

## Lecture 16

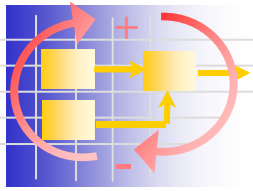


# Project Monitoring and Schedule Variance Control Using the Critical Chain Method

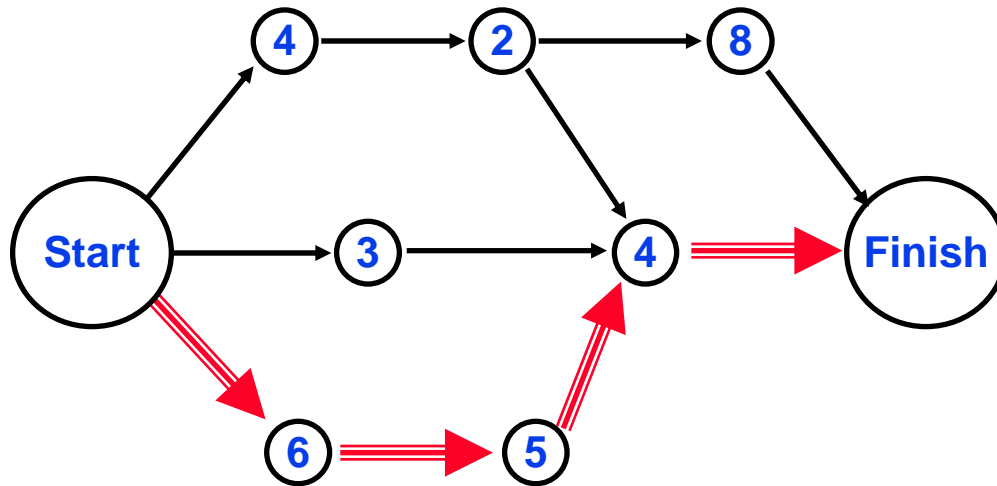
October 28, 2003

Prof. Steven D. Eppinger  
Presented by Prof. Olivier de Weck  
Massachusetts Institute of Technology

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# Traditional Project Control

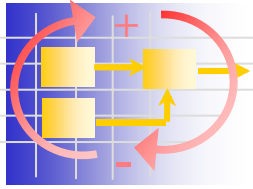


(days) activity and duration

activity precedence  
→

critical path  
==>

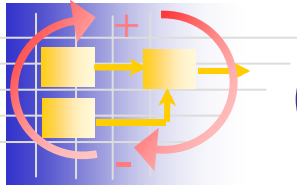
- Critical Path Scheduling
  - sequential/parallel task network
- Due dates and safety buffers
- Focus attention on critical path
- Monitor task completion dates
- Later tasks crash to compensate for early delays



# Typical Result of Project Crashing

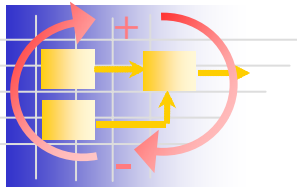
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- Schedule Slippage
- Budget Overrun
- Scope Reduction

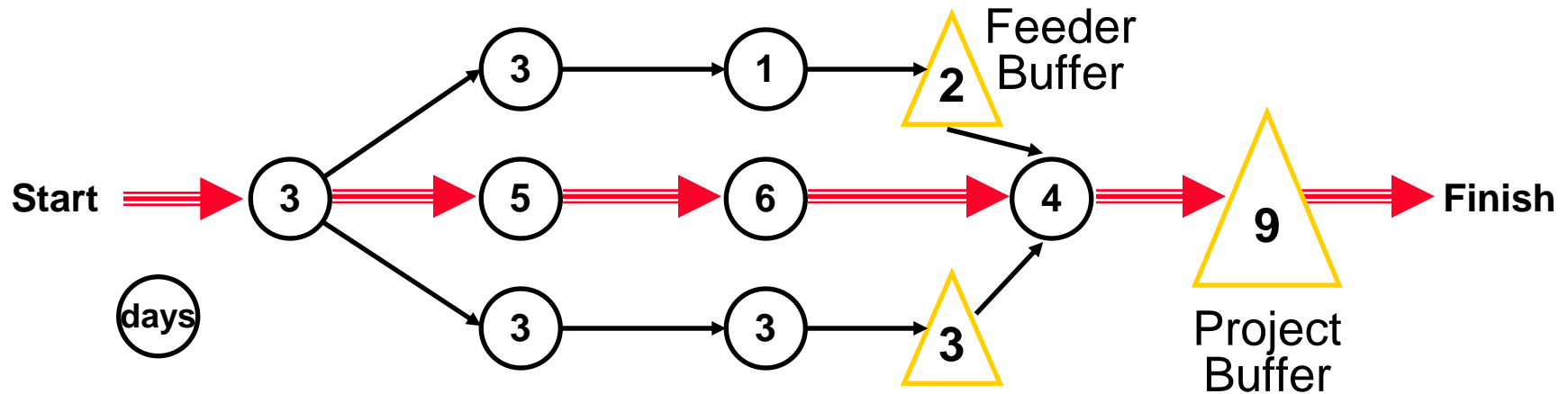


# Critical Chain Method

- The goal of the critical chain (CC) method is to avoid crashing by planning for the variance inherent in each task duration.
- This helps projects finish on time, within budget, and without cutting scope.
- Main points:
  - Don't waste safety time.
  - Aggregate safety time into project and feeder buffers.
  - Monitor the buffers to know when to control.
  - Concentrate on the constraint of the project: the longest chain of dependent tasks or resources.
  - Need a cultural change in how to manage projects and evaluate team members.
- Reference:
  - E.M. Goldratt, *Critical Chain*, North River Press, 1997.

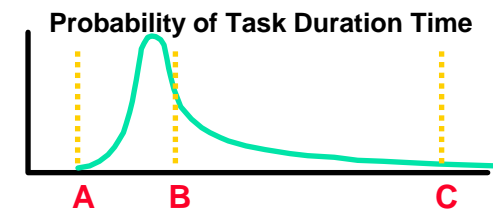


# Critical Chain Method

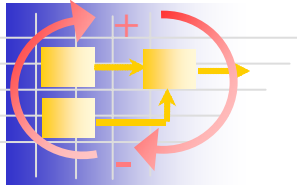


- Start with a sequential/parallel network.
- Use 50/50 (median) task duration estimates.
- Compute the critical path, noting resources.
- Insert feeder and project buffers as safety.
- Ideal buffers are 50% of path duration.
- Monitor buffer status.
- Reduce buffers when tasks overrun.

**critical chain** →

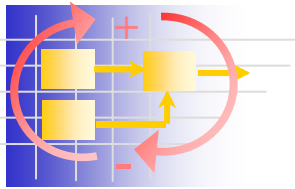


Ref: E.M. Goldratt, *Critical Chain*, North River Press, 1997.

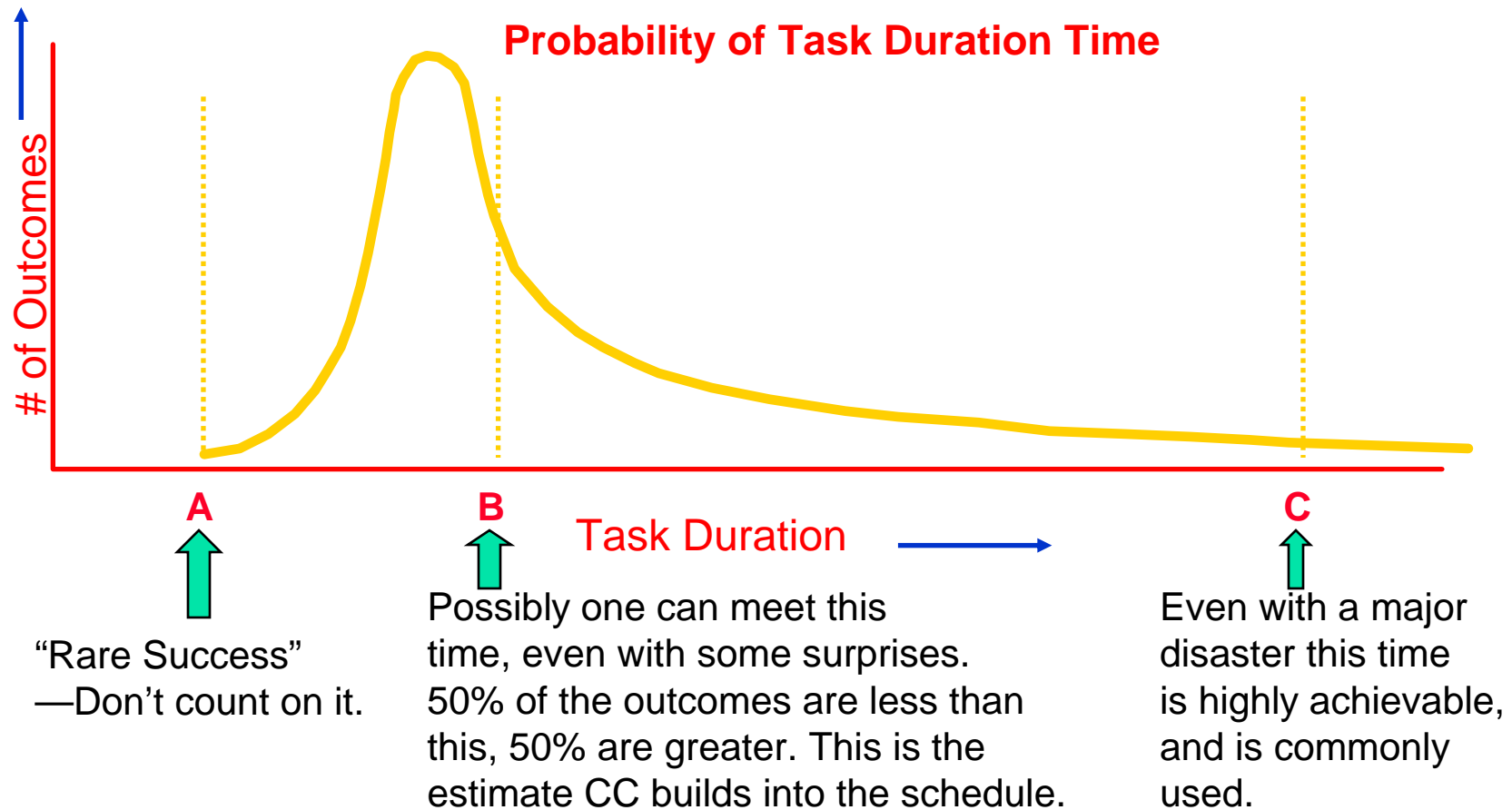


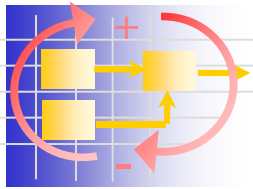
# Research Approach

- Student's Assignment:
  - Implement critical chain method to improve project performance and spread lessons learned throughout the organization.
- Assigned to two product development teams:
  - Low cost power supply (LCPS)
    - High-impact cost reduction; technically complex component
  - Multi-national weapon sight IPD team
    - Very aggressive schedule and technical performance requirements
- Extensive training and interaction with Goldratt Institute

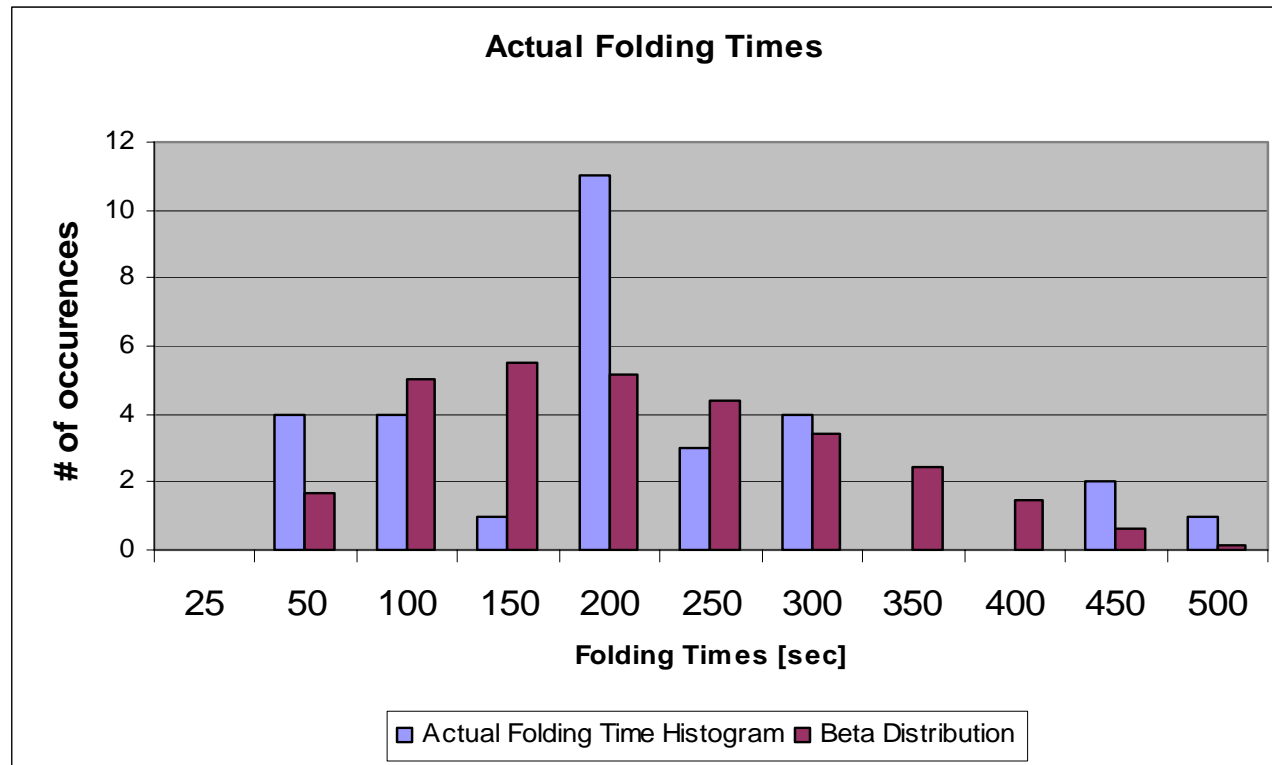


# Where's All the Safety Time? Which Time Are You Likely to Promise?



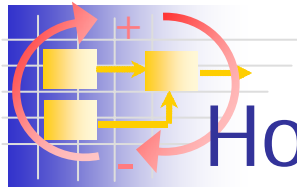


# Paper Airplane Folding Times



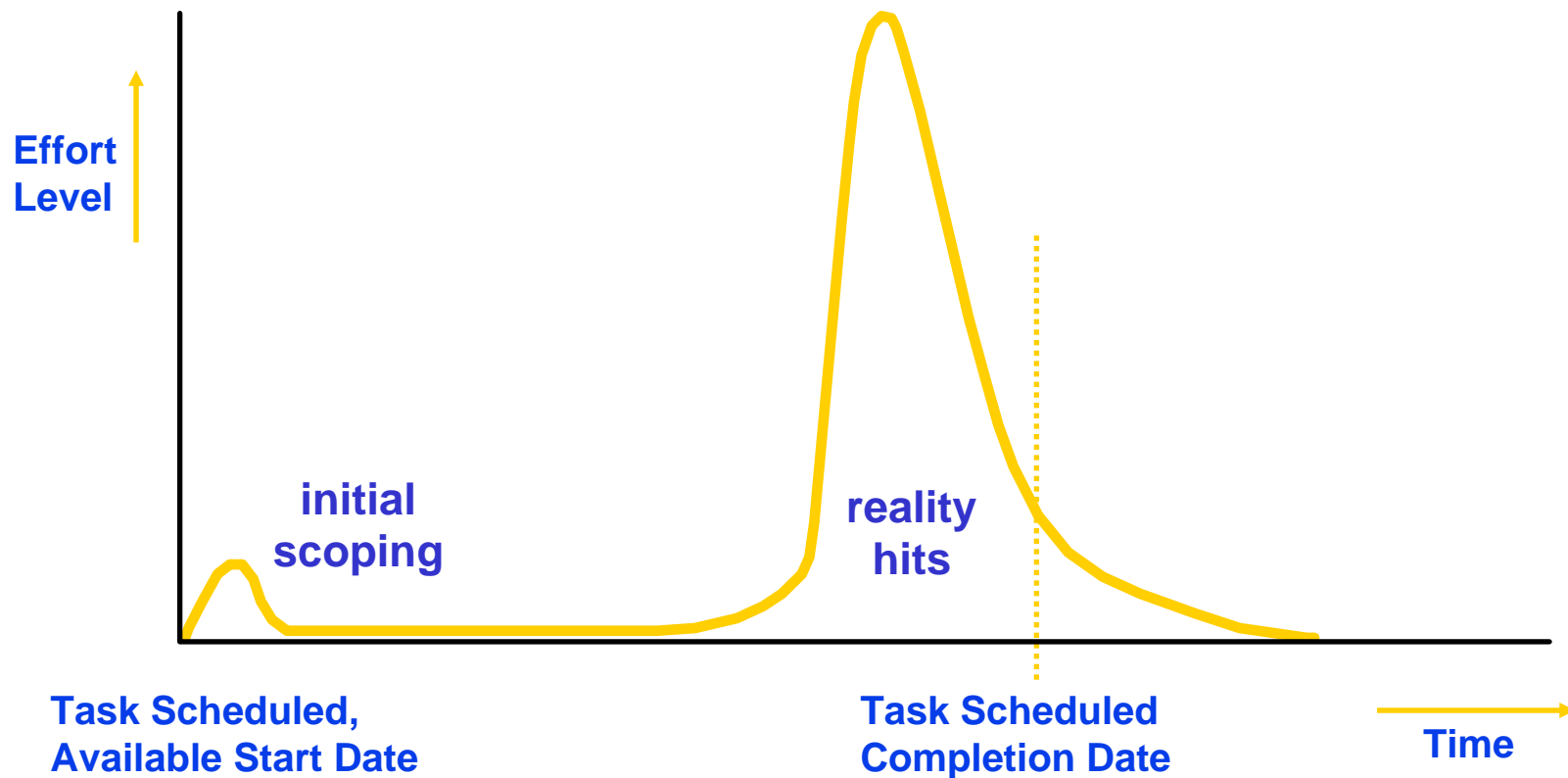
	Est	Actual	Diff
<b>Mean</b>	89.2	187.5	98.4
<b>St. Dev.</b>	77.4	115.3	104.5
<b>Min</b>	15	34	-100
<b>Median</b>	60	187.5	97.5
<b>Max</b>	300	454	425

SDM'03 –September 2003

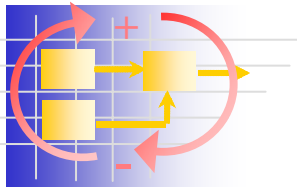


# How Do We “Waste” Safety Time?

## 1) Procrastination: the “Student Syndrome”



Source: Avraham Y. Goldratt Institute



# How Do We “Waste” Safety Time?

## 2) The Effect of Multi-Tasking

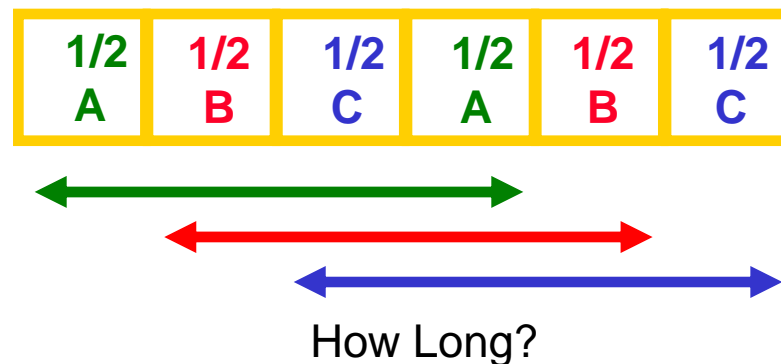
**Task A**  
Project A  
One Week

**Task B**  
Project B  
One Week

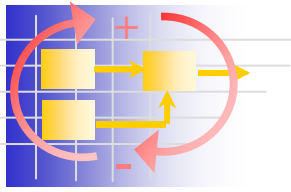
**Task C**  
Project C  
One Week

The resource does half of task A, then half of task B, then half of task C, then finishes task A, then B, then C.

How long does each task take to complete?  
What happened to the safety time?



Source: Avraham Y. Goldratt Institute

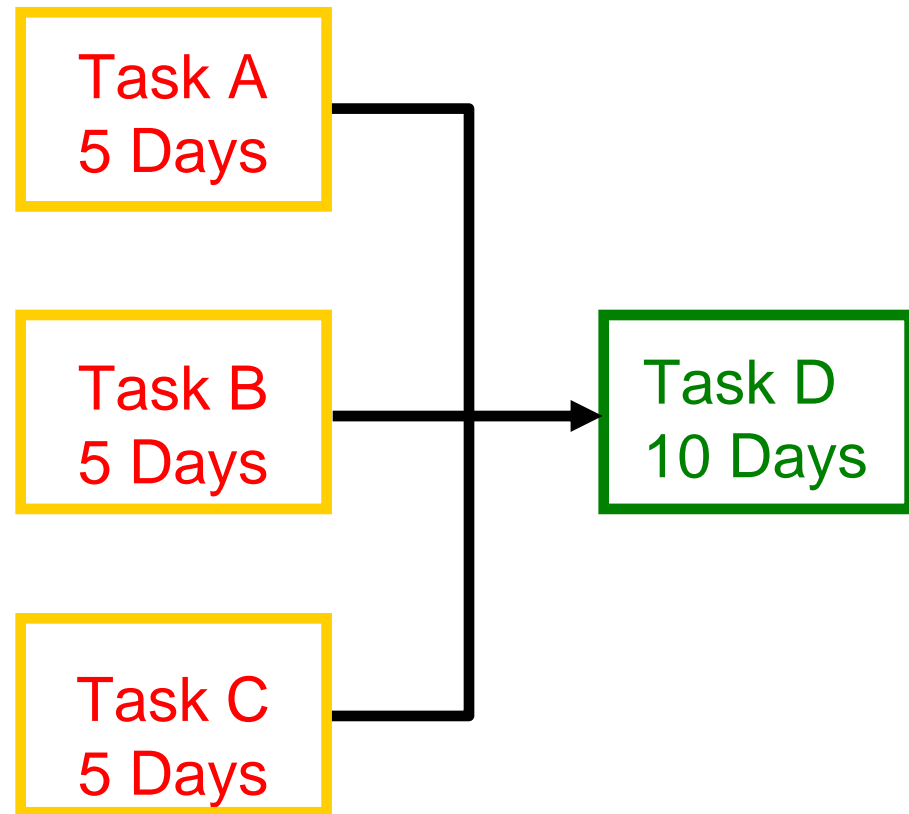


# How Do We “Waste” Safety Time?

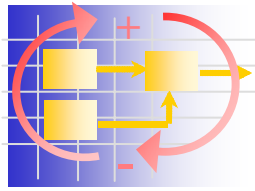
## 3) Delays Are Passed On – Gains Are Not

Merging paths don't allow us to benefit from tasks completed early.

- What is the impact on the total project if Task A is done in only 3 days?
- What if Task C takes 8 days?
- What if Tasks A, B, and C all get done in 3 days?  
Will Task D be ready to start 2 days early?

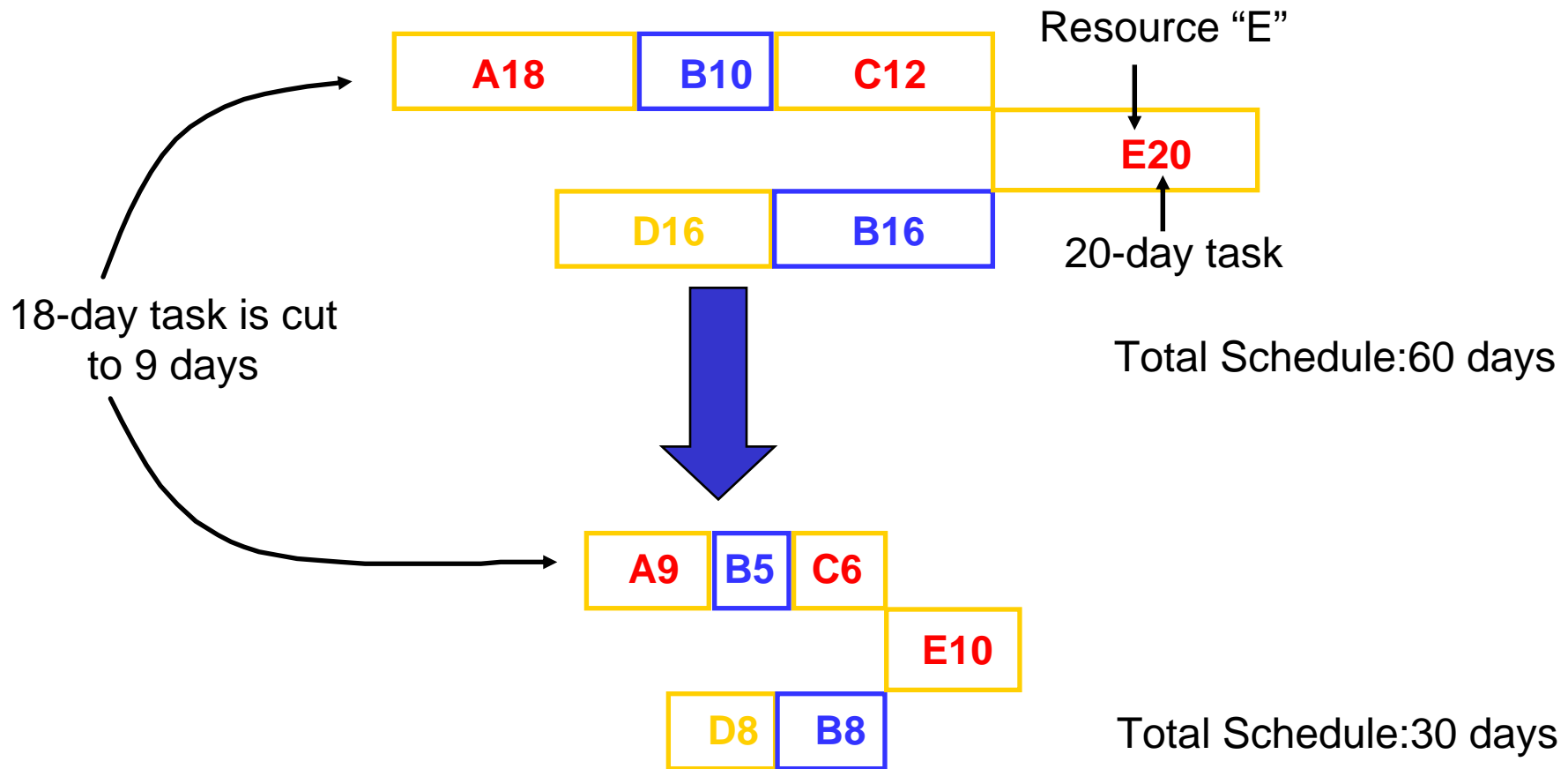


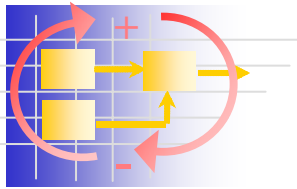
Source: Avraham Y. Goldratt Institute



# Critical Chain Scheduling (1)

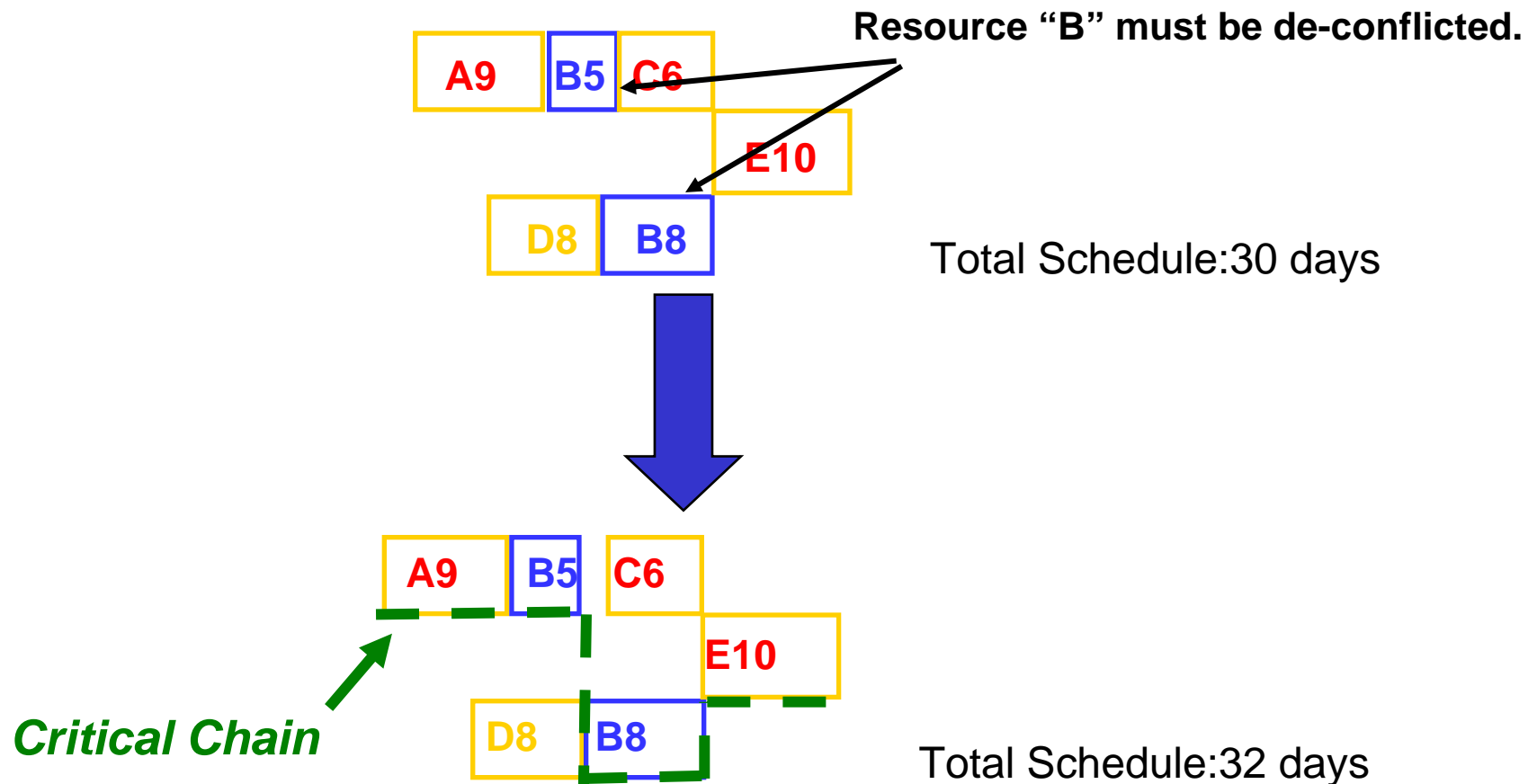
- Create a sequential/parallel project network.
- Remove safety time to shorten task durations.

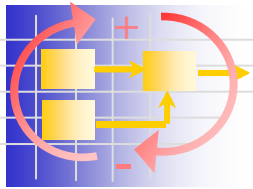




## Critical Chain Scheduling (2)

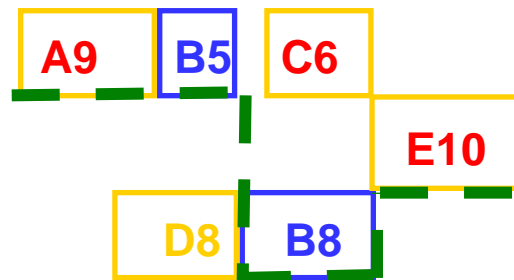
- De-conflict resources.
- Identify the critical chain.





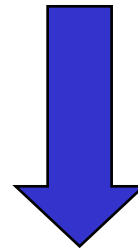
# Critical Chain Scheduling (3)

- Create 50% project buffer and feeder buffers.

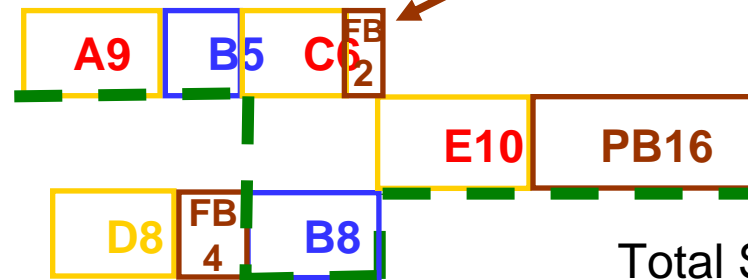


Total Schedule: 32 days

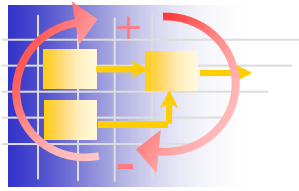
Because of aggregation, the effect variance is lower, and less buffer protection is necessary



FB2 is 2/3 of ideal (50%) buffer size

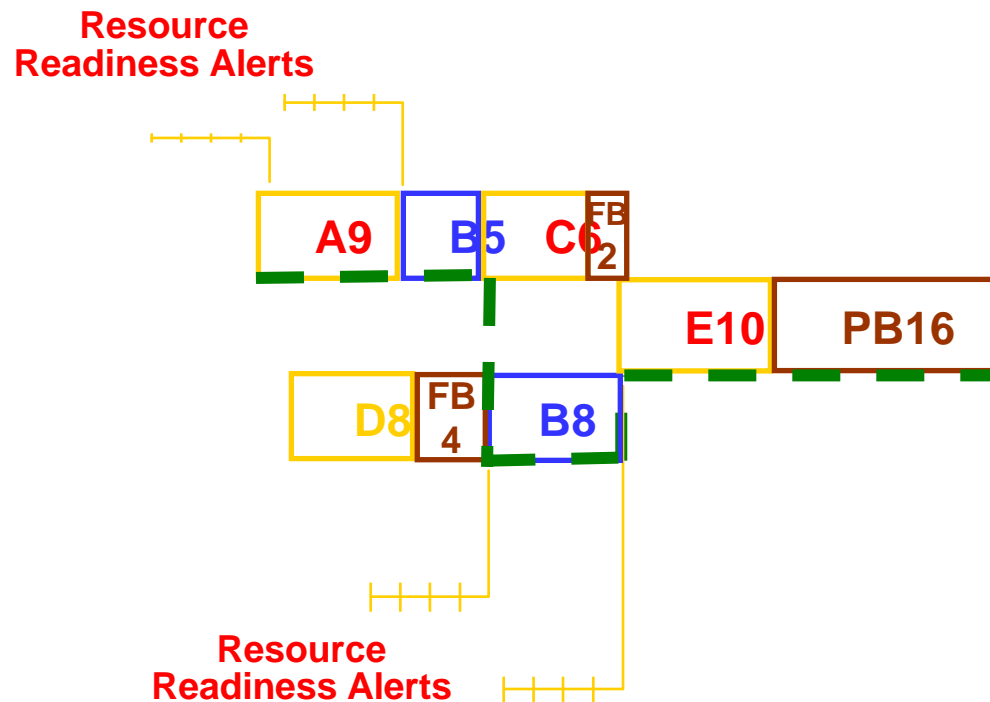


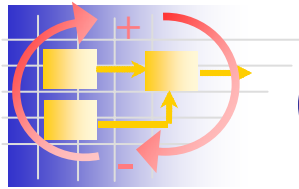
Total Schedule: 48 days



## Critical Chain Scheduling (4)

- Add resource readiness alerts along the critical chain.
- Implement using red and yellow chains.

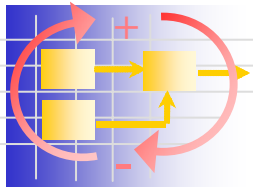




# Critical Chain Definition

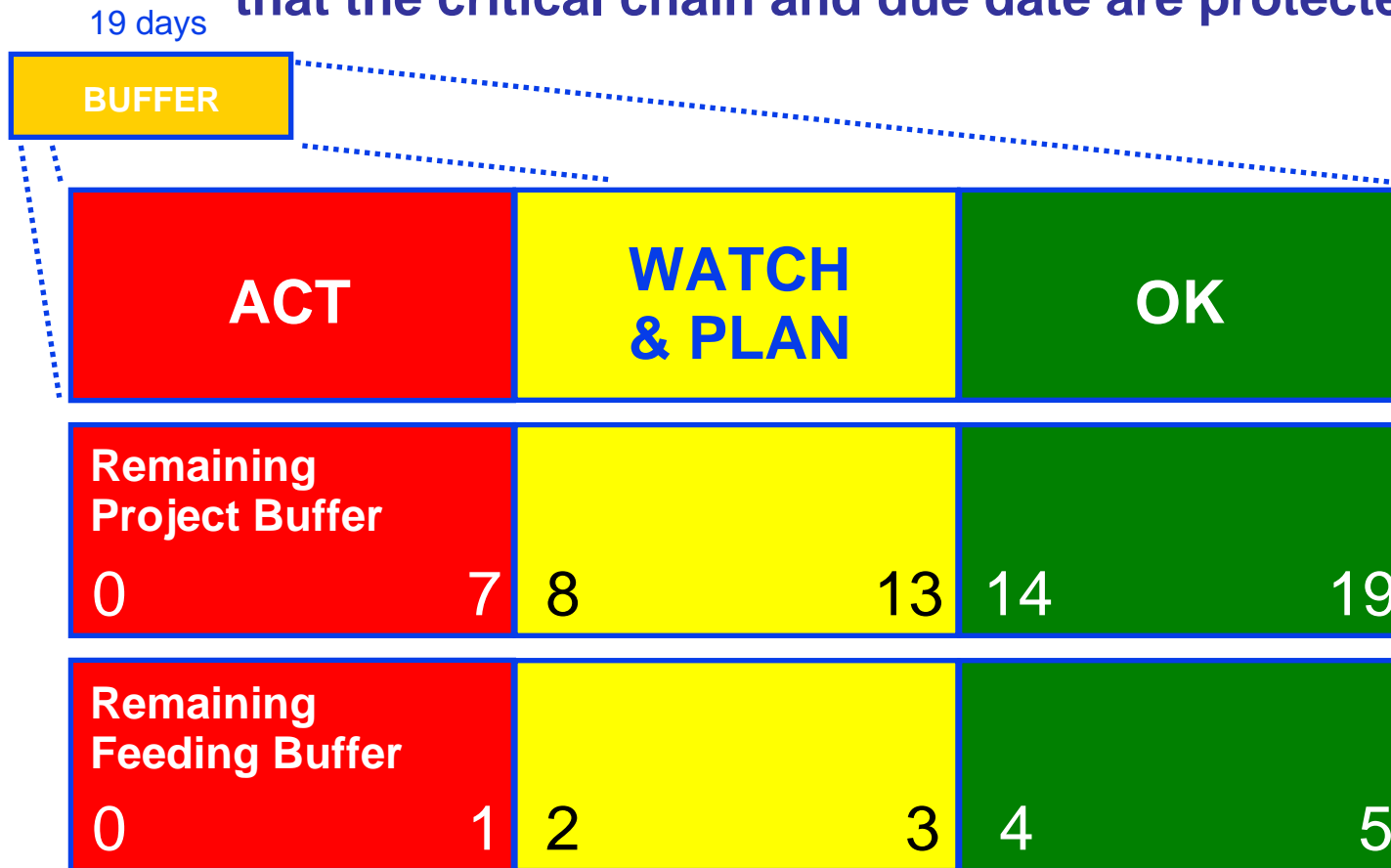
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The **critical chain** is the set of activities for which there is no slack after resource de-confliction.

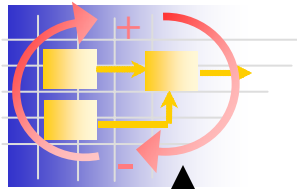


# Monitoring the Project using Critical Chain

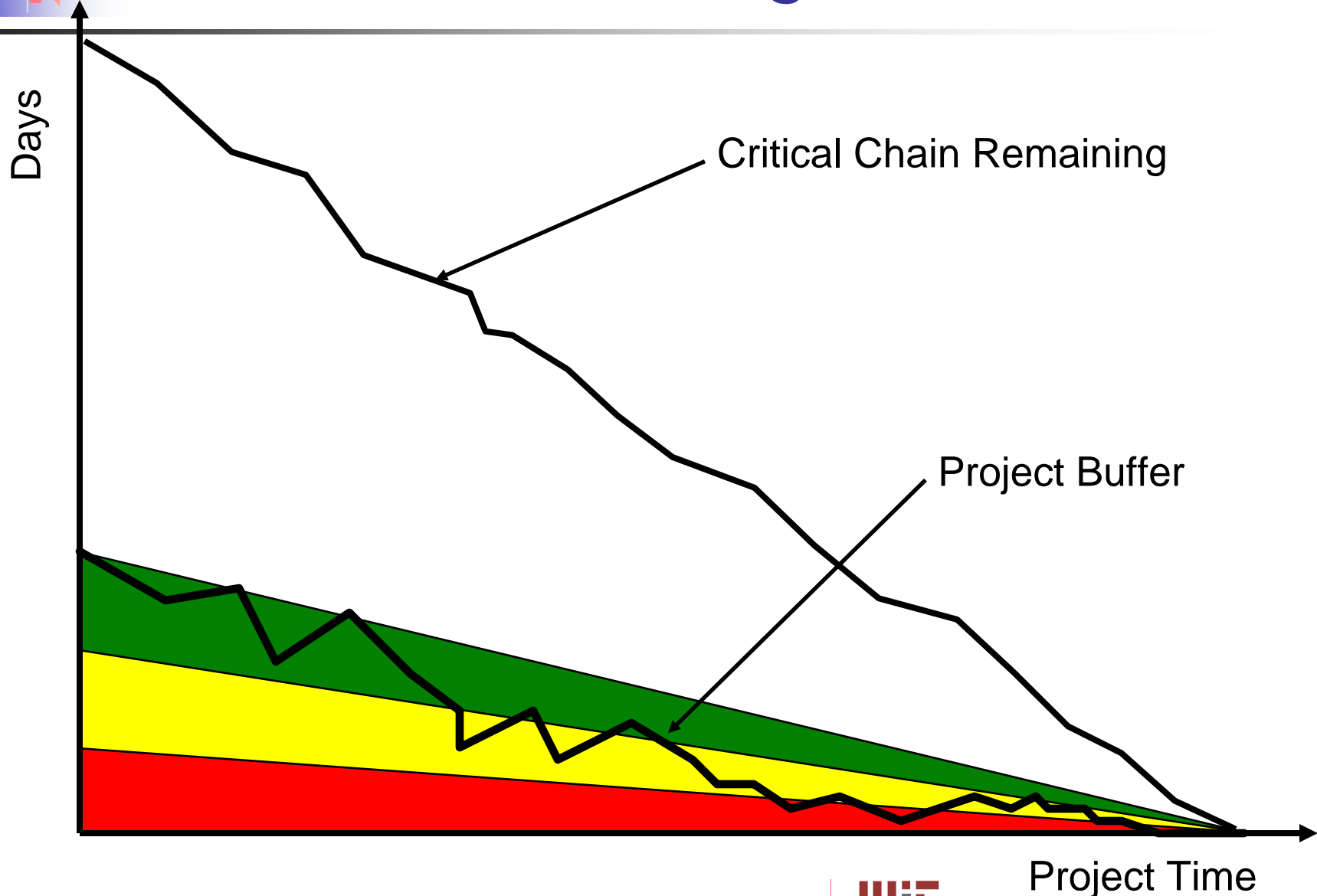
**Monitor buffers to provide focus and early warnings to ensure that the critical chain and due date are protected.**

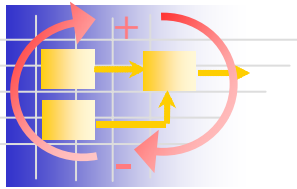


Source: Avraham Y. Goldratt Institute



# Buffer Monitoring Method





# Project Results

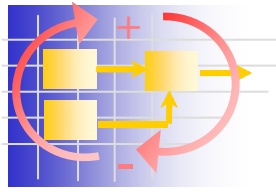
- Implemented buffered critical chain schedules for two projects at ITT Night Vision.
- Managed the projects by monitoring the buffers.
- LCPS completed ahead of schedule.
- Achieved dramatic breakthroughs working with the LCPS supplier as a team.
- INOD had a fatal flaw in the design.
- Benchmarking study inconclusive with two data points for CC.

## INOD

- Defense contract with fixed due date
- Started with only 24 days of project buffer (ideal=100 days)
- Design review issues caused “re-baselining” of the schedule (at both design reviews)

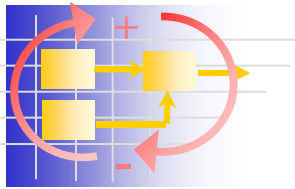
## LCPS

- Started with full (50% of CC) project buffer
- Concentrated on CC throughout
- Completed with ~45 days buffer remaining

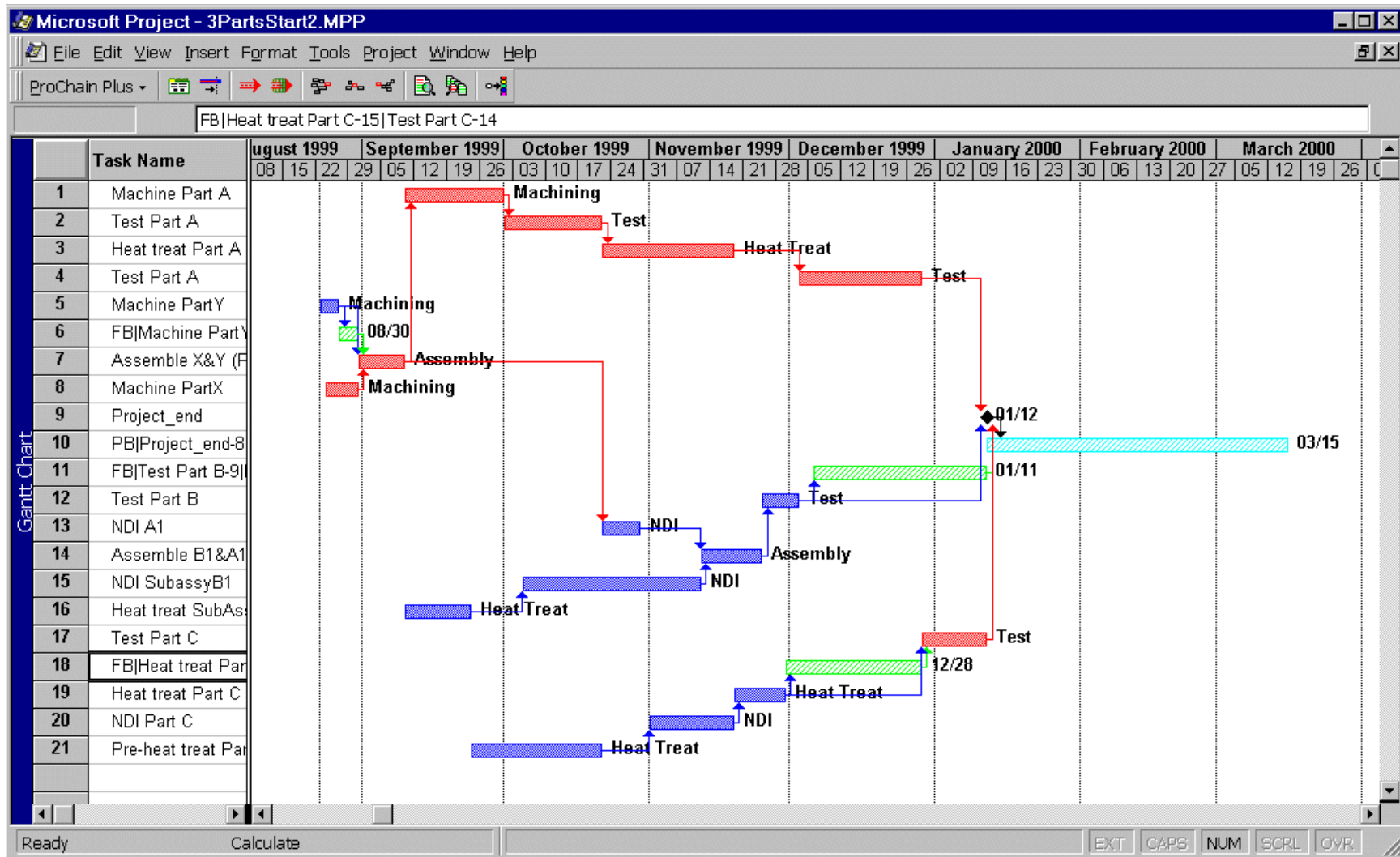


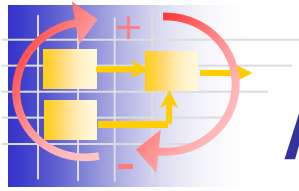
# Cultural Keys to Successful Implementation

- How team members are evaluated:
  - Team is evaluated as a unit on overall project completion success.
  - Individual task completion due dates and milestones must be de-emphasized to avoid sub-optimization.
- Management must hold up their end of the bargain (don't multi-task).
- Need support from the top.
- All key team members must be trained and participate in putting together the schedule.
- Need very clear communication between the schedule keeper and team members.



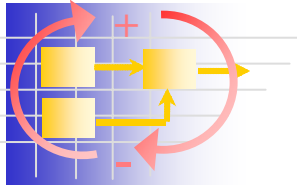
# ProChain Software





# Assigning Task Times

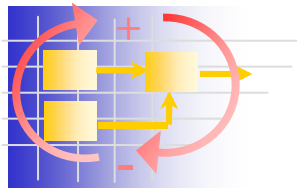
- Predict how long the task will take if:
  - 1) You have all necessary resources and inputs
  - 2) You only work on the task non-stop
  - 3) Either give best estimate of 50/50 time or give 85%-90% time and cut this time in half.
- Peer pressure really helps to get honest estimates.
- We found that teams do make accurate estimates.



## Lessons Learned: Critical Chain

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- Critical chain method makes the effect of task variance explicit (visible).
- For longer projects, we implement buffered schedule within each phase or stage.
- We have some critique of minor points, but overall critical chain appears to be a powerful new common sense management tool.
- For long-term success, the cultural paradigm shifts must take place.



# Linking DSM to Critical Chain

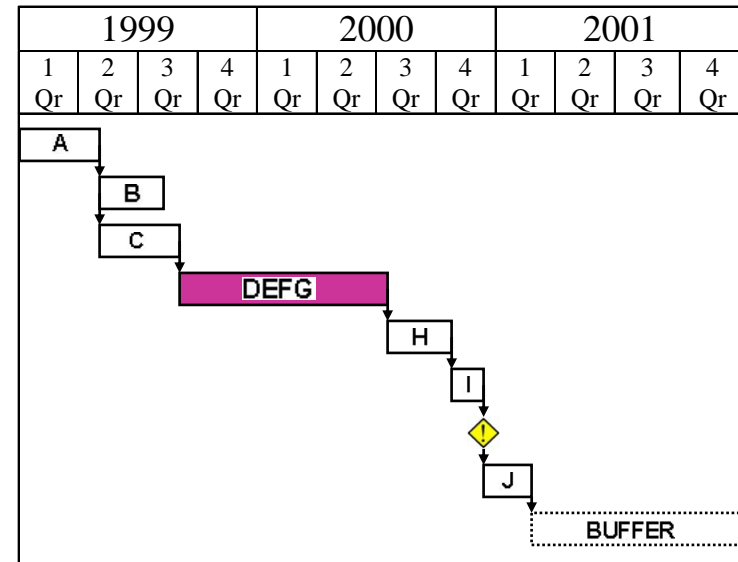


## Design Structure Matrix

	A	B	C	D	E	F	G	H	I	J
A									◇	
B	x								◇	
C	x									
D		x	x		x	x	x			
E			x	x		x	x			
F	x	x		x	x					
G	x				x	x				
H		x	x			x	x			
I		x		x			x	x		
J			x		x	x			x	

Planned Iterations

## Critical Chain Schedule



Unplanned Iterations