TOC Case Study:
The Application of Critical Chain Project Management to the Design of Large Commercial Aircraft at Boeing Commercial Airplanes

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Opportunity or Something Else?

Suppose you're asked to implement Critical Chain on a project in which:

- **The project due date is set and is unchangeable.**
- **Finishing early/under budget won't impact the final product**
- **The implementation is only in one functional area in one part of the overall project.**
- **Only half the resources are on site, 25% are overseas**
- **The organization has a strong intermediary due date culture.**
- **And you've never done an implementation before**

Would you do it? **We said, "Yes."**

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Development of New Aircraft

- **Aircraft models are designed to meet airline needs in specific market niches.**
  - **New designs create platforms that allow derivative models**
- **The demand for aircraft is tied to global economic cycles.**
- **Success is creating the right aircraft at the right time at a price the market can afford.**
- **There are often multiple, competing design efforts across the global system, so *doing more with less in less time* is mandatory. This is particularly true for Airframe engineers.**

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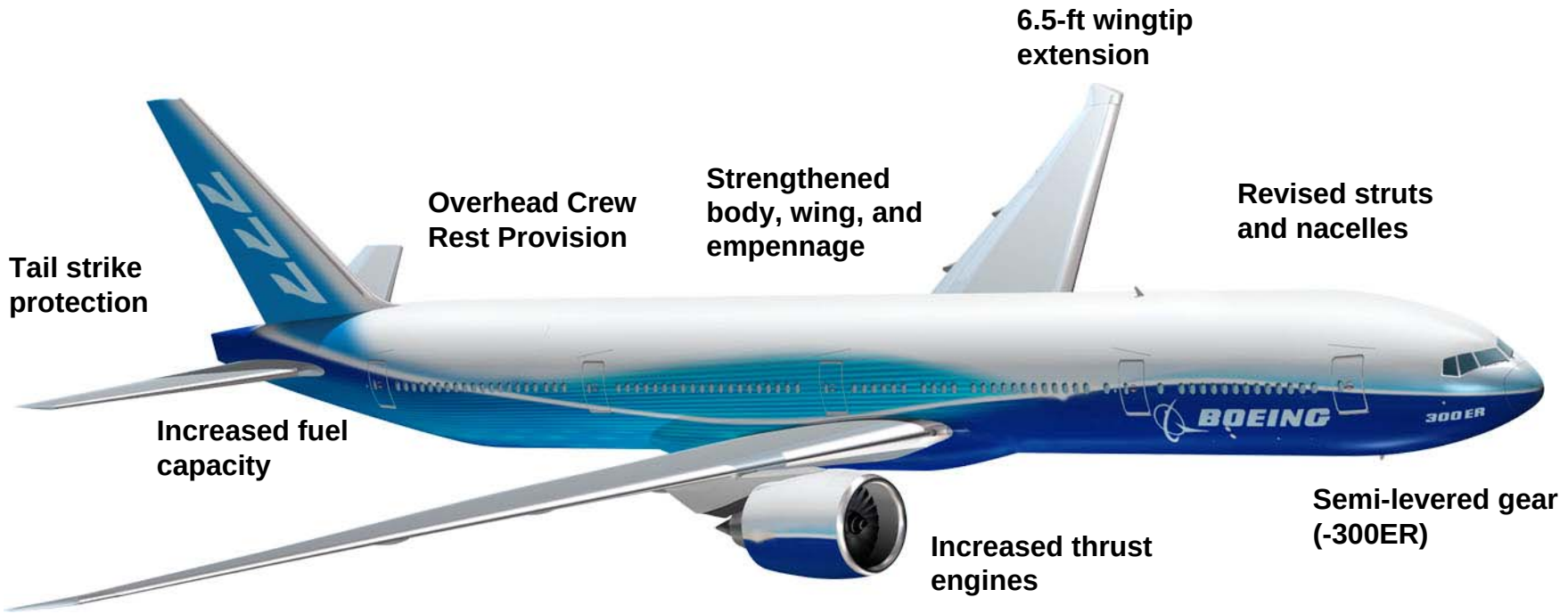
777-200LR/-300ER Derivatives

Over 50% of the airplane had to be changed from current design.
The majority of the development work was done by Airframe.



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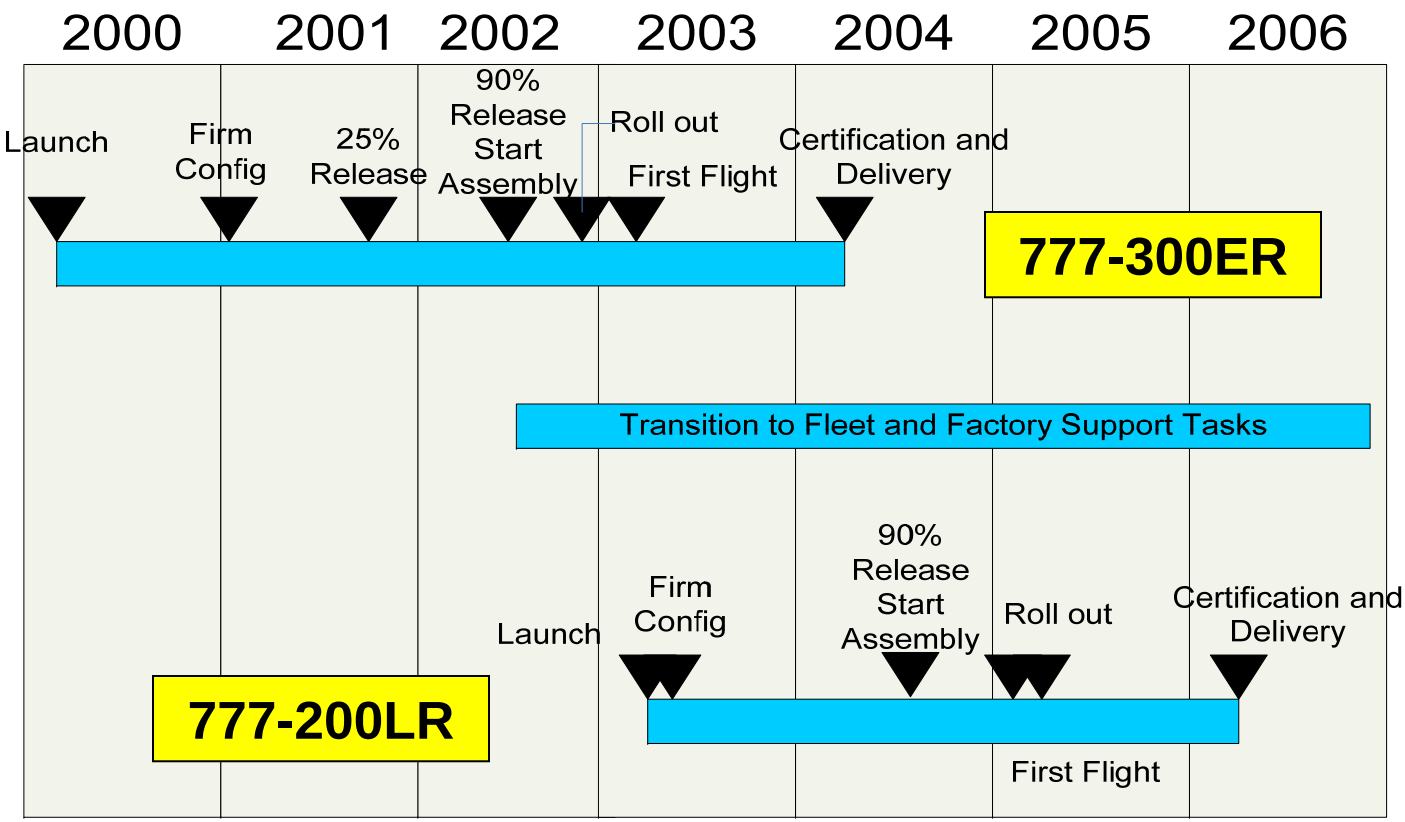
Development Timeline



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The Business Environment

"Challenging" business goals set for both schedule and budget. Entry Into Service dates set at Program Launch.

Airframe resources provided additional challenges:

- **35% Boeing, 65% contract & Industry Assist**
- **50% collocated, 25% in US, 25% outside US**

Suite of Best Practices required by program

- **Earned Value**
- **Lean**

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Implementation Intended Result

Reduce the time and resources needed to complete detail design. This will free up resources for other programs and give the supply chain enough time to make the parts.

"Development resources are proportional to development time." **Clark-Fujimoto Rule**

"All we are doing is looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes."
Taiichi Ohno (1988)

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“A Few Implementation Issues”

- **What is a project? Task? Activity?**
- **What are the boundaries?**
- **CCPM? Why not DBR?**
- **What is included? What’s not?**
- **What software do we use?**
- **Do we need outside help?**
- **Can we overcome a strong “due date” bias?**
- **How do we integrate CCPM with Earned Value?**
- **How do we integrate CCPM with Lean?**

We needed an implementation plan to focus our efforts

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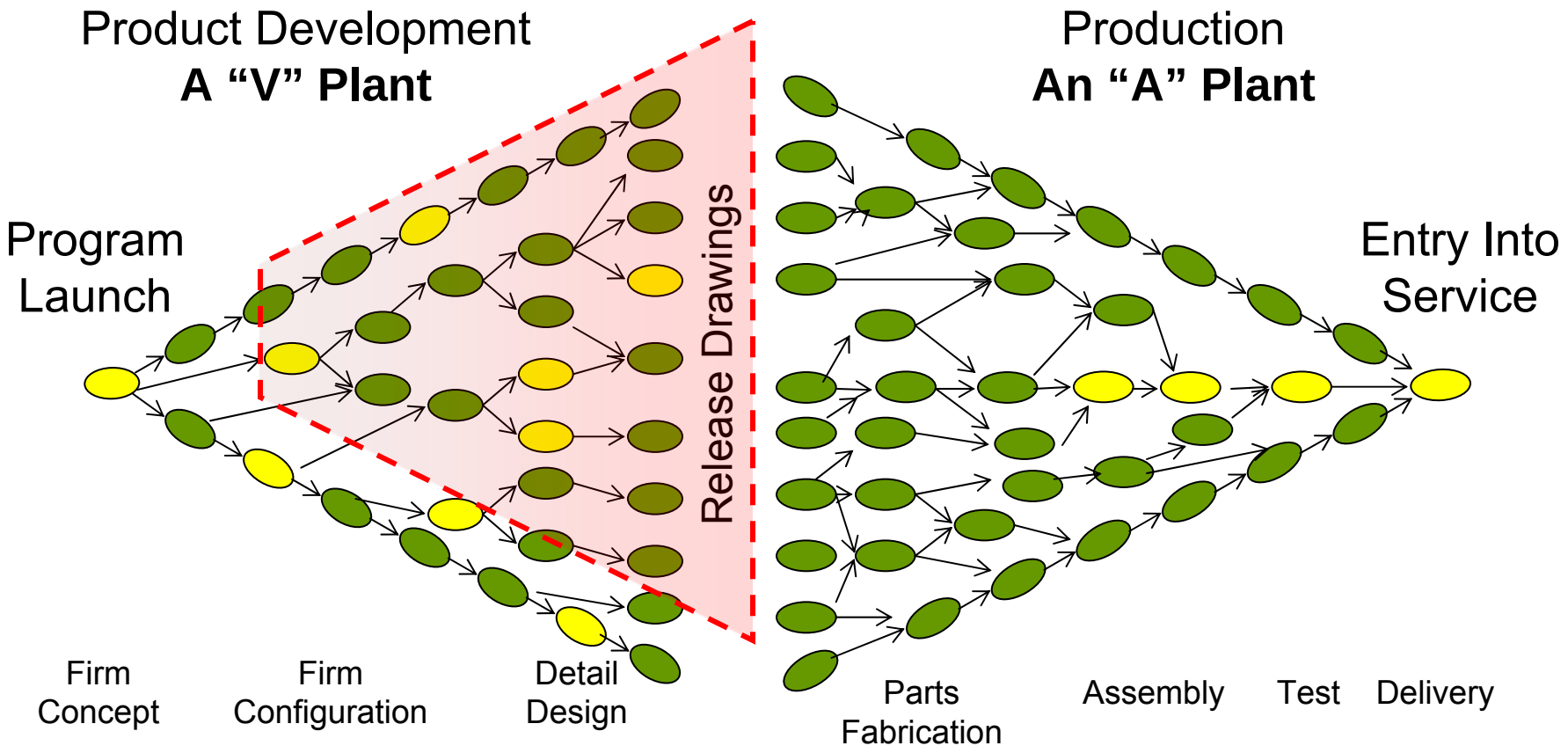
Airframe Span of Control



System boundaries and goals drive the design of the implementation and vice versa.

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Implementation Strategy Table

Decision Categories →

Options ↓

Scope of Organization	Scope of Work Statement	Scope of Process	Project Product	Project Environment	Integration w/ Best Practices	Infrastructure	Buffers Used
Level 4 - Lead Level	200LR, 300ER releases	In-House Only	Drawings	Limited Pilot Project	Independent	In house, local practioners	Schedule
Level 3 - First level management	Add Customer Intros	Add any Define Off-Loads	Add Reference Notes	Multiple Stand Alone Projects	Dependent	Consultants	plus Cost
Level 2-Airplane Section	Add Committed Changes	Add Suppliers	Add Manufacturing Plans	Apply at Critical Bottleneck (program constraint)	Interdependent	plusTrainers	plus Performance Targets
Level 1 - All of Airframe	Add Non-committed Changes	Add Regulatory Agencies	Add Tool Design	Multi-Project, Shared Resouce		plus Application Practicioners	
Level 0 - All of 777		Add Customers and Marketing	Add Tool Construction*			plus Outside experts	
			add Parts				
			Add Components deliver to Fab				

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Getting Started

- **Strategy table helped define the system, the boundaries and our direction**
- **John Kotter's "Leading Change" provided a basis for implementing change**
- **Formed implementation team and Guiding Coalition**
  - **Understand current state, design future state**
  - **Develop the infrastructure (tools, reports, trng)**
  - **Define the tactical implementation plan**
  - **Implement the plan**

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Implementation Decisions

- **Treat each drawing as a separate project.**
  - Drawings are contractual deliverables to suppliers with negotiated due dates.
  - Required to track Earned Value at the drawing level.
- **A multi-project system of 10000 projects.**
  - About 30 unique Sub-Teams/resource pools
  - Each team had 75 to 3000 projects
  - Each team had a Critical Chain scheduler/plan
- **Objective: Prioritized project/drawing release "waterfall" set by a drum for each team that meets supplier's needs**

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Initial System Design Enabled Software Decision

- **Multiple teams and resource pools meant that a complete enterprise CCPM software solution was not (yet) needed.**
  - **Used Sciforma PS8—good value, excellent ability to customize and integrate into other systems.**
  - **We could operate to CCPM run rules and report conventional metrics to business systems with minimal effort. Especially Earned Value.**

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Planning and Execution of the Work

- **Create the Plan**
  - **Apply templates to work statement, no dates**
- **Commit the Plan**
  - **Assign completion dates to projects, adjust resources**
- **Manage to the Plan**
  - **Use resource histograms and fever charts for daily management**
  - **Drawing due date system to check weekly commitments**
  - **Earned Value to show monthly progress**

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First Steps: Prioritize and Train

Eliminate harmful multi-tasking, provide focus, increase speed.

- **Created a Task Prioritization policy**
- **Team training and education**

What we learned:

- **Having a policy isn't enough, it requires constant reinforcement.**
- **Apply the training immediately or people revert to what they know**

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Education and Training

Everyone needed enough knowledge for their role:

- **Internally we drew upon employees with TOC education from the Washington State University's Engineering & Technology Management program for implementation help.**
- **Licensed the capability to present 2 Day TOC Multi-Project Management workshop developed by Tony Rizzo of Product Development Institute**
- **Created a 2 hour overview based in part on simulations from "Project Management the TOC Way."**

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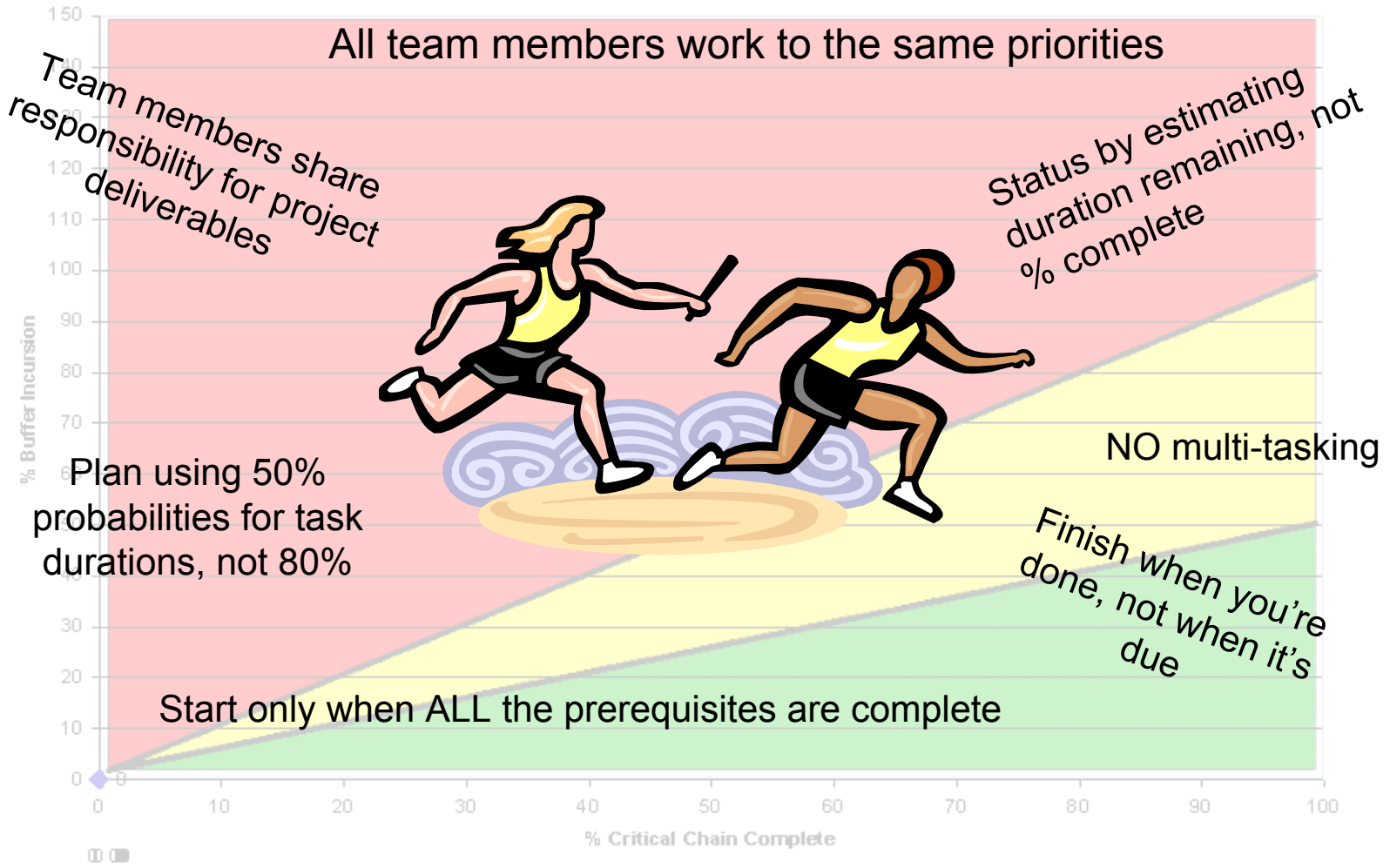
Planning & Working Behaviors



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Next: Create Team Plans

Create *resource-based* project plans

- Create *planning models* using common templates (engineers understand the use of models to simulate reality)
- Critical Chain Project Management plan for every Sub team
- All of the committed work done by the team resources is in the team plan
- The plan is resource feasible and projects are in the right sequence

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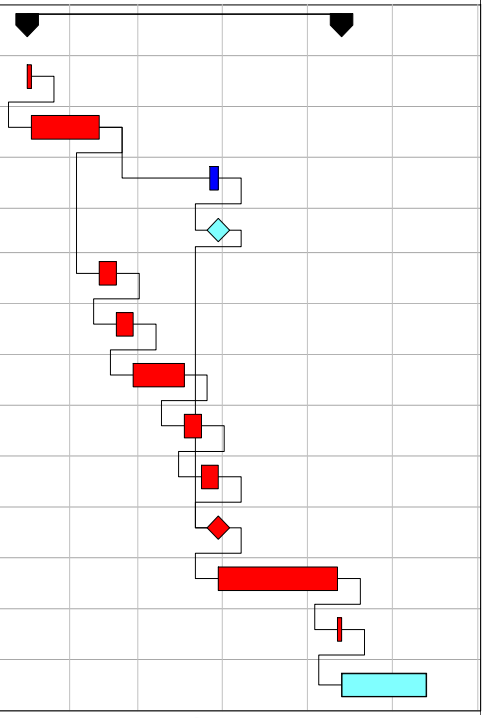
A Sample Project Template

Drawing_Template

Task Name	Resource Names	Duration	Safe Duration
Summary		18.49d	0d
ME Task 1	ME	0.24d	1d
DWG Creation	Design	4d	10d
Checknotes & ANI	Stress	0.5d	2d
Feeding Buffer		0d	0d
Design Check	Design	1d	3d
Pickups	Design	1d	2d
Team Check	Stress,ME,Tooling,Design	3d	5d
Incorporate Pickups	Design	1d	2d
Sig Routing	Design,Stress,ME,Tooling	1d	1d
Release Engineering OB		0d	0d
EDC flow		7d	7d
ME Task 2	ME	0.25d	1d
Project Buffer		5d	0d



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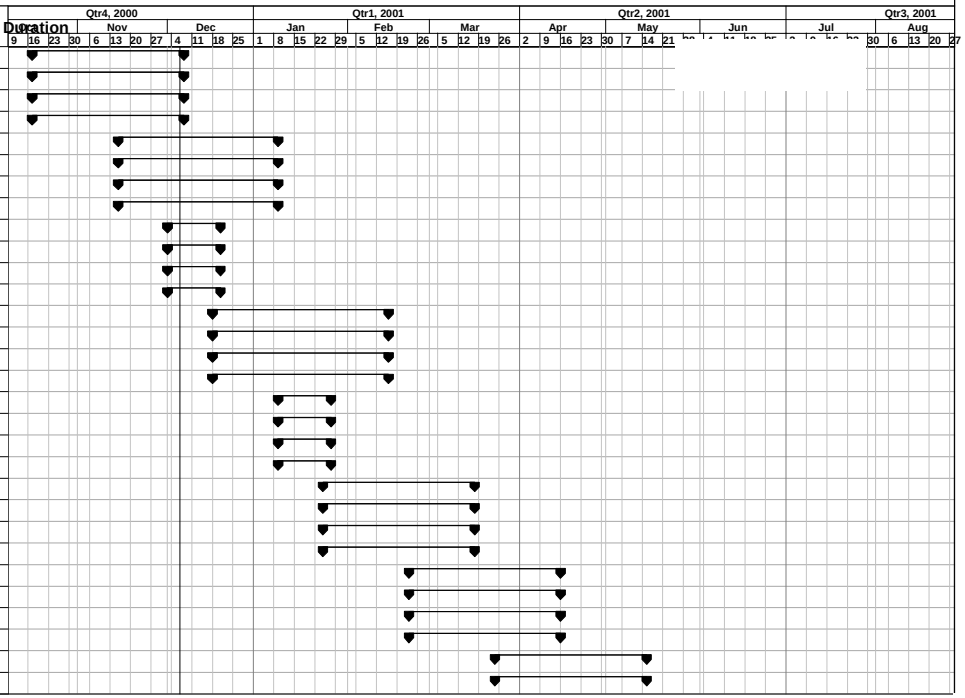
Sample Synchronized Team Plan

Sample Level 4 Team Planning Model (Synchronized)

Project ID	Task Name	Dura	Task ID	Duratic	Safe Duration
003-9P_525		37d	525	37d	0d
004-9P_527		37d	527	37d	0d
001-9P_322		37d	KC8	37d	0d
002-9P_521		37d	521	37d	0d
007-9P_513		39d	513	39d	0d
005-9P_324		39d	324	39d	0d
006-9P_511		39d	511	39d	0d
008-9P_523		39d	523	39d	0d
022-9P_853		13d	1	13d	0d
023-9P_855		13d	1	13d	0d
019-9P_440		13d	440	13d	0d
021-9P_851		13d	1	13d	0d
010-9P_541		43d	541	43d	0d
009-9P_545		43d	545	43d	0d
011-9P_543		43d	543	43d	0d
012-9P_547		43d	KC8	43d	0d
026-9P_800		13d	1	13d	0d
027-9P_801		13d	1	13d	0d
029-9P_803		13d	1	13d	0d
028-9P_802		13d	1	13d	0d
014-9P_412		37d	411	37d	0d
015-9P_421		37d	412	37d	0d
013-9P_411		37d	547	37d	0d
016-9P_422		37d	421	37d	0d
020-9P_441		37d	1KC8	37d	0d
018-9P_432		37d	431	37d	0d
017-9P_431		37d	422	37d	0d
024-9P_652		37d	KC8	37d	0d
025-9P_313		37d	KC8	37d	0d
030-9P_532		37d	KC8	37d	0d



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Lessons from Team Plans

They didn't want to start; then didn't want to stop.

- **"Low hanging" process improvements show up as a result of talking to each other.**
- **Teams without Planning Sessions often commit to unrealistic and infeasible schedules**
- **Having a "planning model" allows new insights and "what if" scenario planning that previously was very difficult and often skipped**
- **Groups that usually don't get involved with planning (like the Critically Constrained Resource) often really want to.**

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Manage to the Plan

Use our plans to manage using Buffer Management and follow our prioritization and No Multi-tasking policies

Put in place tools and processes to:

- **Make informed resource management decisions**
- **Revise task priorities**
- **Predict future performance**
- **Seek help in a timely manner**
- **Provide help in a timely manner**
- **Coordinate downstream impacts**
- **Validate the team's capacity**

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Manage to the Plan (2)

Use Buffer Management to manage.

- **Assign tasks at 2 week look ahead window, do not assign all work to individuals up front**

Lessons: Years of habits are hard to break.

- **Start Buffer Management team by team** as soon as plans are completed **to minimize fall back to "business as usual" behavior.**
- **People want to assign all work to individuals. Don't let them….**

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Due Date Vicious Cycle

- **Common perception:**

  "I must start now or I'll miss my due date. I don't have all the information I need, so I'll make estimates and assumptions and use those."

- **The group most fixated on due dates was responsible for the efforts upstream and downstream of the drum resource.**
  - **This buried the drum with WIP in varying degrees of completeness and correctness.**

Policy: Only pass correct, completed work to the drum.

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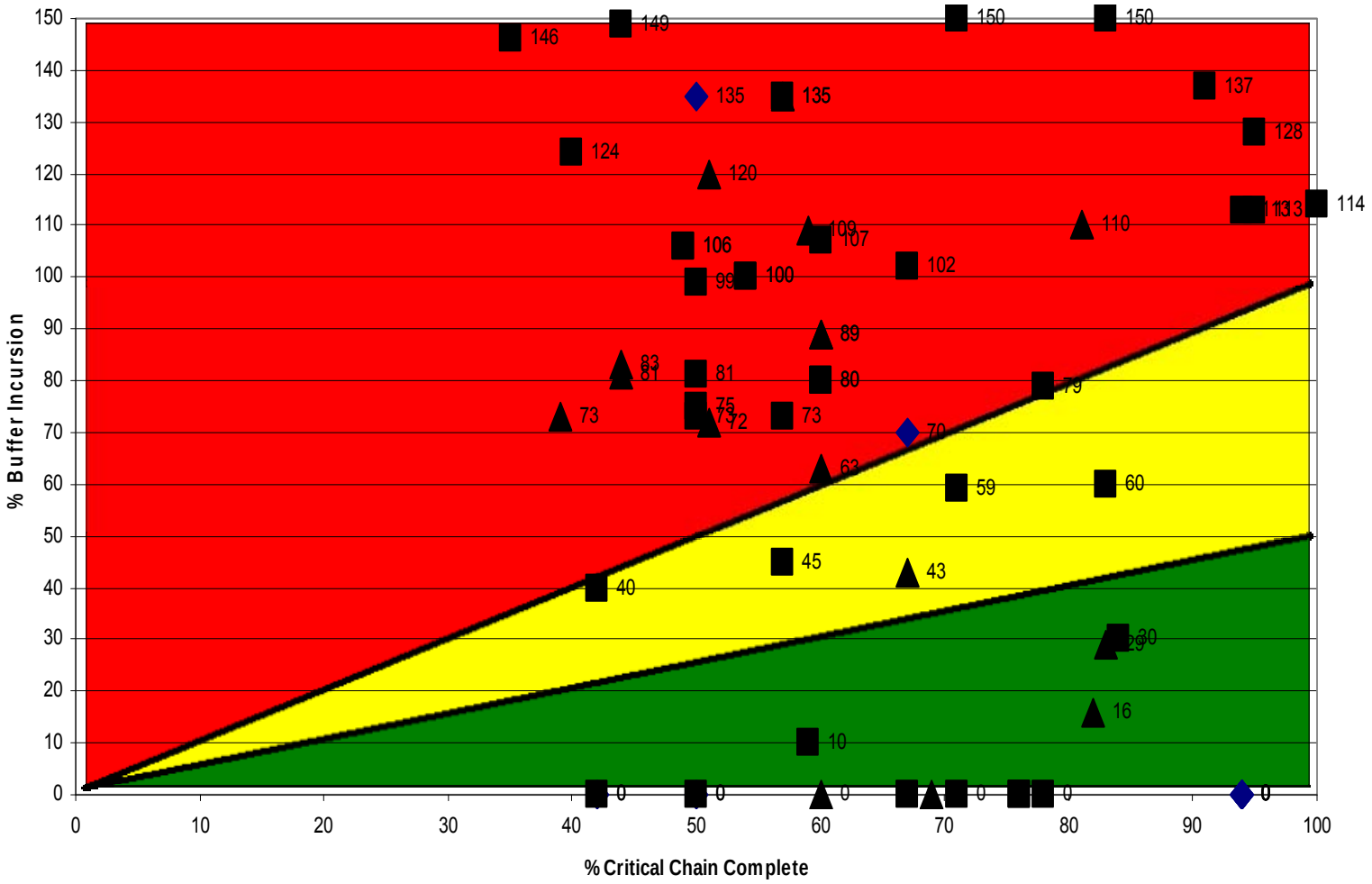
Results of Due Date Focus



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777-300ER Results

- **Airframe 777-300ER: First large scale, Multi-project, Shared resource implementation in Boeing**
  - **Most drawing release commitments made prior to creation of CCPM plans**
  - **Critical Chain prioritization on drum resource brought the program in on schedule and under original budget estimates**

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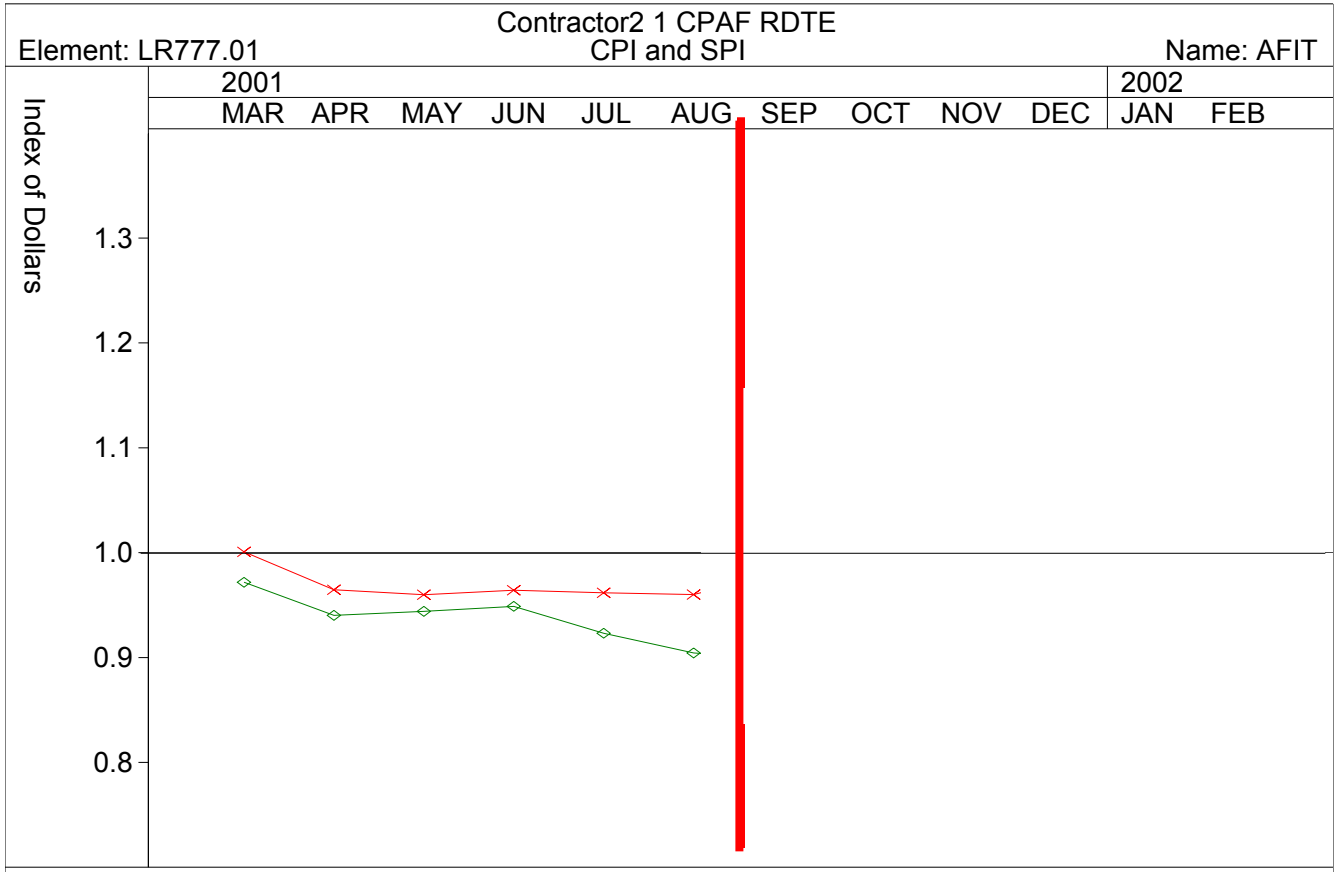
Earned Value Reports-Before



Cost Performance Index (CPI)

Schedule Performance Index (SPI)

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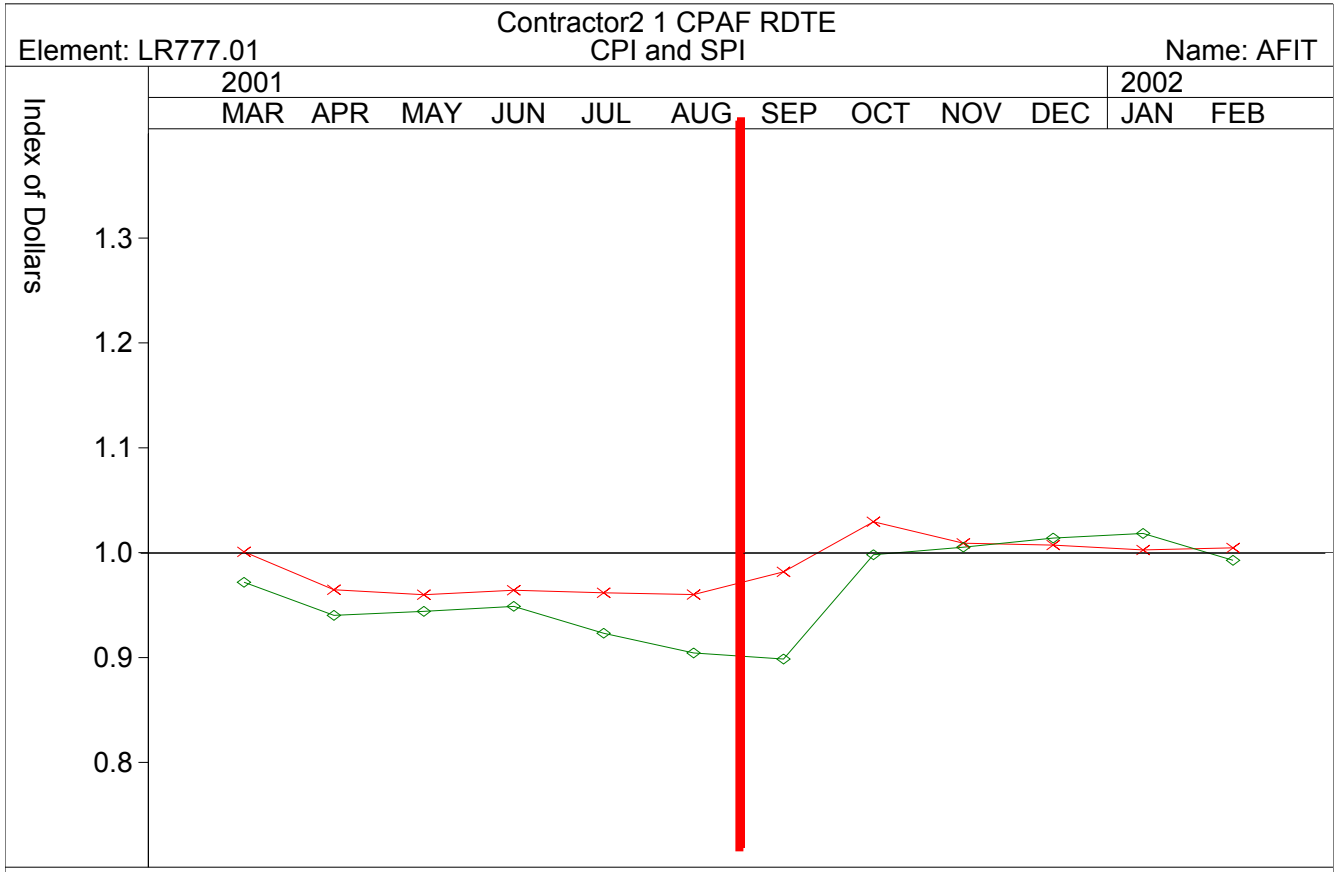
Earned Value Reports-After



Cost Performance Index (CPI)

Schedule Performance Index (SPI)

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2nd 777 Airframe Implementation

777-200LR:

- **Drawing release commitments made based on resource feasible CCPM plans**
- **Project network and templates used to create entire plan**
- **Had trained staff, documented processes**
- **Resource Histograms showed overload situation late in 2003, team took action immediately (Everyone believed the data!).**

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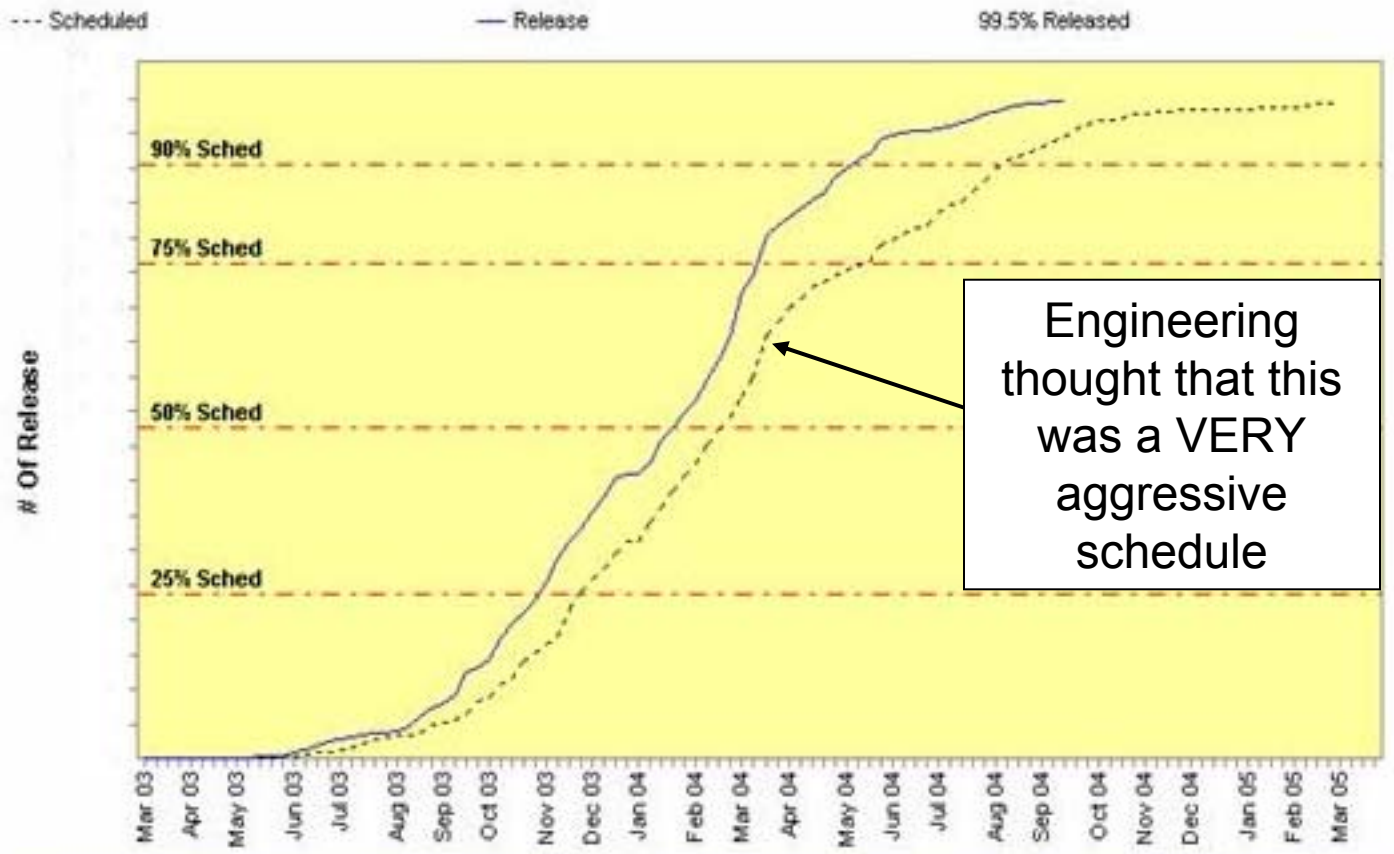
777-200LR Release Performance



Total Sched		Total Rel		Sched To Date		Delinq	0
Sched 25%	11/27/2003	Sched 50%	2/26/2004	Sched 75%	5/20/2004	Sched 90%	8/12/2004
Rel 25%	11/6/2003	Rel 50%	1/22/2004	Rel 75%	3/18/2004	Rel 90%	5/13/2004

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Speed & Quality "Virtuous" Cycle

- **If you're a month ahead of schedule and you find a problem, you fix it.**
- **Fewer errors means less rework in the system means you finish work earlier and start the next project earlier.**
- **One measure of this is the number of reschedule requests:**
  - **Requests at 1/12th and 1/8th previous two derivatives**

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Yes, but why....?

- **Why CCPM and not DBR?**
  - **We were used to project management and being measured to a project management system.**
- **Why only Airframe?**
  - **With increasing span comes increasing benefits…and risks.**
- **Why 10000 projects, why not 1?**
  - **We leveraged our natural tendency to think in terms of due dates. Note that if people release when the work is done and ignore due dates then due dates have no impact on behavior.**

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Yes, but how…?

- **How did you integrate CCPM with EV?**

  We used several methods:

  - **Count method**
  - **% Critical Chain = EV % Complete**
  - **Automated 0/100 earning method (considered tamper proof)**

- **How'd you integrate with Lean?**

  - **Taiichi Ohno uses the relay-race analogy and it provides a good way to show how CCPM promotes a continuous flow of projects**

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The Implementation Challenges

- **The biggest challenge to implementing Critical Chain is getting people to work to an event driven, Pull paradigm and not a task due date driven Push paradigm. And, adding more details doesn't help.**
- **Second biggest challenge: Yes, it really does work.**

"Whether you think you can or think you can't--you're right."

Henry Ford

"Whether you think CCPM can work or think it can't--you're right."

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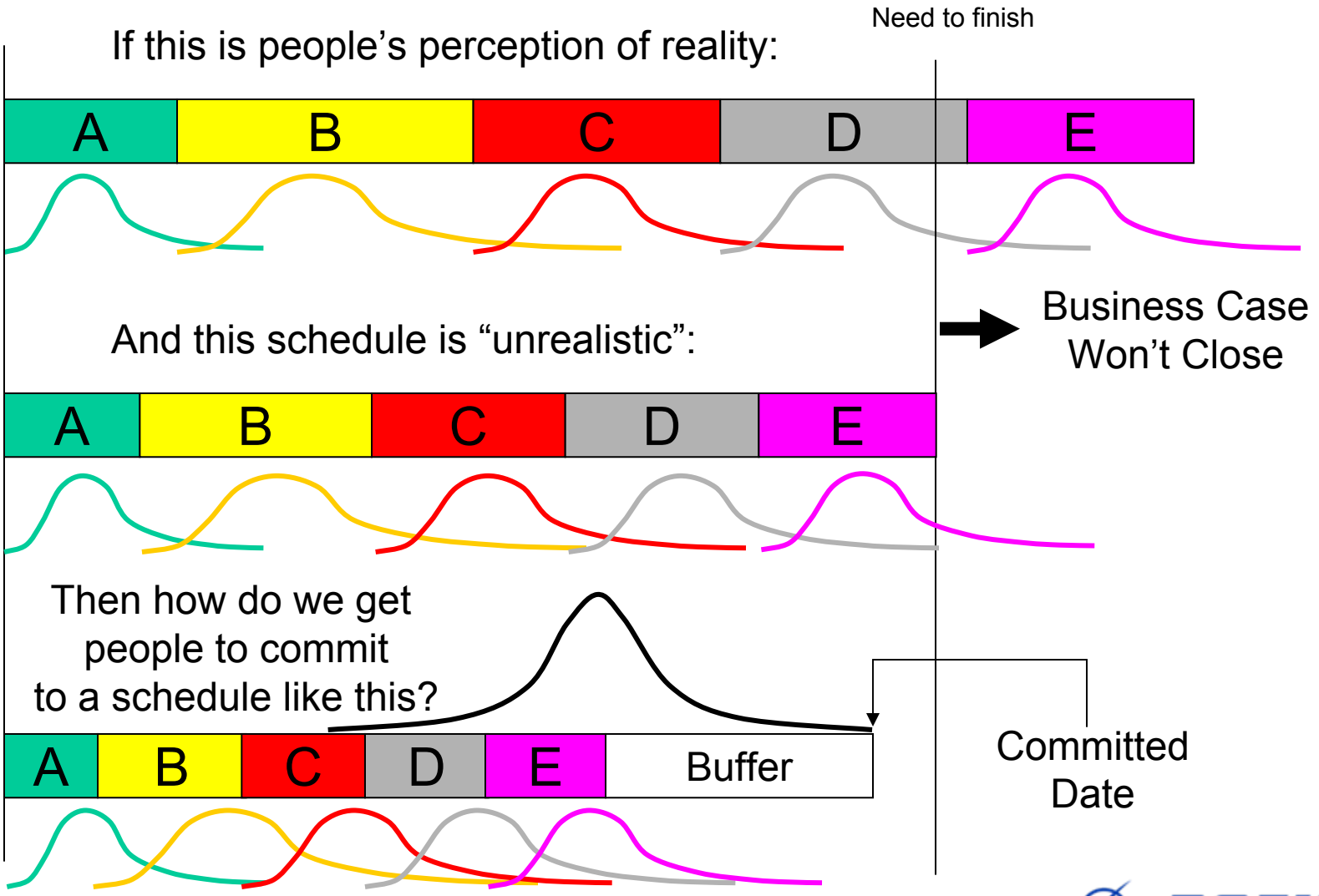
The Implementation Situation



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Where We are Today:

- **We have a way to implement Large Scale Multi-Project Critical Chain in Engineering Product Development.**
- **We have proof of success.**
- **There is easy access to implementation information.**
- **There are a growing number of experienced practitioners.**
- **There's significant upside potential for productivity improvement and associated business performance increases with the only risk being "business as usual" performance.**

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