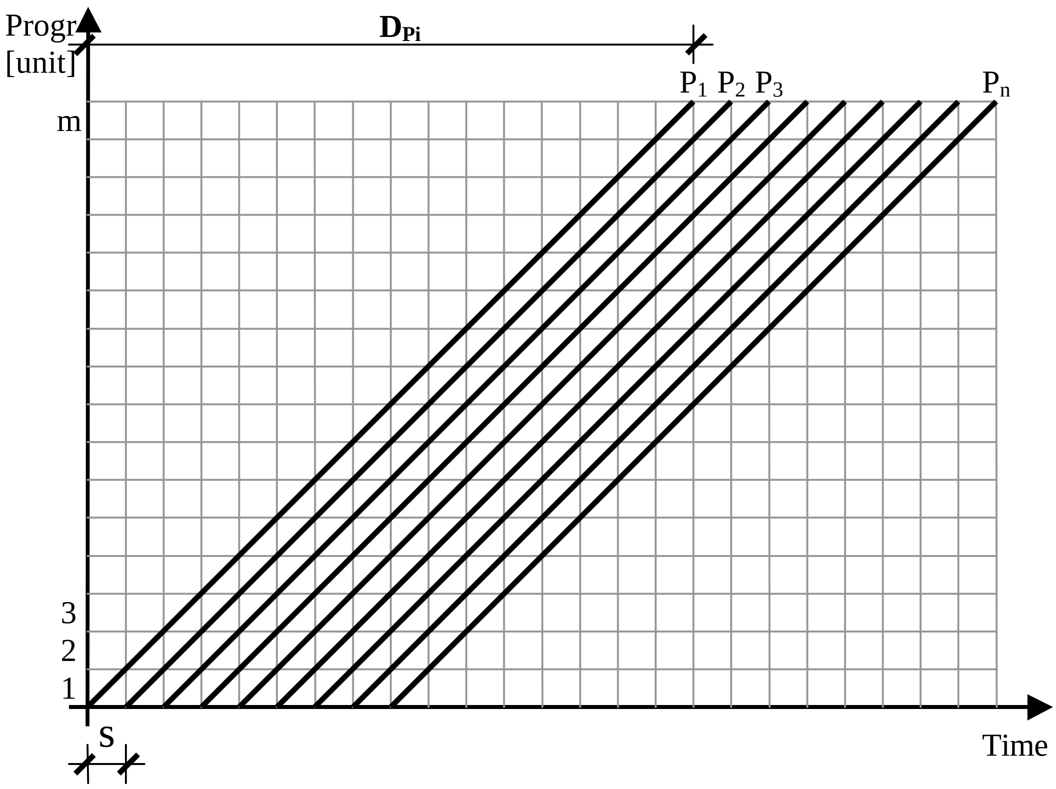




Synchronization

(the ultimate parallels)

U.S.: Ford, model-T, serial production
"Production-Belt System"



H i s t o r i c a l R e l a t i o n s

Belt-System Construction / Industrialization

After-War (II) Reconstruction

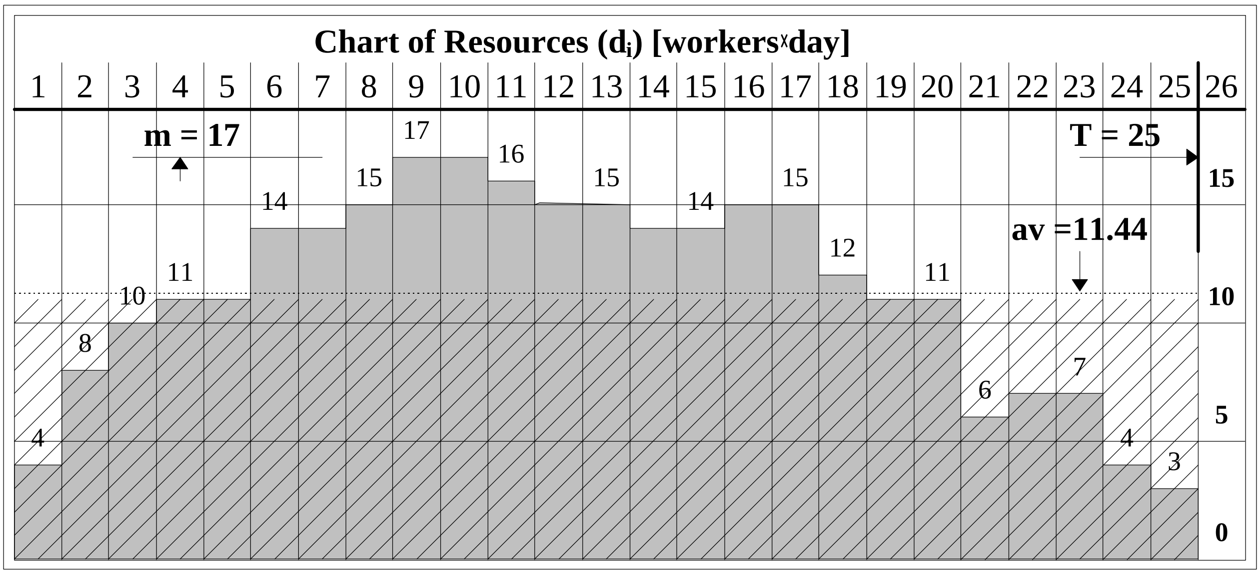
(Lack of Resources / Bulk of Needs)

Typical: Infrastructure development

(highway, railway, public services, etc.)

RESOURCE MANAGEMENT

Capacity-typed (not storable) resources



$$W = \sum_{i=1}^{T} d_i = \sum_{i=1}^{25} d_i = 286 \qquad av = \frac{W}{T} = \frac{286}{25} = 11.44 \qquad k = \frac{m}{av} = \frac{17}{11.44} \approx 1.486$$

W = total work performed [workers^{x}day]

T = total execution time [day]

d_i = daily work performed [workers^{x}day]

i = day index

av = average of workers employed a day [workers]

m = maximum of workers employed a day [workers]

k = resource variency indicatrix

e.g.:

- Labour
- Equipment
- Electricity

Loss in utilization can not be recovered

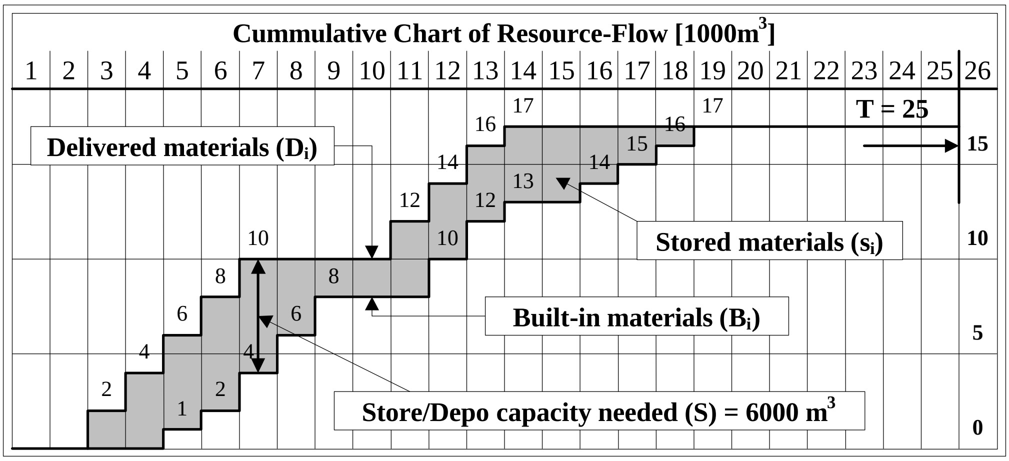
(Efficiency has great importance)

RESOURCE MANAGEMENT

Stock-typed (storable) resources

Schedule of Resource [1000m^3/day]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Delivered (d_i)			2	2	2	2	2				2	2	2	1									**T = 25**			
Built-in (b_i)					1	1	2	2	2			2	2	1		1	1	1	1							



$D_i = \sum_{j=1}^{i} d_j$ $\quad B_i = \sum_{j=1}^{i} b_j$ $\quad s_i = D_i - B_i$ $\quad S = \max_i \{ s_i \}$ $\quad i = 1,2, ...,T$

D_i = cummulated amount of resource delivered by the day „i" [m^3] **i, j = day indices**

B_i = cummulated amount of resource built-in by the day „i" [m^3]

s_i = amount of resource to be stored on the day „i" [m^3] **S = store/depo capacity needed**

d_i = amount of resource delivered on the day „i" [m^3] **b_i = amount of resource built-in on the day „i" [m^3]**

e.g.:

- Material
- Structure
- Fuel

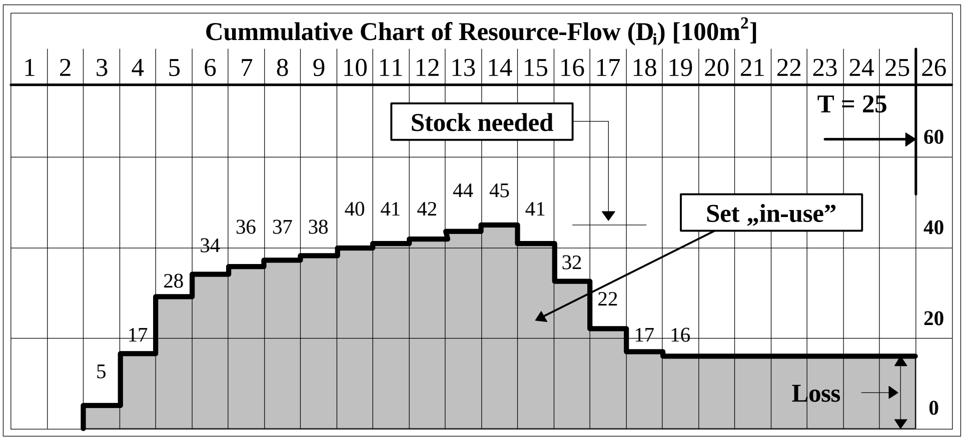
Transport and storage has great importance

(Top-time delivery can save money)

RESOURCE MANAGEMENT

Renewable (recycled) resources

Activity		Schedule of Resource Use (a_{ki}) [100m²/day]																									
ID	Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Internal formwork			5	5	5	5	5	5	5	5	5	5	5	5									T = 25			
2	External formwork				6	6	6	6	6	6	6	6	6	6	6	6											
3	Partitioning formwork				1			1			1			1			1										
4	Remove internal formw.						-5	-4	-5	-5	-4	-5	-5	-4	-5	-5	-4	-5									
5	Remove external formw.							-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5								
6	Remove partit. formw.							-1			-1			-1			-1			-1							



$d_i = \sum_{k=1}^{n} a_{ki}$ $D_i = \sum_{j=1}^{i} d_j$ $S = \max_i\{D_i\}$ $i = 1,2, ...,T$

a_{ki} = set of resource assigned to (used at or produced by) activity „k” on day „i” [m²] **i, j = day indices**

d_i = increment of set „in-use” on the day „i” [m²] **k = activity index**

D_i = set „in-use” on the day „i” [m²] **n = number of activities**

S = necessiated set (stock) of resource [m²] **T = total execution time [day]**

e.g.:

- Top-Soil / Plantage
- Earth / Rubbish
- Auxiliary / Temporary Structures

Minimal loss (savings) has great importance

(Environment protection has preference)