TOC – Critical chain

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TOC concisely I (see PWP presentation about TOC)

- origin: E.M.Goldratt, Jerusalem
- cost world<->throughput world
- analogy weight of the chain – solidity of the chain
- how to find a bottleneck?
- tools of TOC – tree structures
- CRT – EC – TT – PT – FRT meaning:
- Current Reality Tree - Evaporating Cloud Tree– Transition Tree -

  - Prerequisite Tree – Future Reality Tree

TOC concisely I (see PWP presentation about TOC)

- **bottleneck** in the project management is a critical path
- finding (assessment) of bottleneck is not easy and often it is not explicit (uncompromising)
- everybody knows something about TOC and nobody knows **how to implement it** to the real world- and this is again another bottleneck (tendon of Achilles from the heel to the scruff)

TOC-five steps (revision)

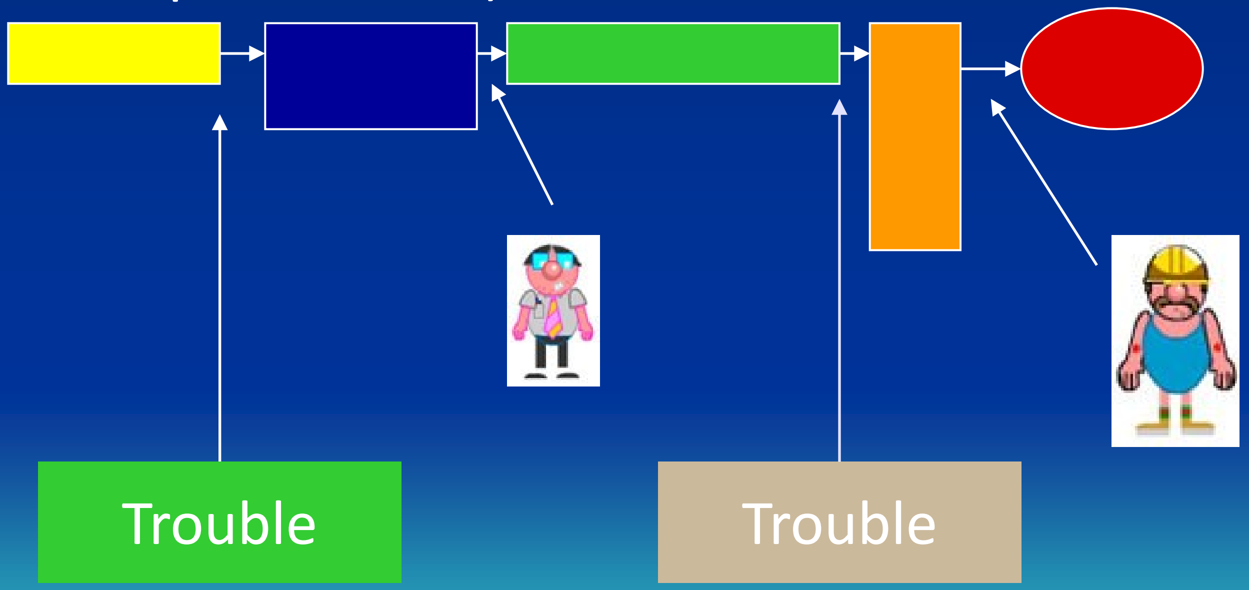
Five steps process:

Step 0. Identify the Goal of the System/Organization
Step 0.5 Establish a way to measure progress to Goal

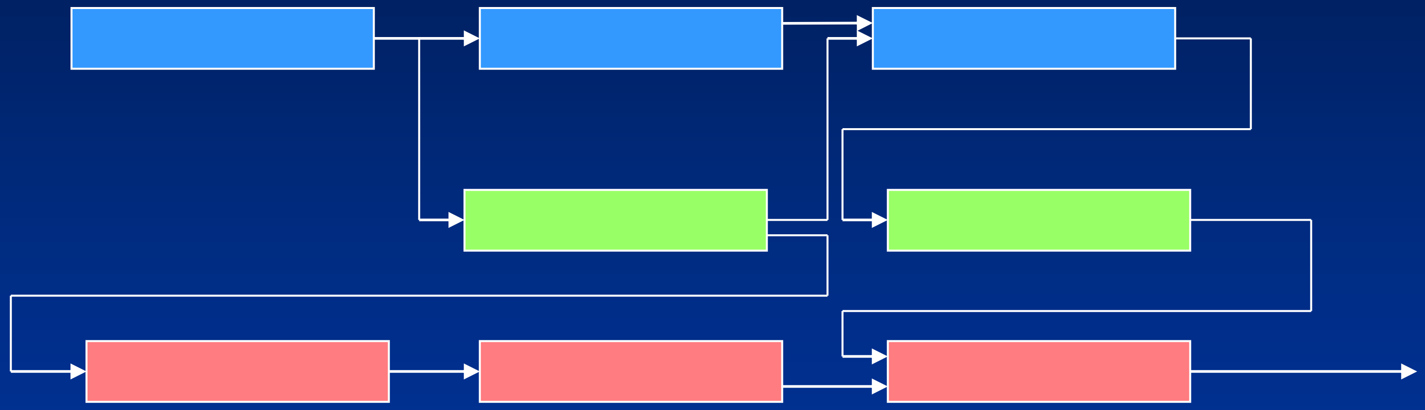
- **Step 1.** ***Identify*** the system's constraint.
- **Step 2.** ***Exploit*** the system's constraint.
- **Step 3.** ***Subordinate*** everything else to the above decision.
- **Step 4.** ***Elevate*** the system's constraint.
- **Step 5.** If a constraint is broken (that is, relieved or improved), go back to Step 1. But don't allow ***inertia*** to become a constraint.

Linear image of the project

- activities – abscissas – Gantt graph
- constantly changing conditions (Parkinson low, Murphy low, Student syndrome, customer changes - „fancies “,“caprices“.. ….),



Parallel image of the project



Project and its budget

- price of the whole project
- project length (time)
- project stages and length of each activity
- assigned resources to every activity and their capacities (time per defined period)
- time reserves (buffers) and their estimation
- unfavourable influences (see Murphy s lows - http://murphy.euweb.cz, etc.)
- additional activities (unexpected costs)

Selected Murphy s laws

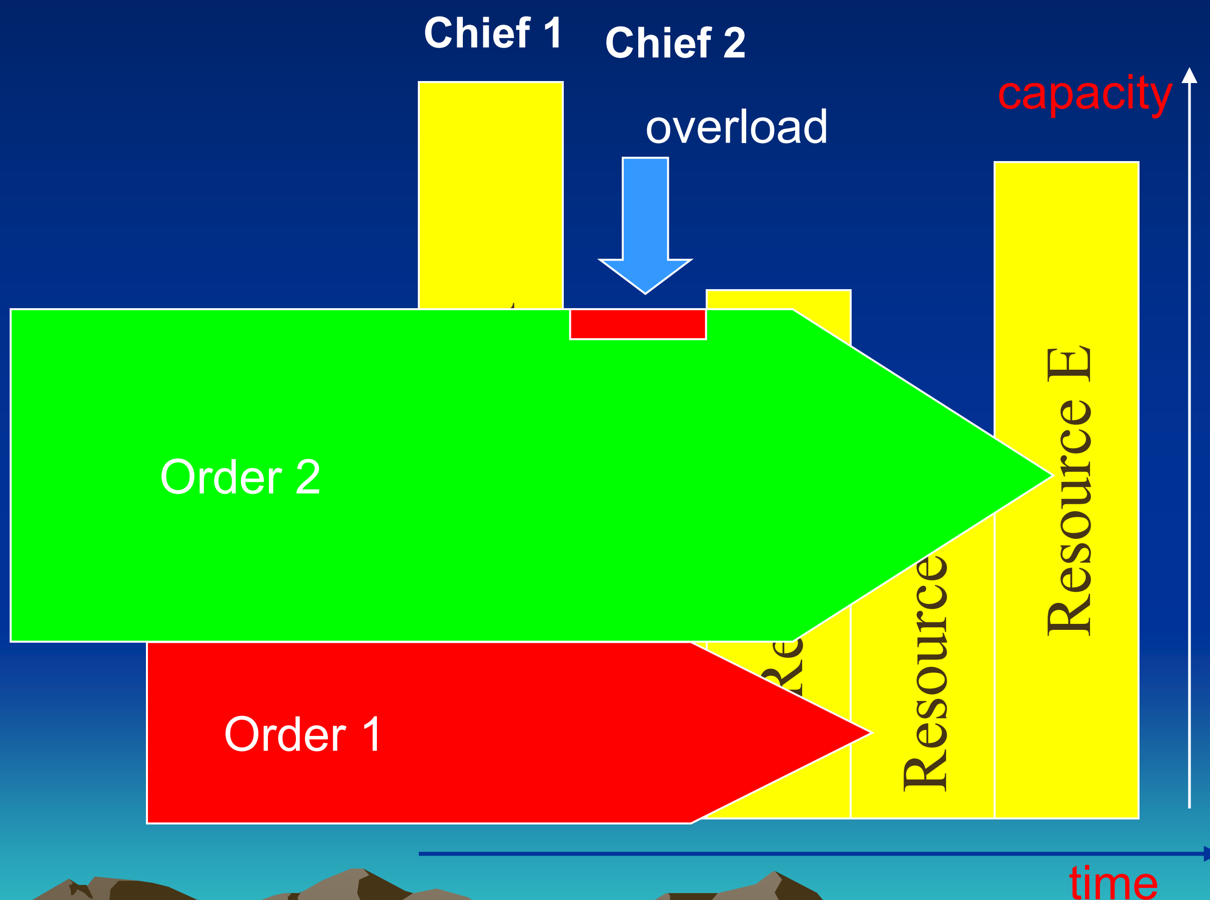
- If your attack is going well, you have walked into an ambush (trap)
- Planner is alerted about modification of the plan exactly in the moment, when the plan is finally adjusted
- To carry out **n+1** trivialities you need two times more time than time necessary to carry out **n** trivialities (law 99 %)
- **If anything can go wrong, it will**
- Any given program, when running, is obsolete
- No matter how many resources you have, it is never enough
- Brains x Beauty x Availability = Constant. This constant is always zero.

Resources and orders

Matrix structure of multi-project environment – responsibility of project managers and responsibility of department managers are **in conflict**

Project manager 1

Project manager 2



Partial time of any activity in the project

Variability of the real time assigned to activity

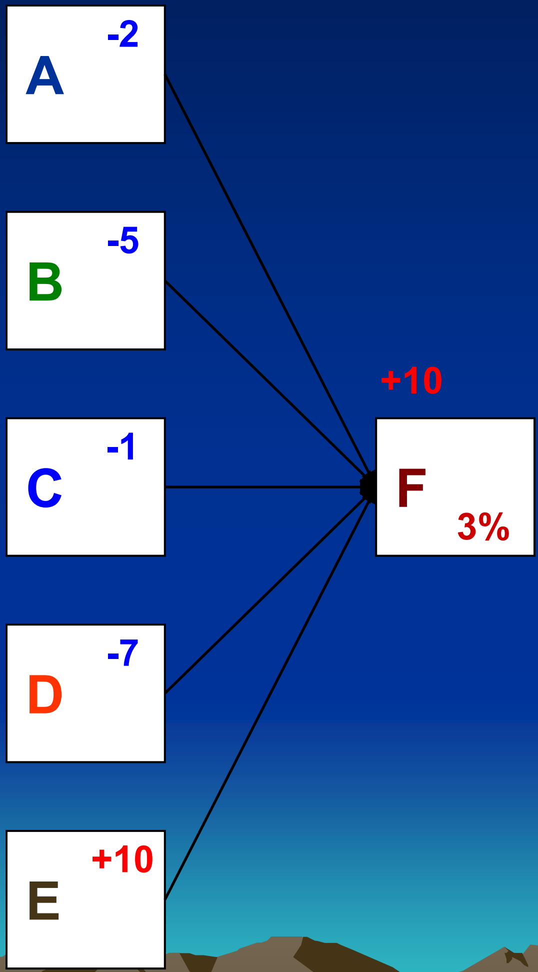
Probability– median an element of statistical file,
which is after sorting in the middle .Median of the set (1,5,2,2,1) is 2

100 „5-miniutes meeting happened.
How many times it took 5 minutes only ?

Colleague ask for a quick rendez-vous: „Do not worry, it will take maximum 5 minutes!“.

How long it takes on average?

Project environment is very complicated because of integration linkages and their dependencies



Probability of finishing tasks A to E in time is 50%. (50*50*….*50=3,125 %)

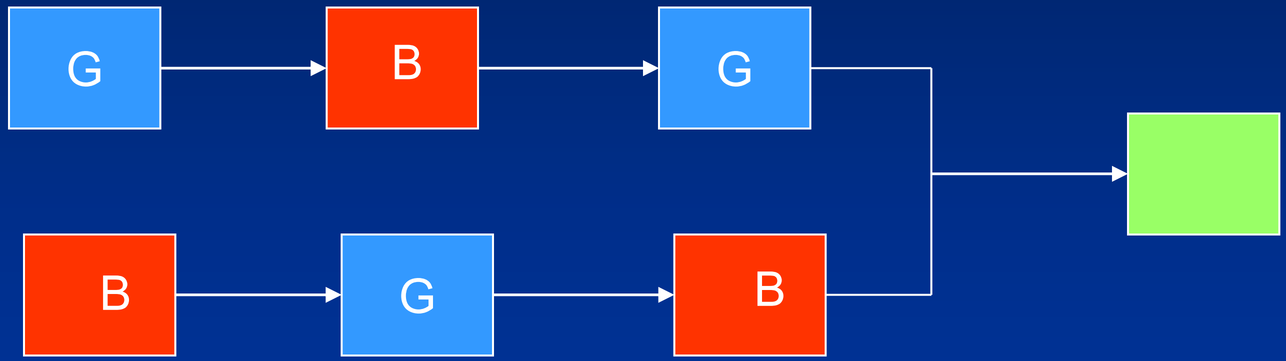
What is a probability, that task F will start in time ?

How the timely finishing of the tasks A,B,C and D will influence the integration point ?

a) saving are fully wasted

b) delay in one task will be immediately transferred to the next project task (activity) see +10

Project environment is very complicated because of integration linkages and their dependencies



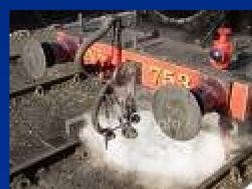
In order to start **B** in the upper branch, you have to finish **G** and also **B** in the lower branch. The probability, that **B** start in time is 50 % worse, than it was shown on the previous slide.

The project must be protected against influences of breakdowns (troubles)

Standard estimation with protecting buffers for every activity

activity 1 | B → activity 2 | B → activity 3 | B

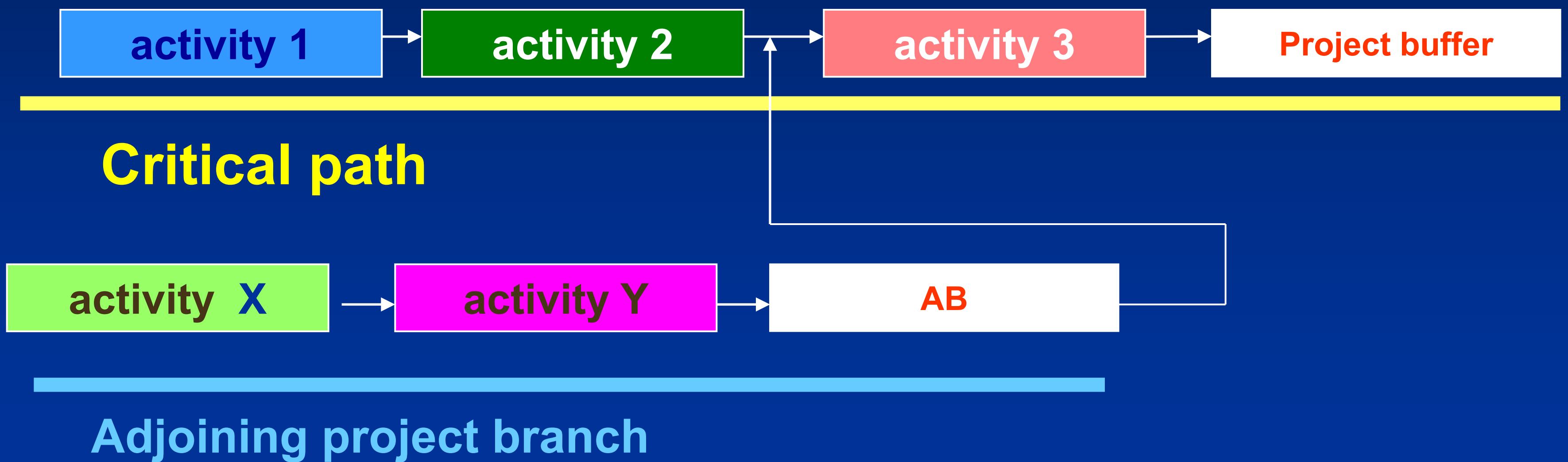
B = buffer



activity 1 → activity 2 → activity 3 → buffer

1st step : every activity is shorten to 50 % of its original time size.
2nd step : **critical path buffer** at the end of the project
will have size of 50 % of the total sum of saved time
created by shortening all partial activities

Critical path, adjoining branches of the project and adjoining buffers (AB)



Buffer serves as a safety tool to accumulate reasons of expected and unexpected delays

Critical Path (CP)

• Critical path is defined as **the longest way** (meaning time) from the starting point of the project graph to the ending point.

• Every project has at least one critical path

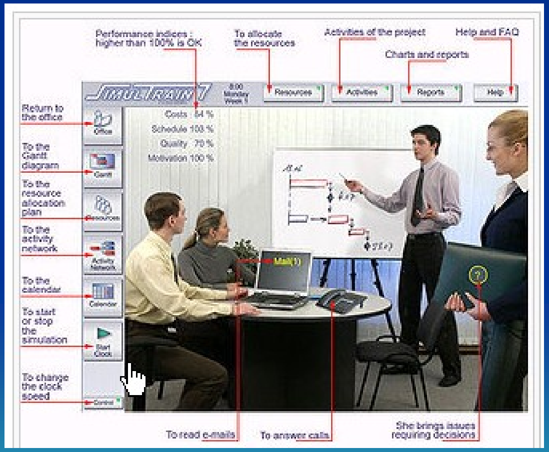
The rules of CP:

• Every delayed task on CP will essentially delay the whole project

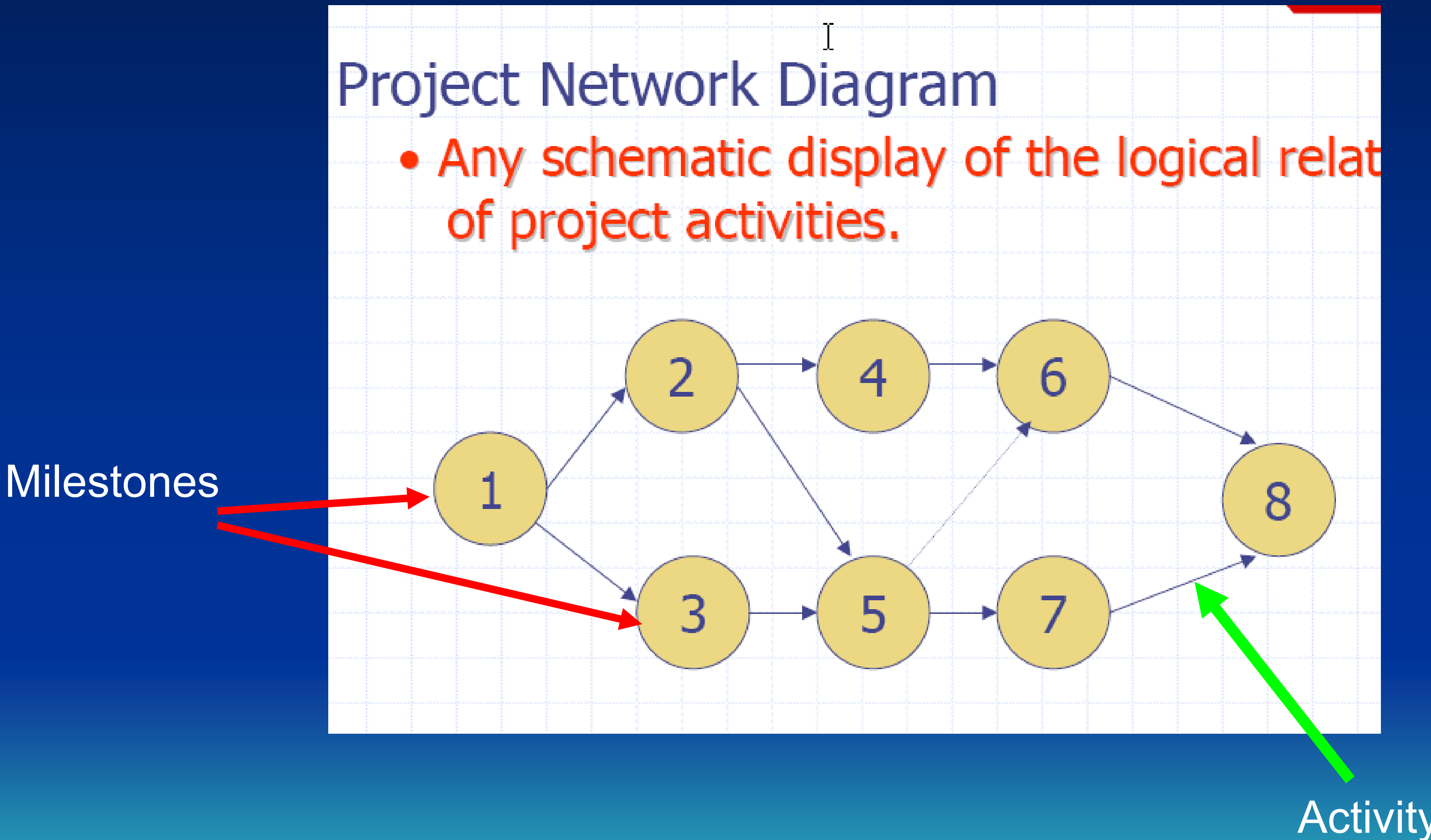
• Truncation of duration of any task on CP will shorten whole project

Critical Path (CP)

- **Critical Path Method**, abbreviated **CPM**, or **Critical Path Analysis**, is a mathematically based algorithm for scheduling a set of project activities. It is an important tool for effective project management.

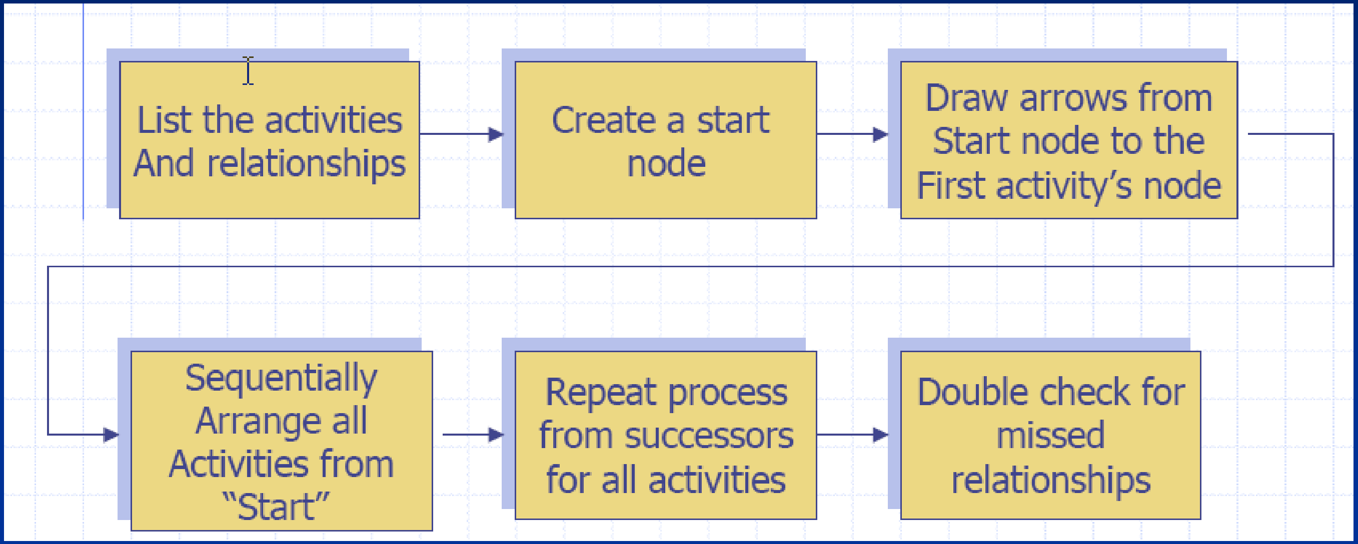


Critical Path (CP)



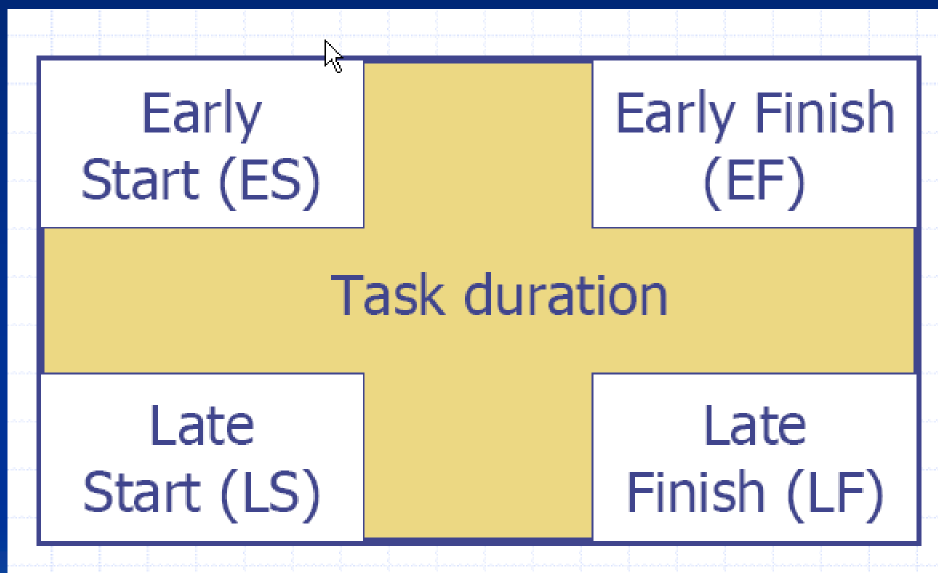
Critical Path (CP)

Building a diagram 1



Critical Path (CP)

Building a diagram 2



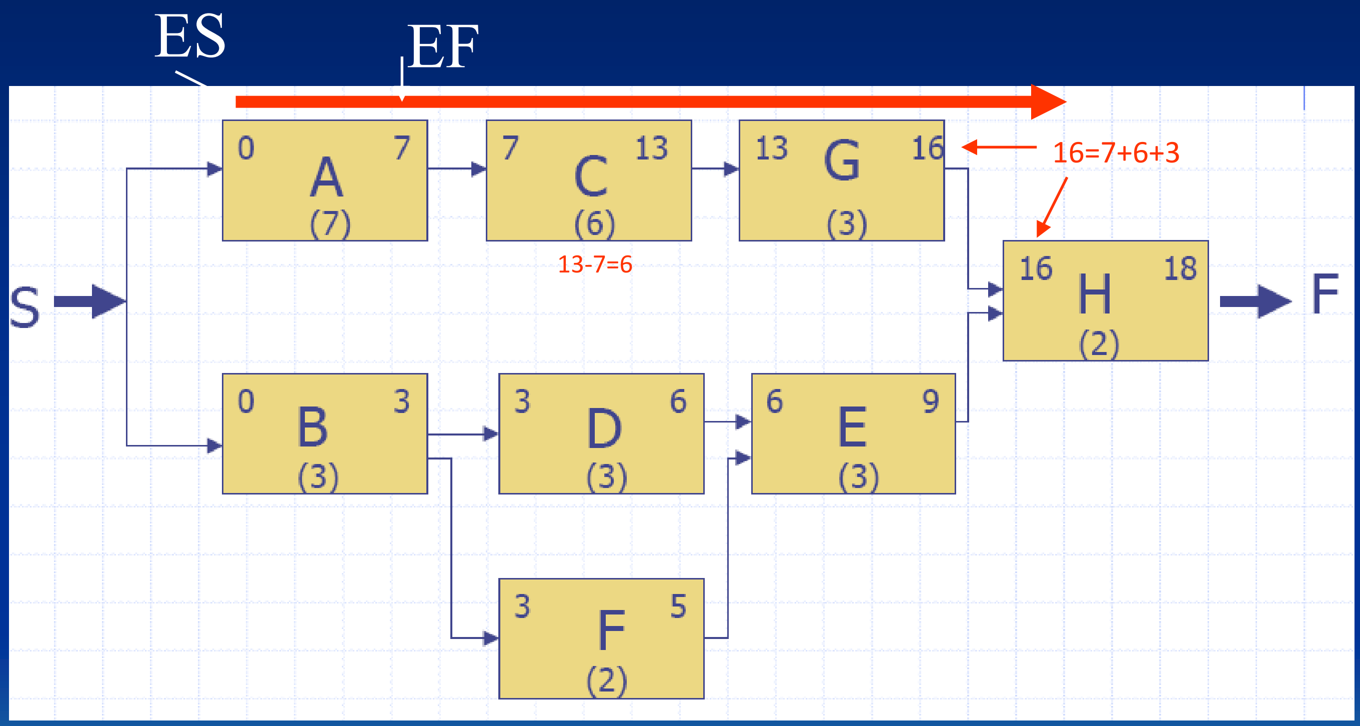
Critical Path (CP)

Building a diagram 3

Task ID	Duration	Dependency
A	7	
B	3	
C	6	A
D	3	B
E	3	D,F
F	2	B
G	3	C
H	2	E,G

Critical Path (CP)

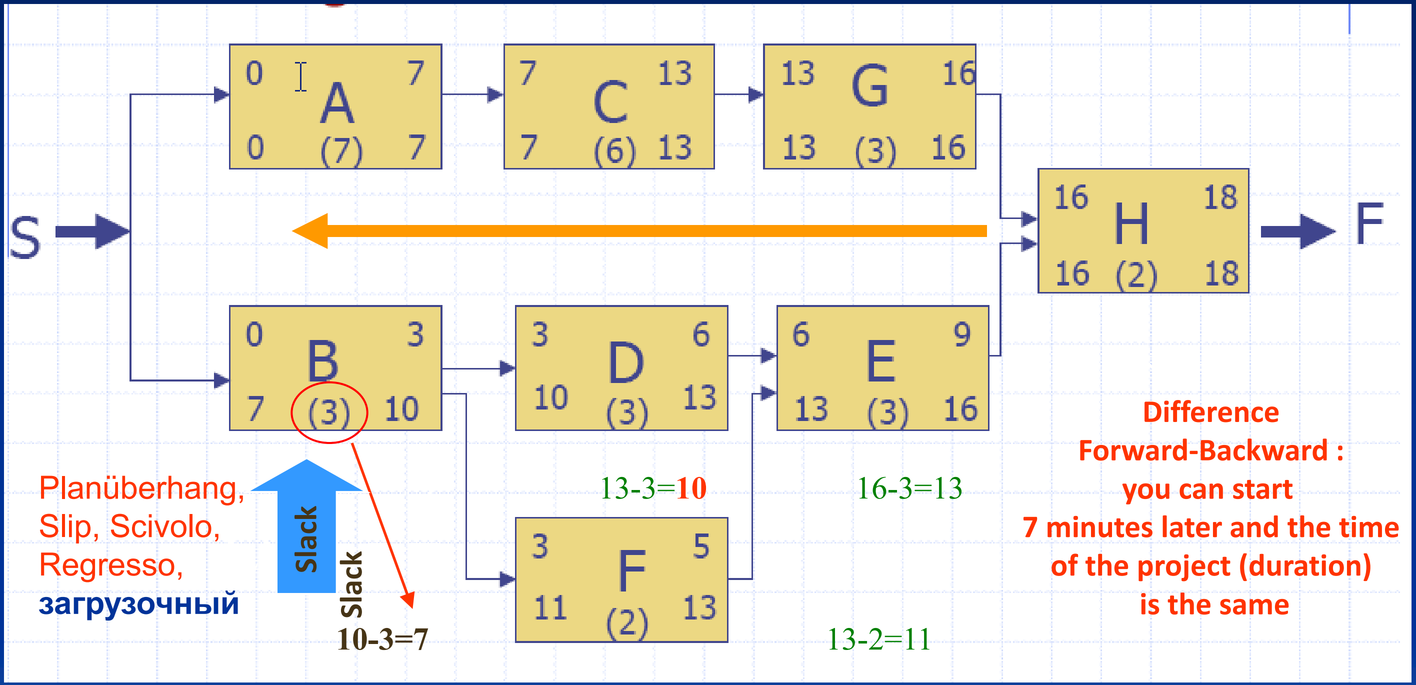
Building a diagram 4 – calculating the **FORWARD PASS**



Early Starts and Early finishes dates are calculated by means of **Forward Pass**

Critical Path (CP)

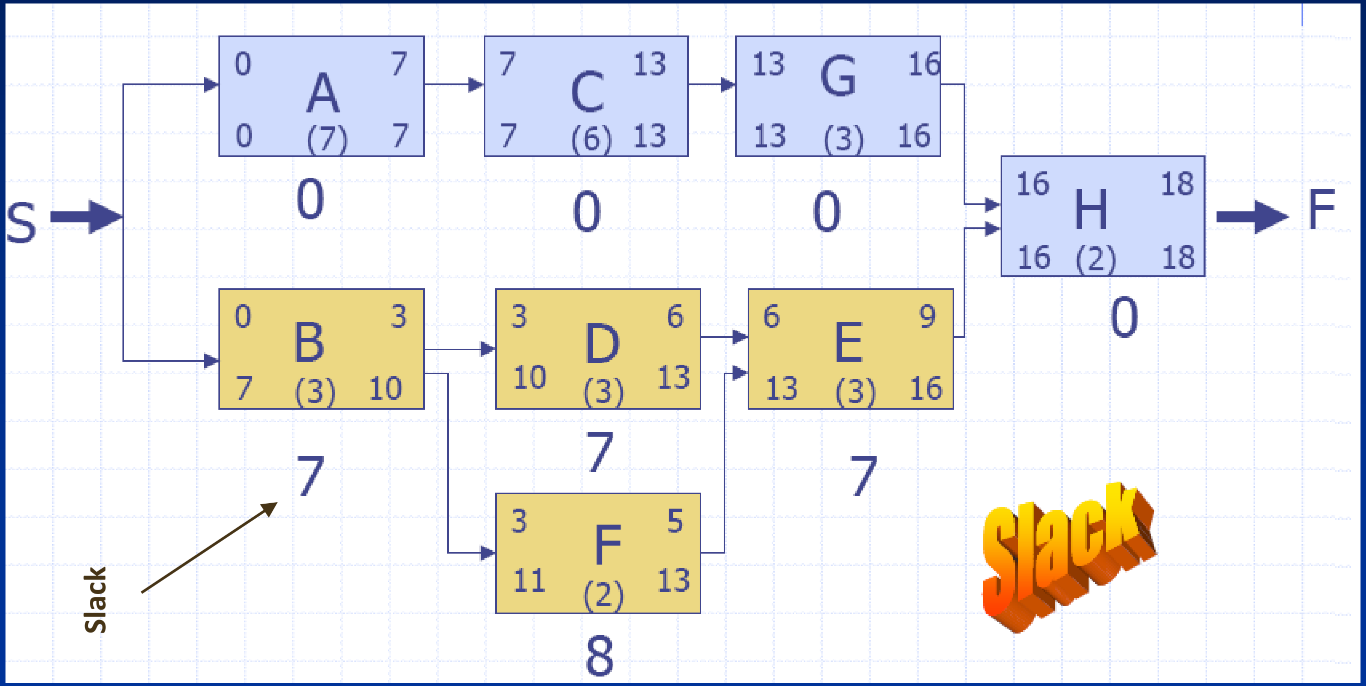
Building a diagram 5 – calculating the **BACKWARD PASS**



Late Starts and Late Finishes dates are calculated by means of Backward Pass

Critical Path (CP)

Building a diagram 6 – calculating the **FLOAT(SLACK)/CP**



Free Float: Amount of time a single task **can be delayed** **without** delaying the early start of any successor task =LS-ES or LF-EF

Critical Path (CP)

CPM is helpful in :

- Project Planning and control.
- Time-cost trade-offs.
- Cost-benefit analysis.
- Reducing risk.

Critical Path (CP)

Limitation of CPM :

- Does not consider resource capacities.
- Less efficient use of buffer time.
- Less focus on non critical tasks that can cause risk.
- Based on only deterministic task duration.
- Critical Path can change during execution.

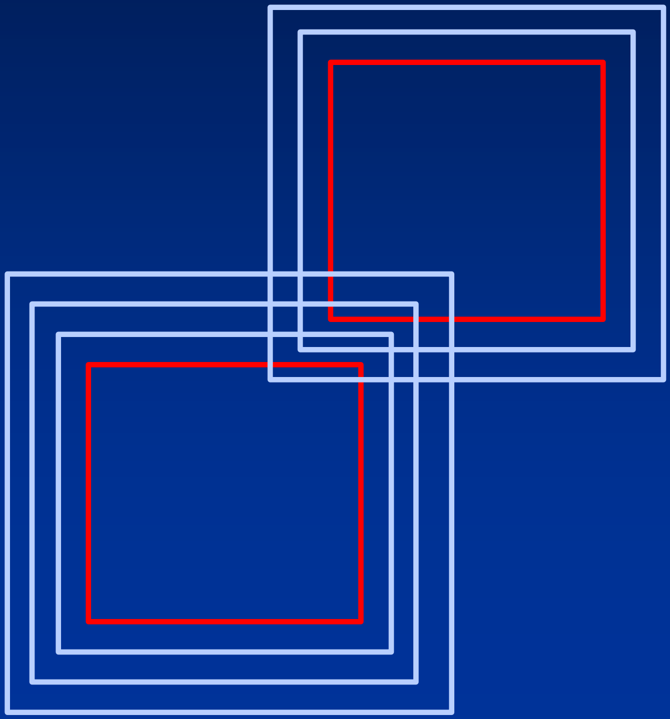
Multi-project Management

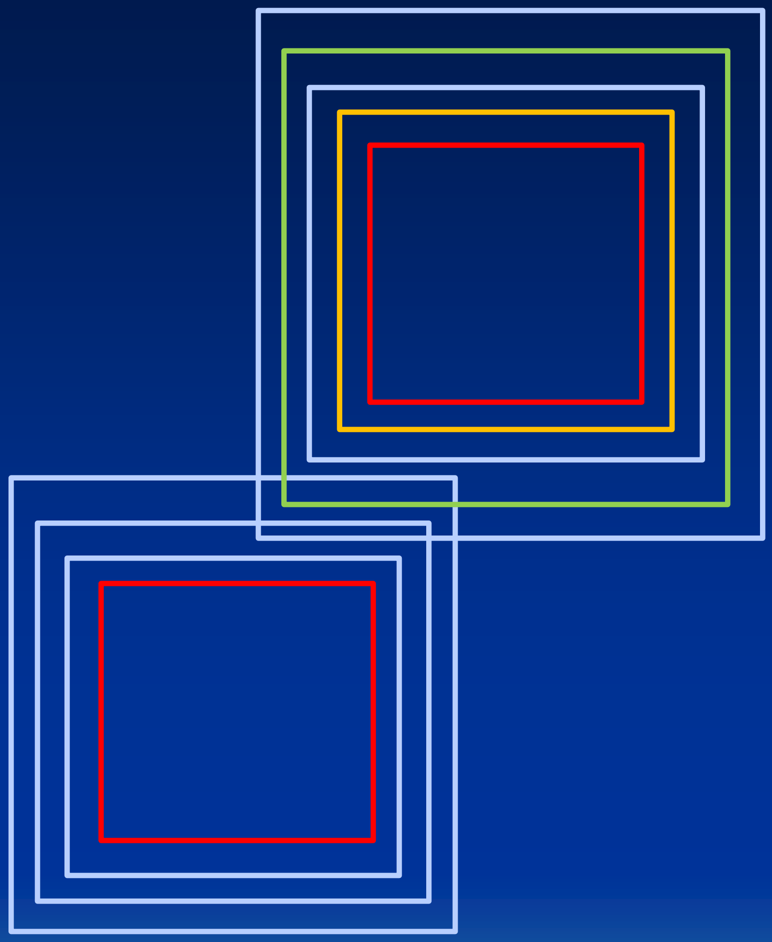
	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	w11	w12	w13	w14	DAP
Project 1															12
Project 2															12
Project 3															12
															36

Bad multitasking causes, that one project will be significantly longer and no other project will be shorter

K1	K2	K3

	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	w11	w12			DAP
Project 1															6
Project 2															6
Project 3															6
															18





Multitasking characterization

- people always **overestimate the length of their tasks**
- salesman offers impracticable terms (dates)
- The fight for reserves (capacities) causes, that all saved time is fully wasted (Student s syndrome)
- Reserves (if any) are used badly !!!!!!
- Bad use of reserves causes lack of transparent assignment
- Non transparent priorities are parents of bad multitasking
- Bad multitasking causes longer duration of all activities (tasks) and thus all the projects

CP definition (more in detail)

Critical path is defined as the longest way (meaning time) from the starting point of the project graph to the ending point

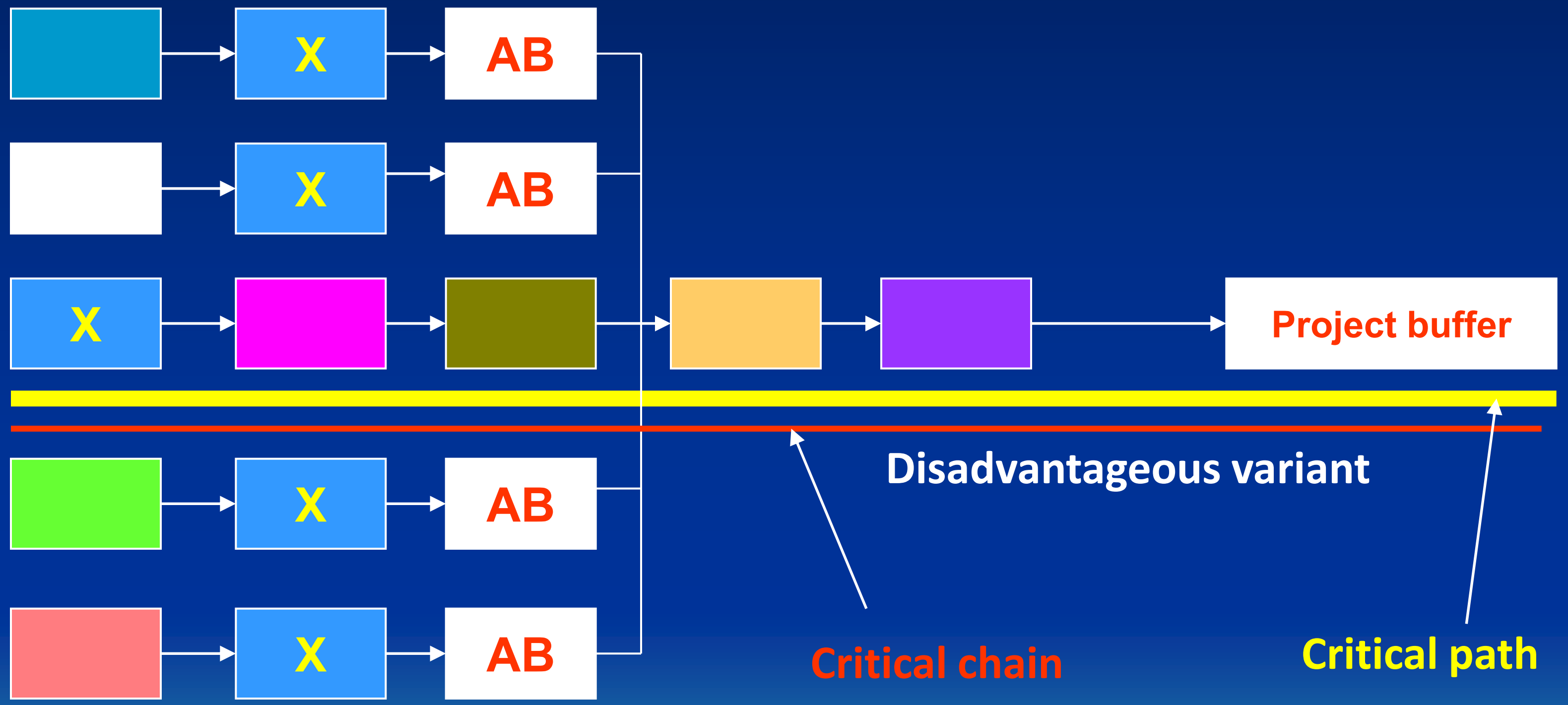
Critical path represents technological dependencies and given times of every task on Critical path inclusive of necessary condition for fulfilment of foregoing tasks (activities) framed by integration points.

Critical chain definition

In TOC the Critical chain is defined as the longest way (meaning time) from the starting point of the project graph (Gantt) to the ending point which takes into account **technological dependencies** as well as time of the tasks and moreover, **capacities of assigned resources**.

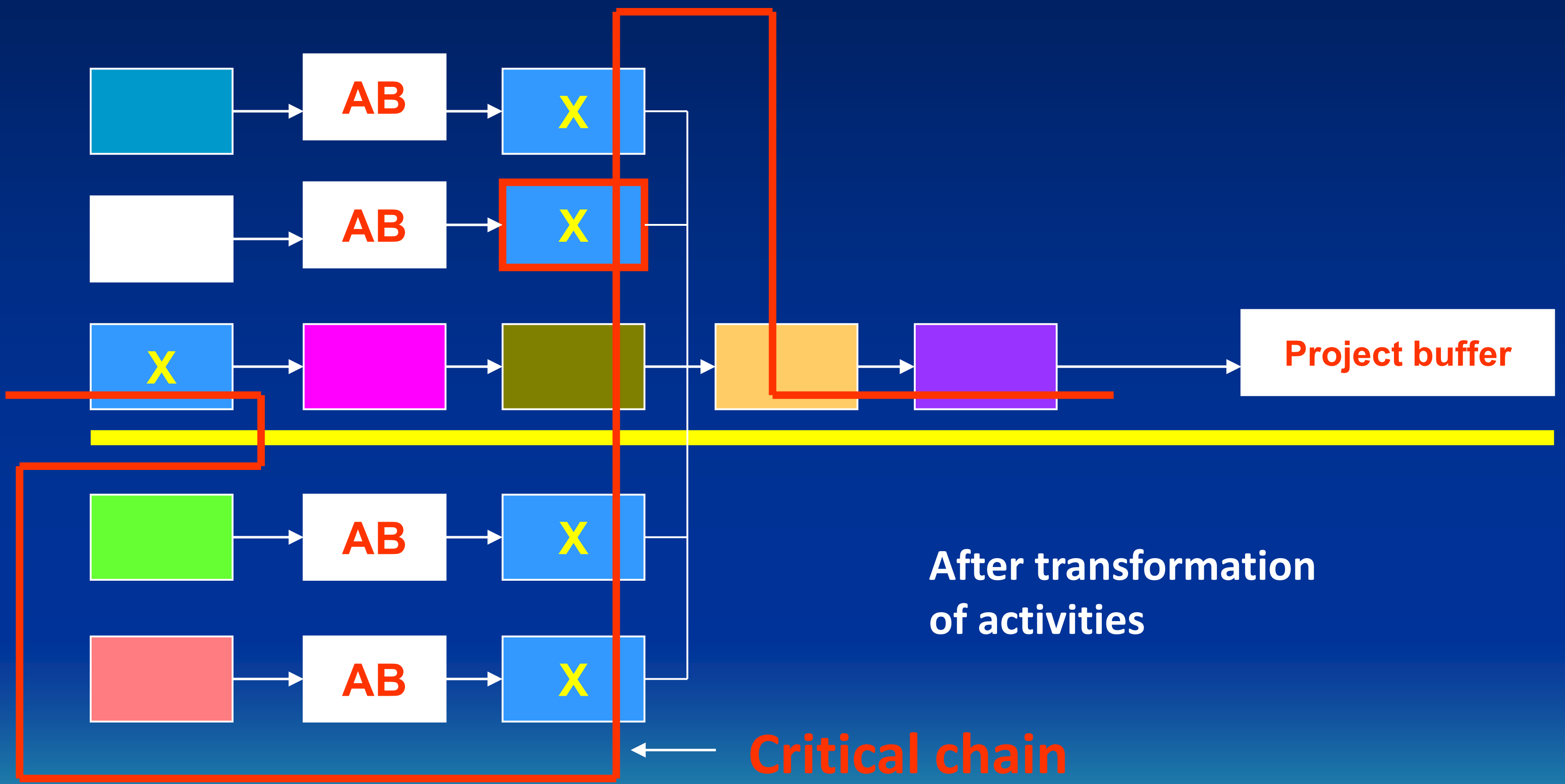
With infinite capacities of resources you can consider Critical path=Critical chain

Multi-project management and critical resources (CCR) used in more that one project branch



CCR = Capacity Constrained Resource = X

Multi-project management and critical resources (CCR) used in more that one project branch



Project management based on remainimg time in buffers – **Buffer Management**

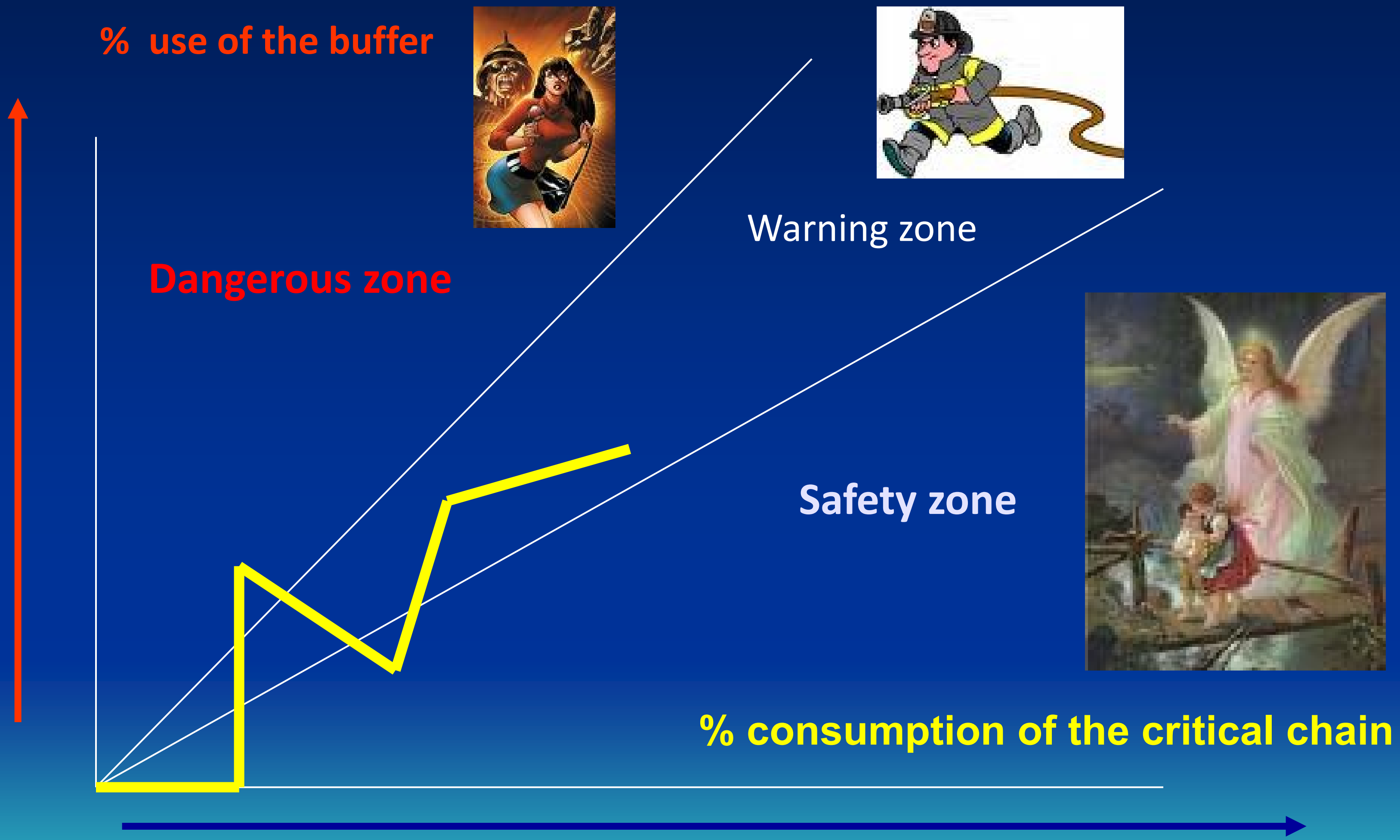
- Buffers are used for timely warning and that is to say predicting and avoiding future problems related to project deadlines (milestones)

- It is also used as a guideline for corrective actions

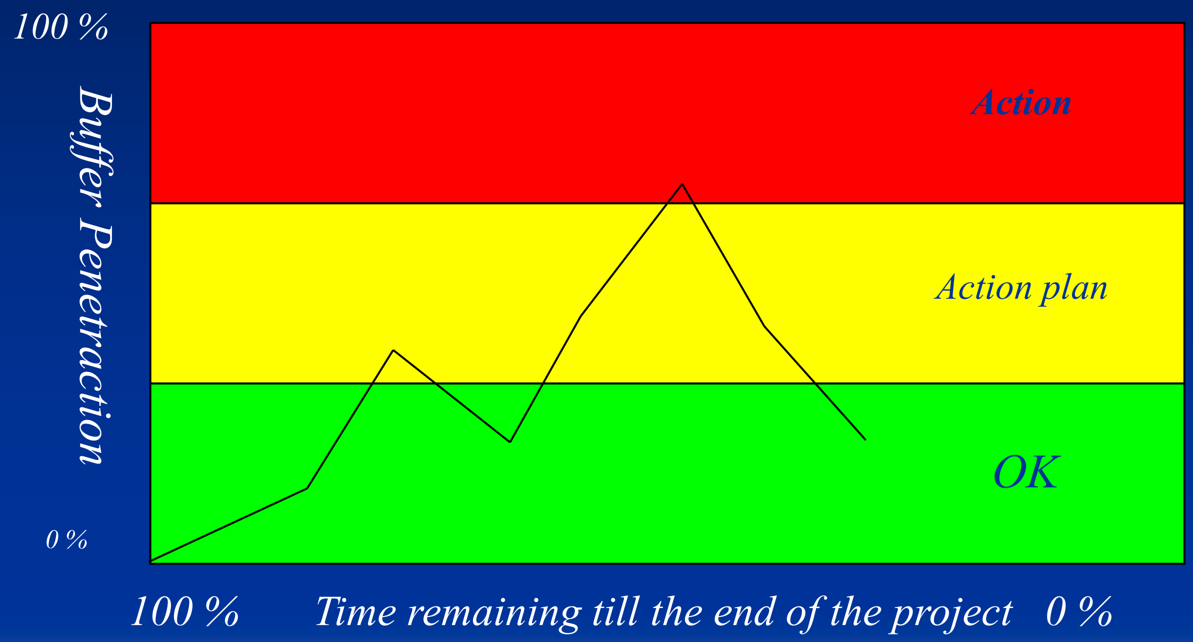
Basic metrics showing the project status

- The partial size of Critical chain (CC) fulfilled in days (in %)
- How much of buffer size was used to fulfil above mentioned partial size of CC ?
- Trend of project (buffer consumption graph- see next slide)
- Consumption of the financial buffer
- Priorities – bigger buffer penetration- bigger priority
- Adjoining branches have always lower priorities
- It is not allowed to create bad multitasking

Trends of the project



Trend of the project advancement – (another angle of view)

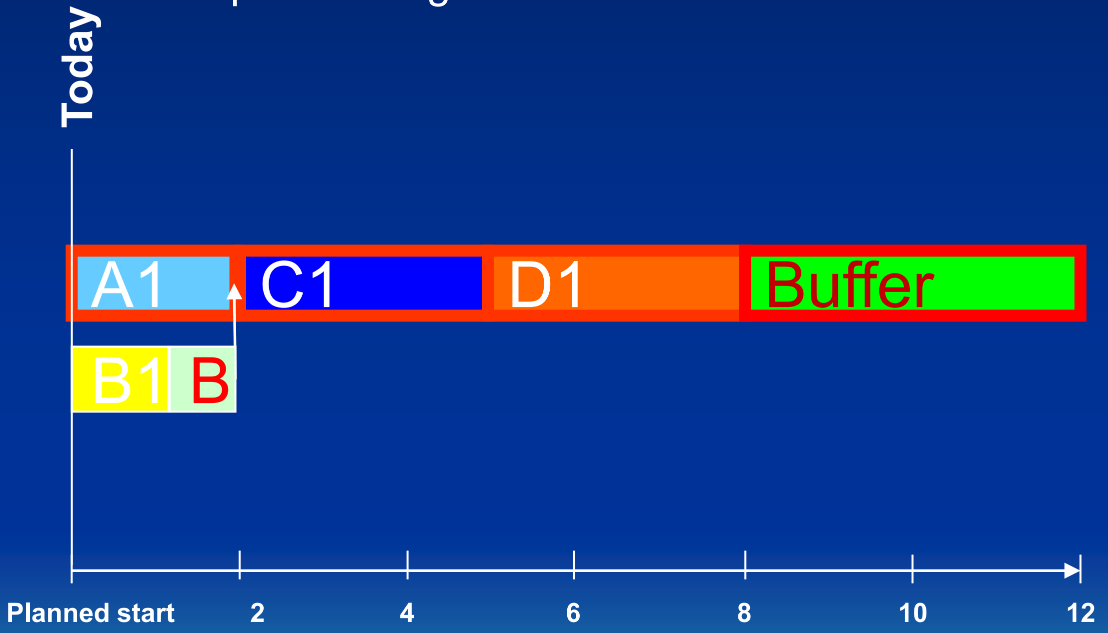


Resource: DP R.Jurka (2006); taken from LEACH, L., P. (2004), s. 12.

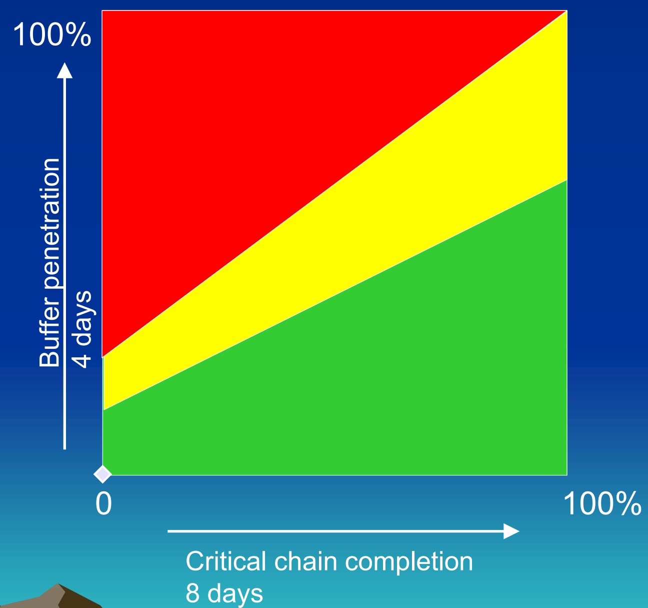
Planning - principles

We are working with plan , which takes into account different times of tasks :

- start of the tasks are changed based on termination of preceding tasks
- you have to react in project in such a way , that handover is done as a baton pass during races



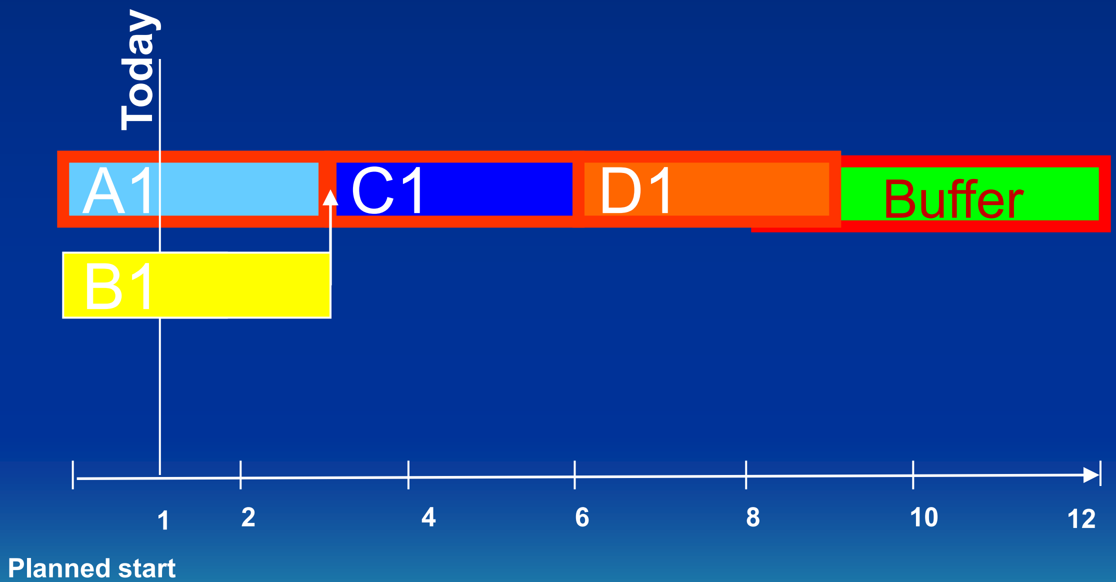
Plan with sharp deadlines with buffers 50% (2+3+3=8 8+4=12)



Planning - principles

A1 did not started yet , because this A1 resource is still working on another order (task), which may be part of another project

B1 already started an for completion will need another two days



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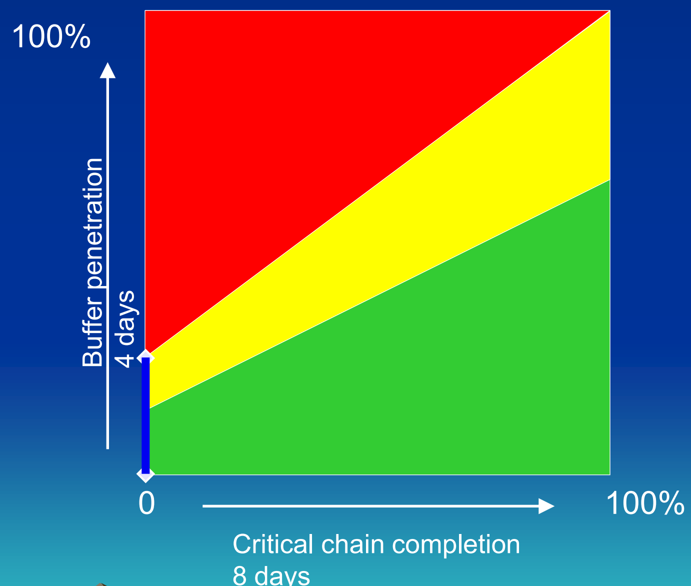
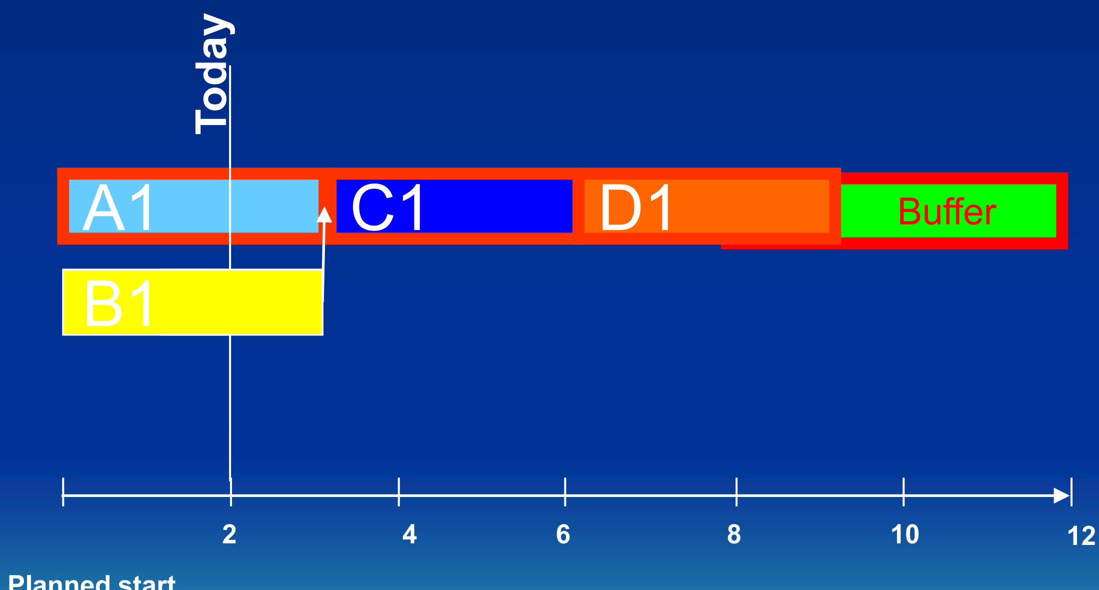


Resource MPM systems

Plan 2nd day after start

A1 started and will be finished (completed) tomorrow.

B1 will be finished (completed) tomorrow



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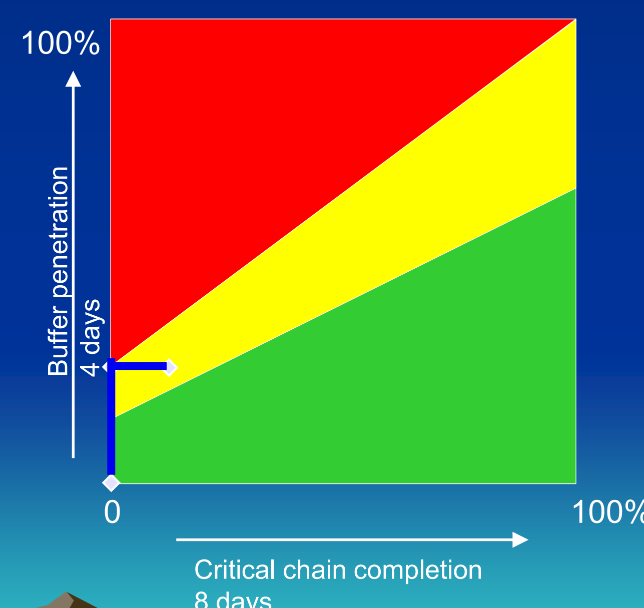
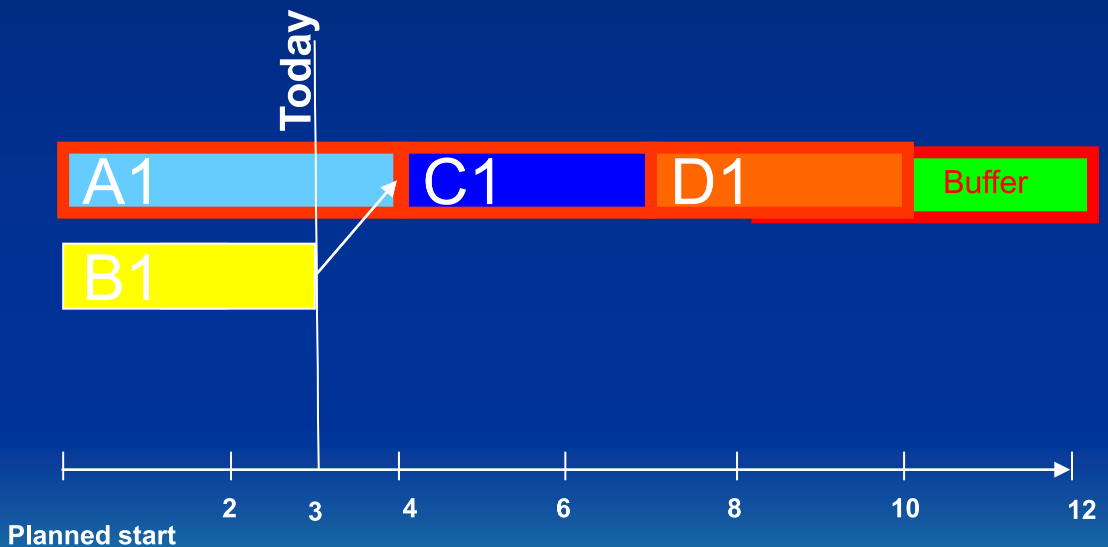
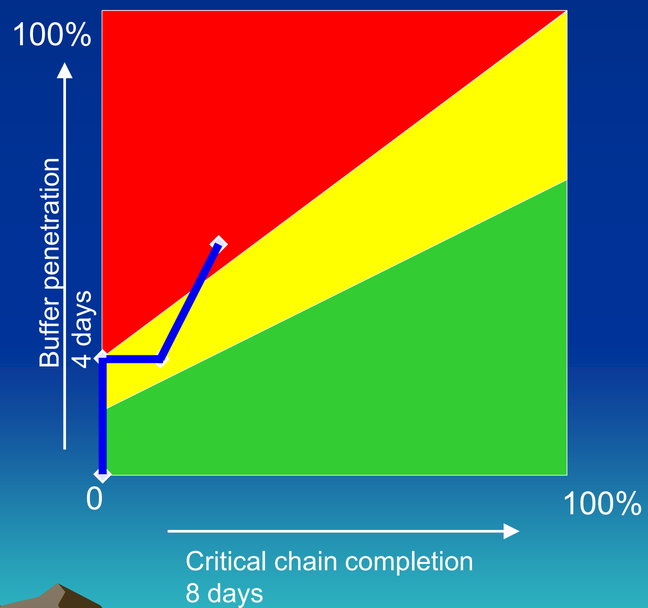


Plan 3rd day after start

A1 despite all efforts resource A1 needs another day to complete.

B1 has completed his work with 2 days delay

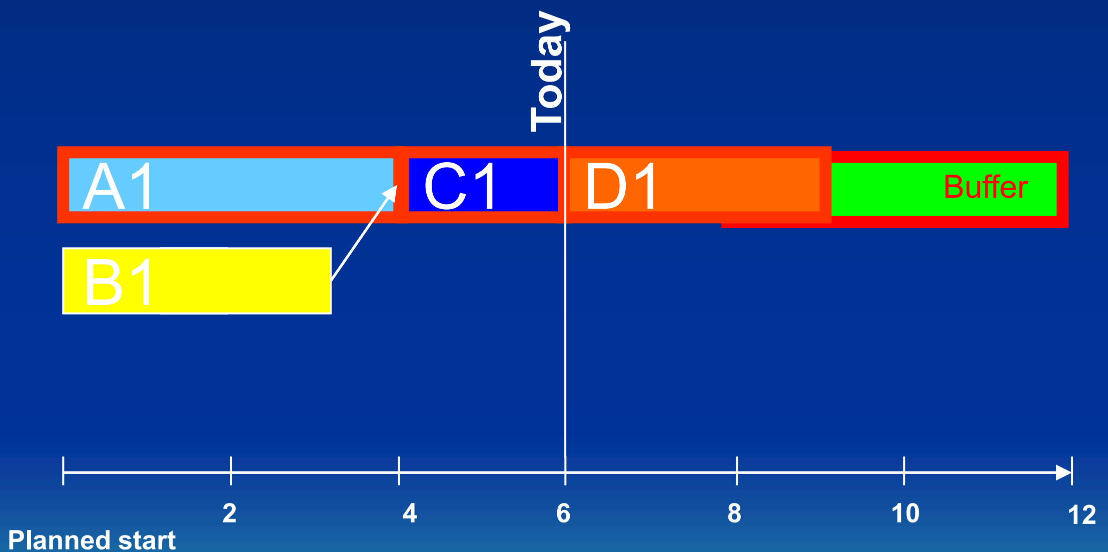




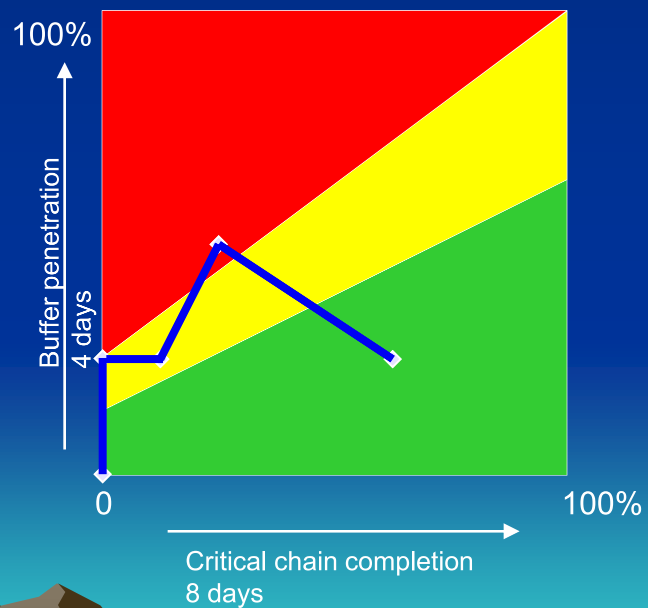
Plan with sharp deadlines with buffers 50% (2+3+3=8 8+4=12)

Plan 6 day after start

A1 completed his task with 2 days delay
B1 completed his task with 2 days delay
C1 completed his task 1 day earlier than expected (planned)
D1 will start to work tomorrow

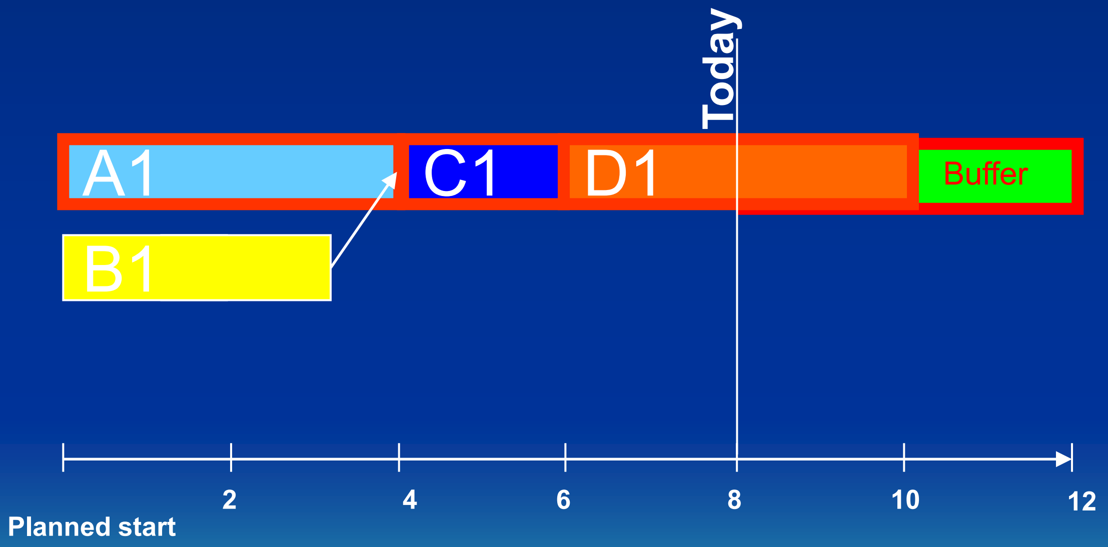


Plan with sharp deadlines with buffers 50% (2+3+3=8 8+4=12)

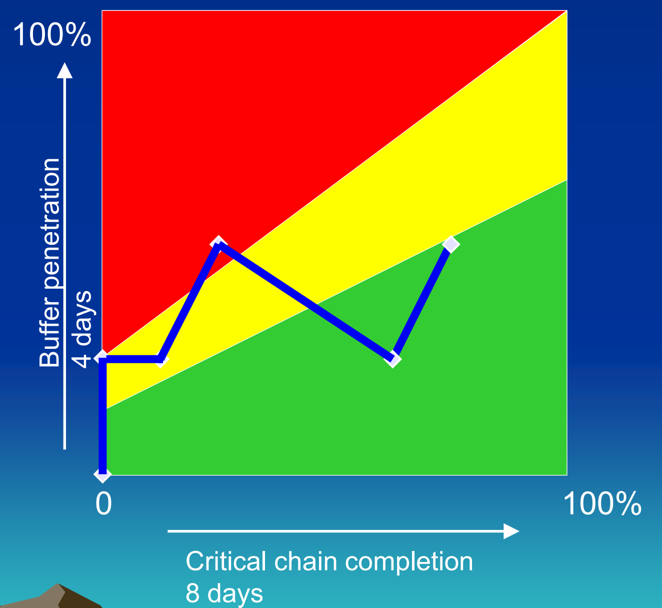


Plan 8 day after start

A1 completed his task with 2 days delay
B1 completed his task with 2 days delay
C1 completed his task 1 day earlier than expected (planned)
D1 needs one day more to complete

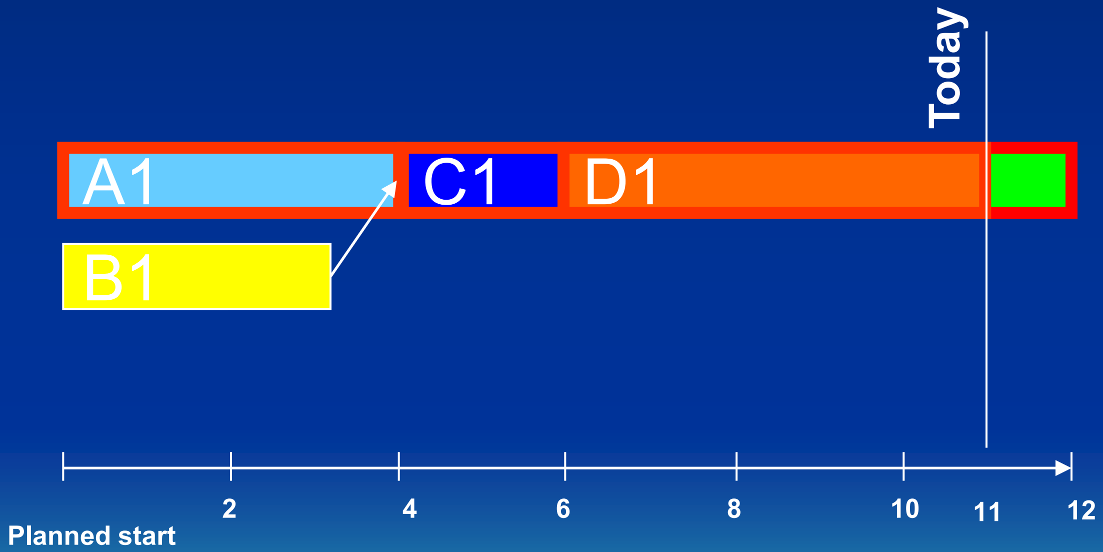


Plan with sharp deadlines with buffers 50% (2+3+3=8 8+4=12)

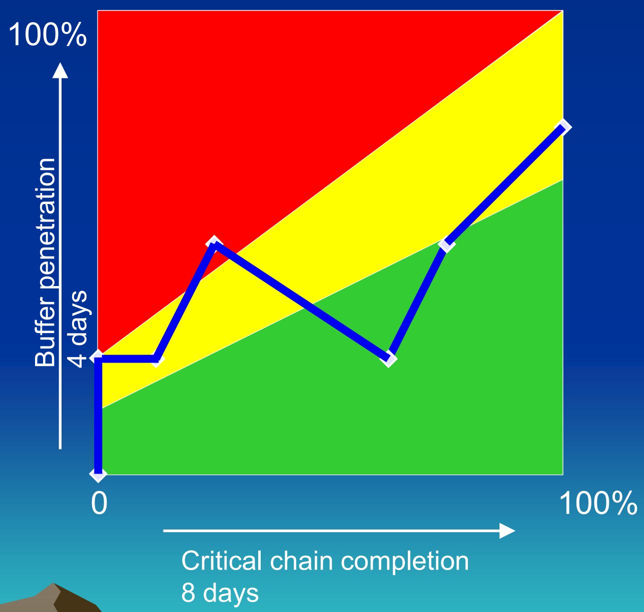


Plan 11 day after start

A1 completed his task with 2 days delay
B1 completed his task with 2 days delay
C1 completed his task 1 day earlier than expected (planned)
D1 completed his task with 2 days delay



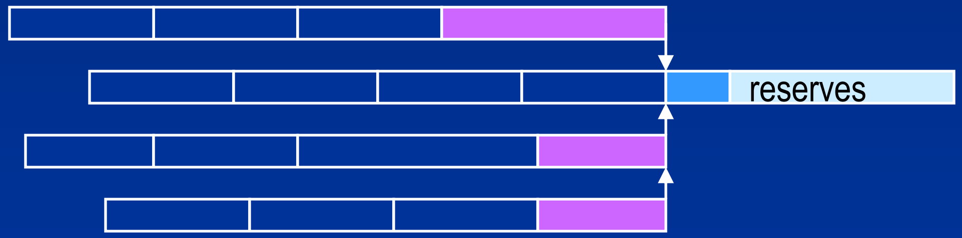
Plan with sharp deadlines with buffers 50% (2+3+3=8 8+4=12)



Clear way to setup and control priorities.

Setup of priorities of partial tasks based on assigned reserves.

Do as good as you can, but only where it is needed



Project Quick, resources A-E and activities X,Z,X,W, and V

Resource and activity	Median of the required time
A-Y	**10 days**

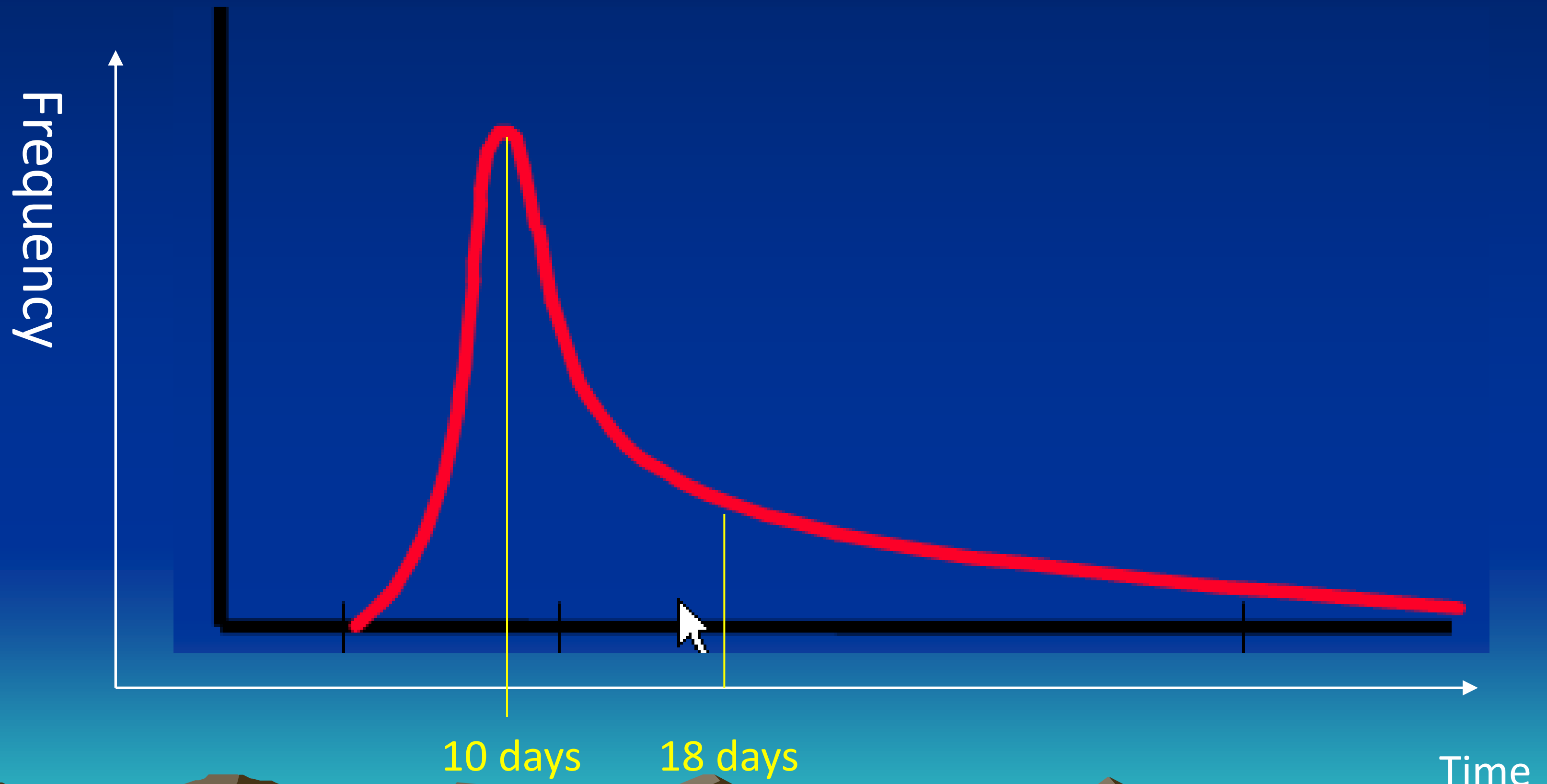
Activity=Task

You can say, that 50 % of any activities finish earlier, and other **50 %** will be delayed, meaning, that **10 days** represents **50 %** of the estimated time for chosen activity
Project managers decided, that activity ends if **90 %** of estimated time will be consumed. It means, that they add a time buffer of **8 days** (for the safety reasons). 10 d= 50%, 20d=100%, 2d=10%, 20d-2d=18d, 18d-10d=8d

A-Y	B-Z	C-X	D-W	E-V

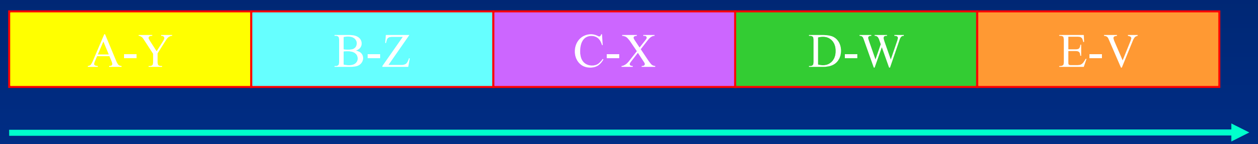
5 x 10 days=50 days

Time distribution

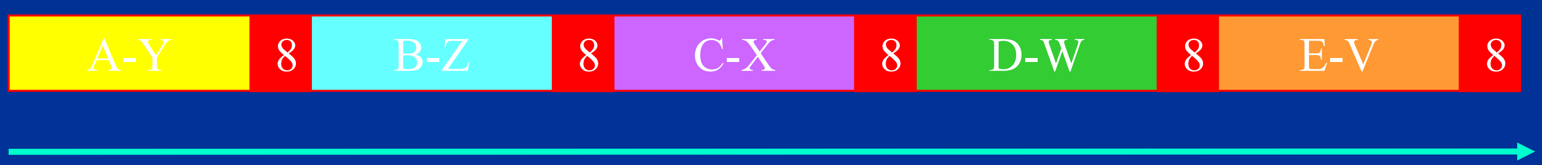


Five activities (tasks) and applied modifications

- If we consider for every activity time buffer 8 days we will get :

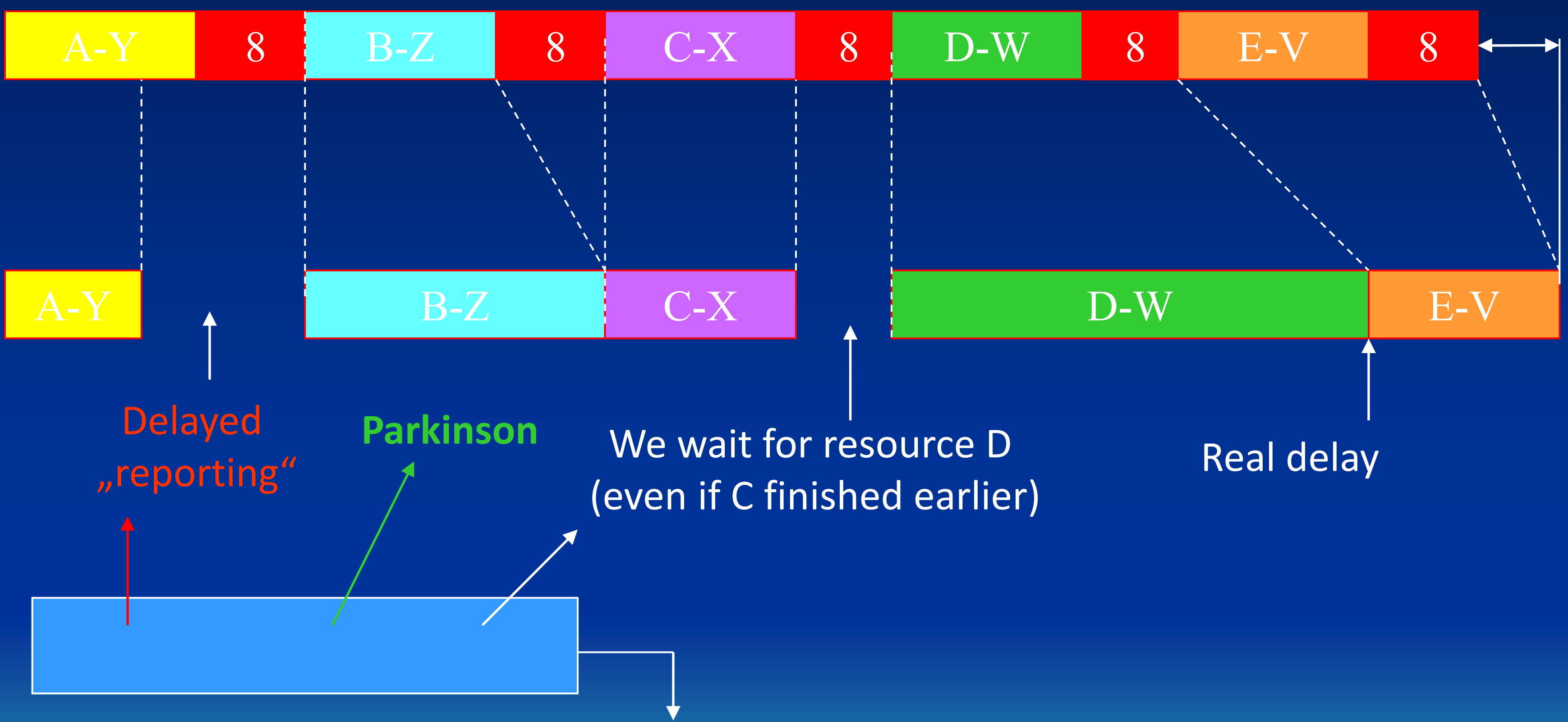


5 x 10 days= 50 days



5 x 18 days= 90 days

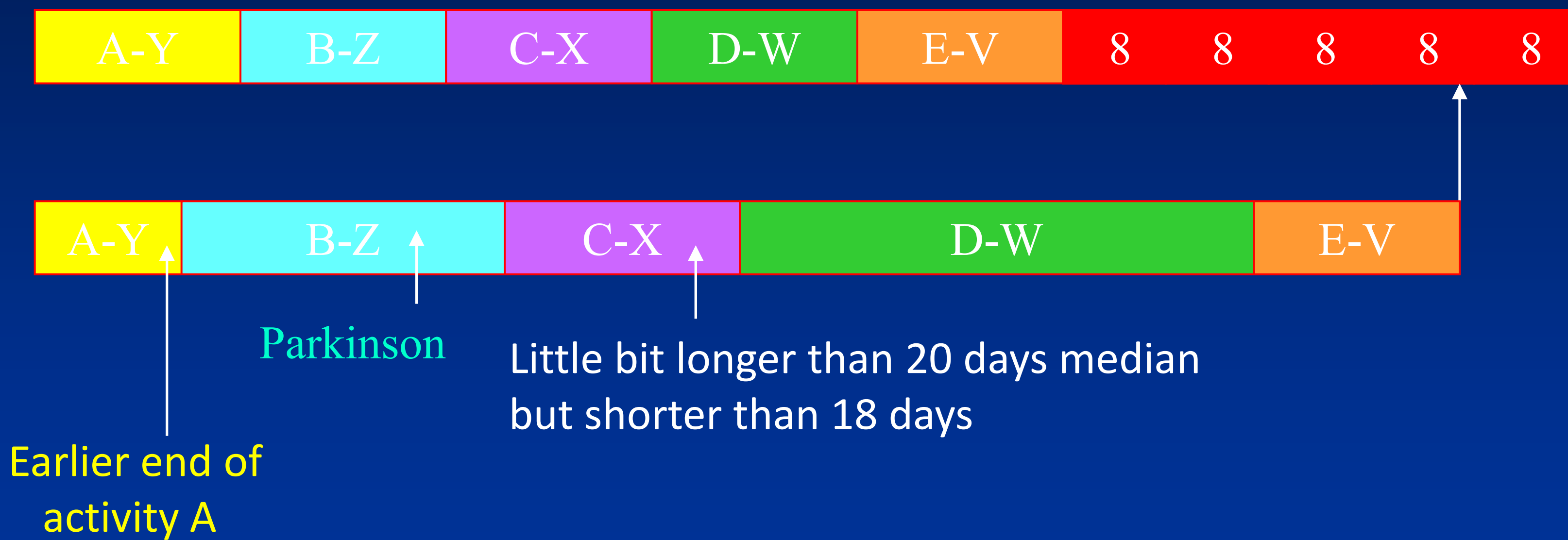
Five activities and modifications (added buffers) and four types of troubles



No one trouble causes project delay taking into consideration planned delivery date (agreed date of the project).

Dissipation of acquired time reserves was caused by company strategy saying strictly stick to the planned project schedule (example of rigid management)

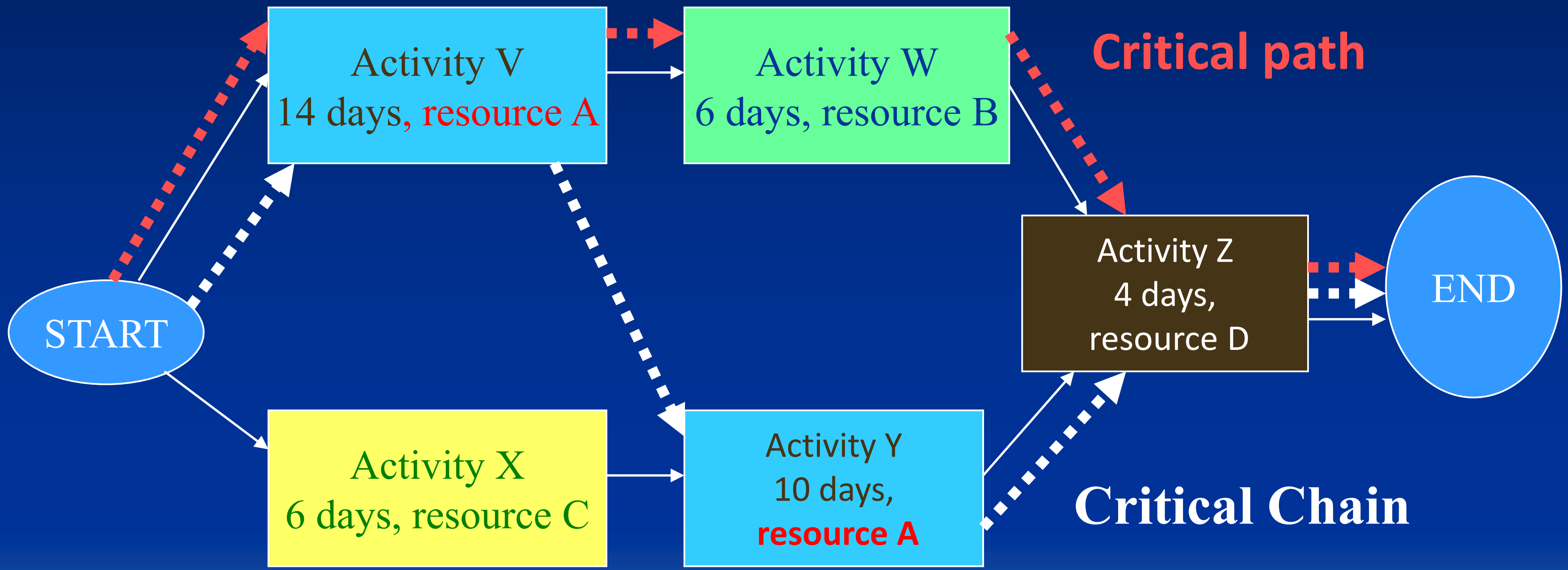
Five project activitiesp(tasks) after another modification (buffers united to one and placed to the end of the project)



8 8 8 8 8 = CPB=current project buffer = 40 days

8 8 4 = new buffer = 50 % out of CPB, which makes CPB/2

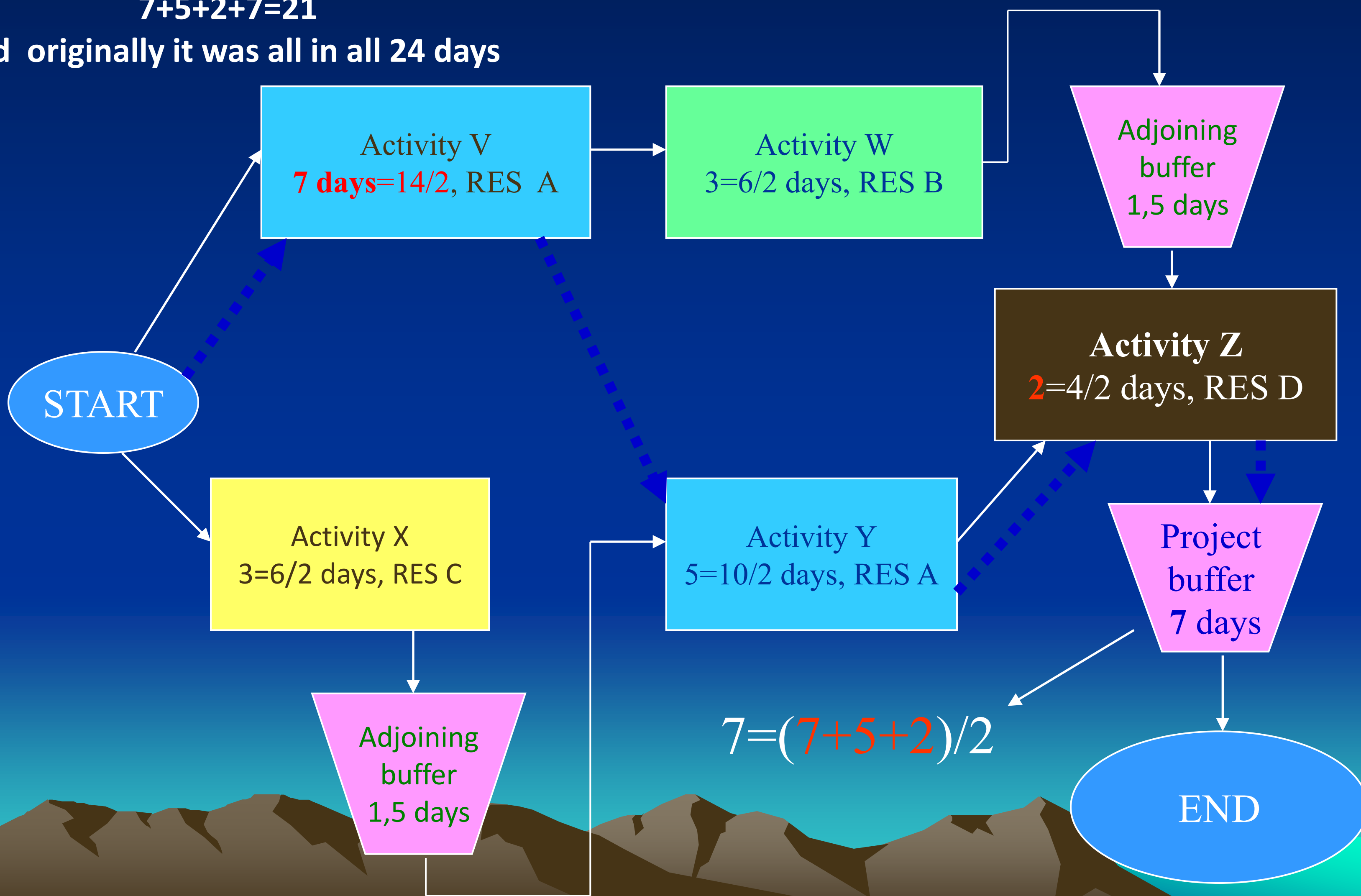
Critical path- Critical chain



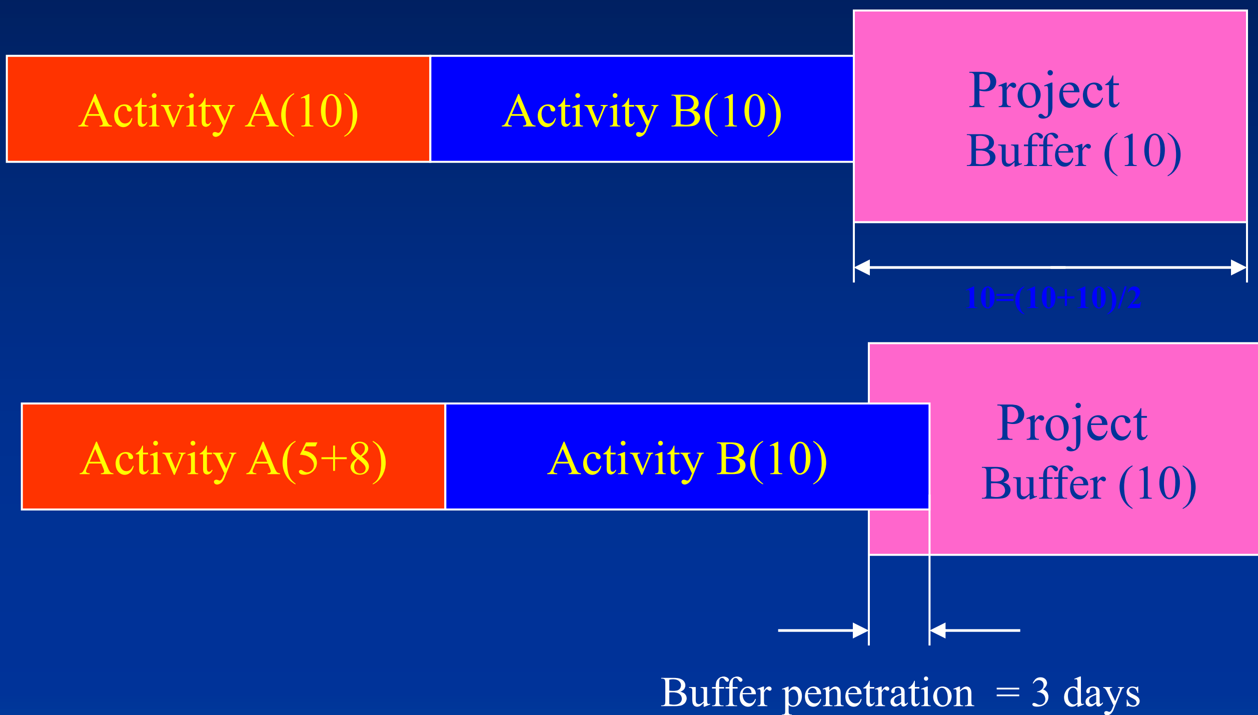
Project is considered as successful if is finished in expected time and financial budget is not exceeded

Critical chain with buffers

Length of the Critical Chain:
7+5+2+7=21
and originally it was all in all 24 days



Buffer consumption

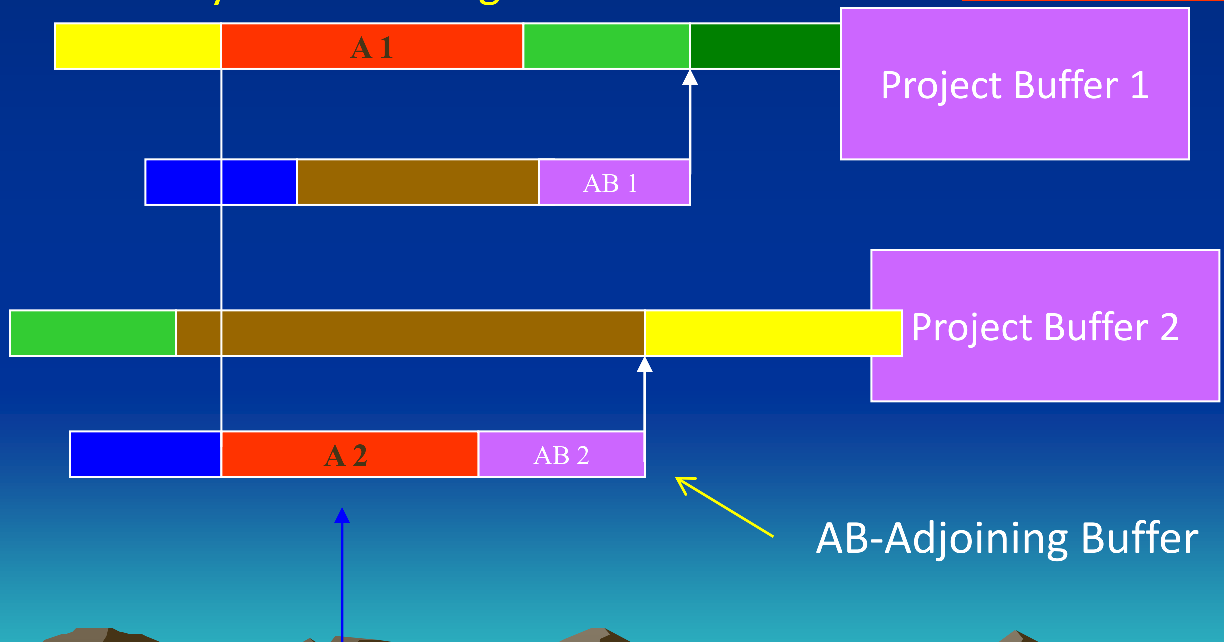


Rate of penetration is used to assign priorities to the partial activities

PB-Project Buffer

Priorities assigned to resources

- If one resource have to be assigned to two activities starting in the same moment so the first activity which will start is the one belonging to the project with bigger project buffer penetration
- If none of all project buffers were penetrated with previous activities, so the first starts this activity which belongs to the critical chain.

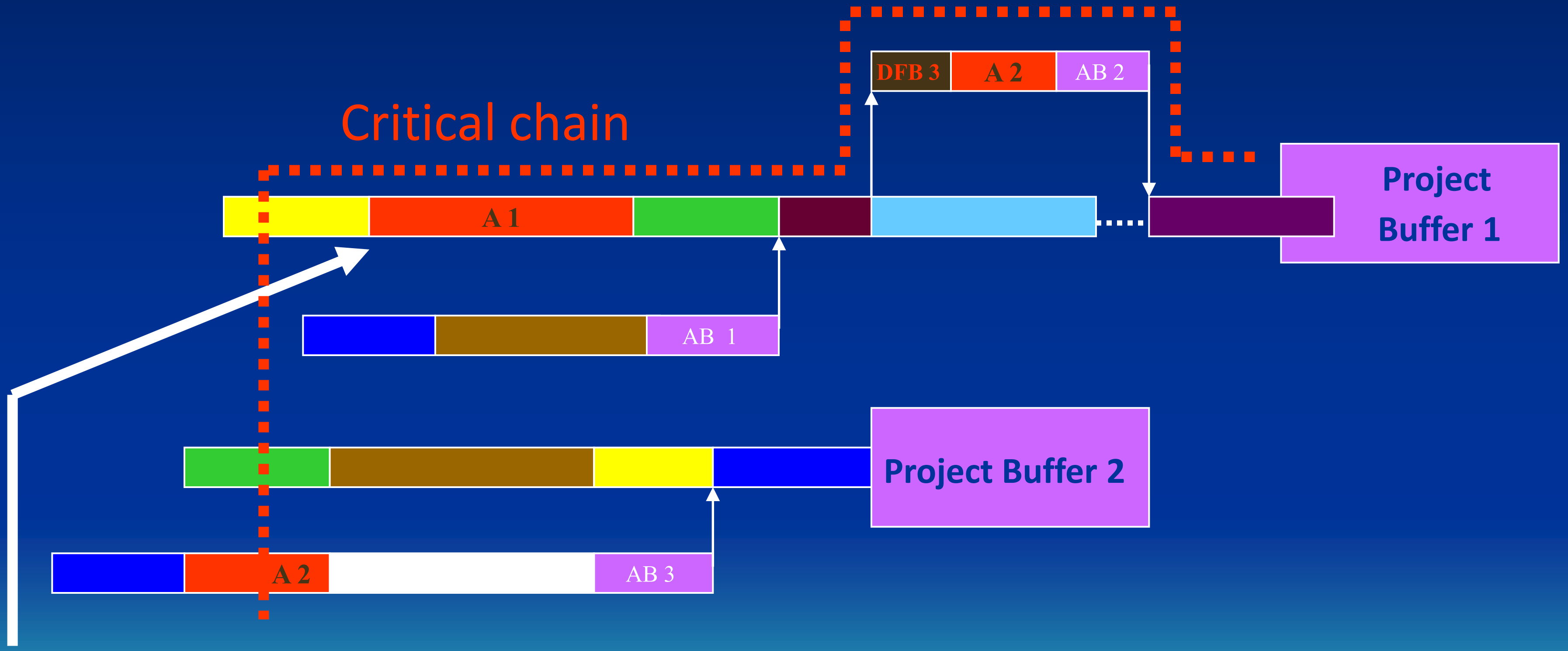


A2 starts first because PB 2 is partially consumed (penetrated)

PB-Project Buffer

AB-Adjoining Buffer

Priorities assigned to resources



This activity starts first because it is a part of the Critical chain and Project Buffer 1 is penetrated

Main benefits of the Critical Chain (CC) usage

- Every single project ends significantly earlier, than projects where other project management methods than CC were applied

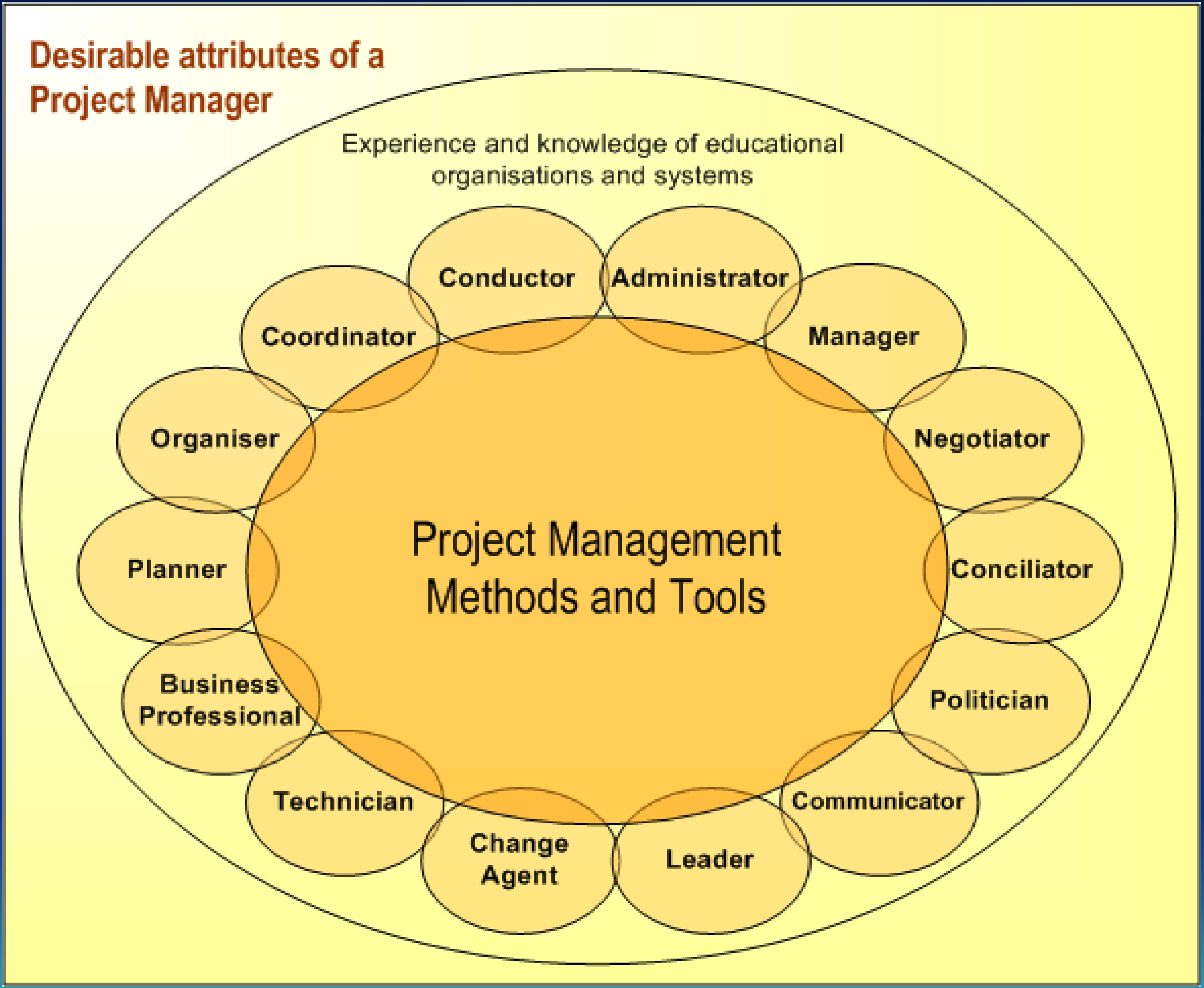
- Total time needed to end more project than one is markedly shorter

- Promised delivery times are fulfilled with higher rate of credibility

- You will have more free capacity of all used resources

Main benefits of the Critical Chain (CC) usage

- Better initial estimation about project timing and thus bore accurate planning
- During starting of the projects you did not meet any problem taking into consideration drum resource
- Decrease of unfavourable effects such as Student syndrome, Murphy attacks and impacts of Parkinson s laws by redeployment and integration of all buffers to one and only one project buffer at the end of the project
- Utilization of benefits caused by earlier ended activities
- Use of reporting system which provides you with valuable information of buffer penetration , the extent of time reserves and thus better helping system for assigning priorities


Desirable attributes of a Project Manager
Experience and knowledge of educational organisations and systems
Conductor
Administrator
Coordinator
Manager
Organiser
Negotiator
Planner
Project Management Methods and Tools
Conciliator
Business Professional
Politician
Technician
Communicator
Change Agent
Leader

Thanks for Your Attention