

PROJECT MANAGEMENT FOR SCIENTISTS

COST & SCHEDULE ESTIMATES

CHRISTOPH U. KELLER, C.U.KELLER@UU.NL

STERREKUNDIG INSTITUUT UTRECHT

UTRECHT UNIVERSITY

WWW.ASTRO.UU.NL/~KELLER

OUTLINE

- Resource Assignments
- Estimates
- Types of Estimates
- Cost Estimates
- Schedule Estimates
- Task Dependencies
- Scheduling
- Cash Flow Plan

RESOURCE ASSIGNMENT

- Answer:
 - Who and what is needed to make project a success?
 - Who is really available?
 - What to do if resources are not available when needed?
 - Will resource constraints cause schedule slip or cost overrun?

ESTIMATES

- Forecasts, approximations of cost, schedule to produce deliverables
- Needed to
 - determine length and cost of project
 - schedule work ahead of time
 - develop cash flow requirements
 - track progress of project
 - develop baseline plan

TYPES OF ESTIMATES

Accurate estimates require accurate specifications

- *Ballpark estimate* (gut feeling of an expert)
 - Very fast, easily wrong by factor of 2
 - Only use to decide whether more accurate estimate should be obtained
- *Rough Order of Magnitude* (ROM)
 - Extrapolation from previous projects
 - Often good enough to start project
- *Detailed, bottom-up estimates* from WBS

TOP-DOWN ESTIMATES

- Fastest, least precise method
 - Divide project into major components
 - Estimate each component based on previous experience with similar projects
 - Adjust for differences between new project and the ones estimate is based on
- Most accurate when past experience with similar projects, historical data available

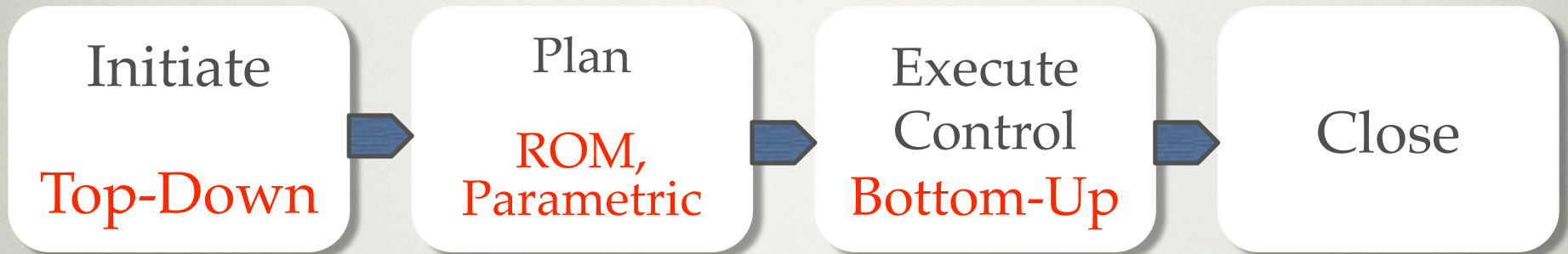
PARAMETRIC ESTIMATING

- Uses formula to predict time and cost of future work based on past, completed projects
- Fast if good models and historic data from many projects are available
- Good when estimating something that has been done many times before
- Example: €500 per m³ for residential house in The Netherlands

BOTTOM-UP ESTIMATING

- Estimate each work package individually
- Sum up all estimates for total project estimate
- Requires comprehensive and detailed WBS
- Cannot be used before detailed planning stage of project
- Takes most time, but often most accurate

PHASED ESTIMATING



- Estimates become more accurate as project progresses from definition through planning to execution
- Phased estimating uses different estimating techniques for different phases
- Works well in scientific projects

BAD ESTIMATES

- “Let’s get started”, i.e. no or not enough planning
- Fuzzy definition of scope, i.e. fuzzy scope leads to fuzzy estimates
- Unwarranted optimism, i.e. failure to expect and account for problems
- Insufficient historical information

EXPENSE TYPES

- **Direct Costs**
 - Directly linked to specific work package
 - Materials, labor, equipment, contracts
- **Overhead**
 - Fixed costs spread over whole project
 - Workplace facilities, training, supervisors, contracting support

TOP-DOWN COST ESTIMATES

- Project Charter contains cost estimates
- Typically management generates estimate
- Based on previous experience
- Externally given contract value
- Not very precise
- Not useful for cost tracking
- Mostly constraints (spending limit)

BOTTOM-UP COST ESTIMATE

- Add all expense types for each work package (involve people assigned to WP)
- Sum all work package costs to get total project cost
- Add contingency
- Compare with top-down estimate and resolve discrepancies

CONTINGENCY

- Estimates never 100% certain
- Must cover risk of underestimating cost and unforeseen problems
- For scientific project, at least 20% cost contingency for well-defined plan
- Otherwise, 100% during definition, 50% during design, 20% for construction
- May have to be hidden as many funding agencies do not allow inclusion of contingency

REALISTIC SCHEDULES

- Includes detailed knowledge of work to be done
- Has task sequence in correct order
- Accounts for external constraints beyond control of project team
- Can be accomplished on time given access to skilled people and sufficient equipment

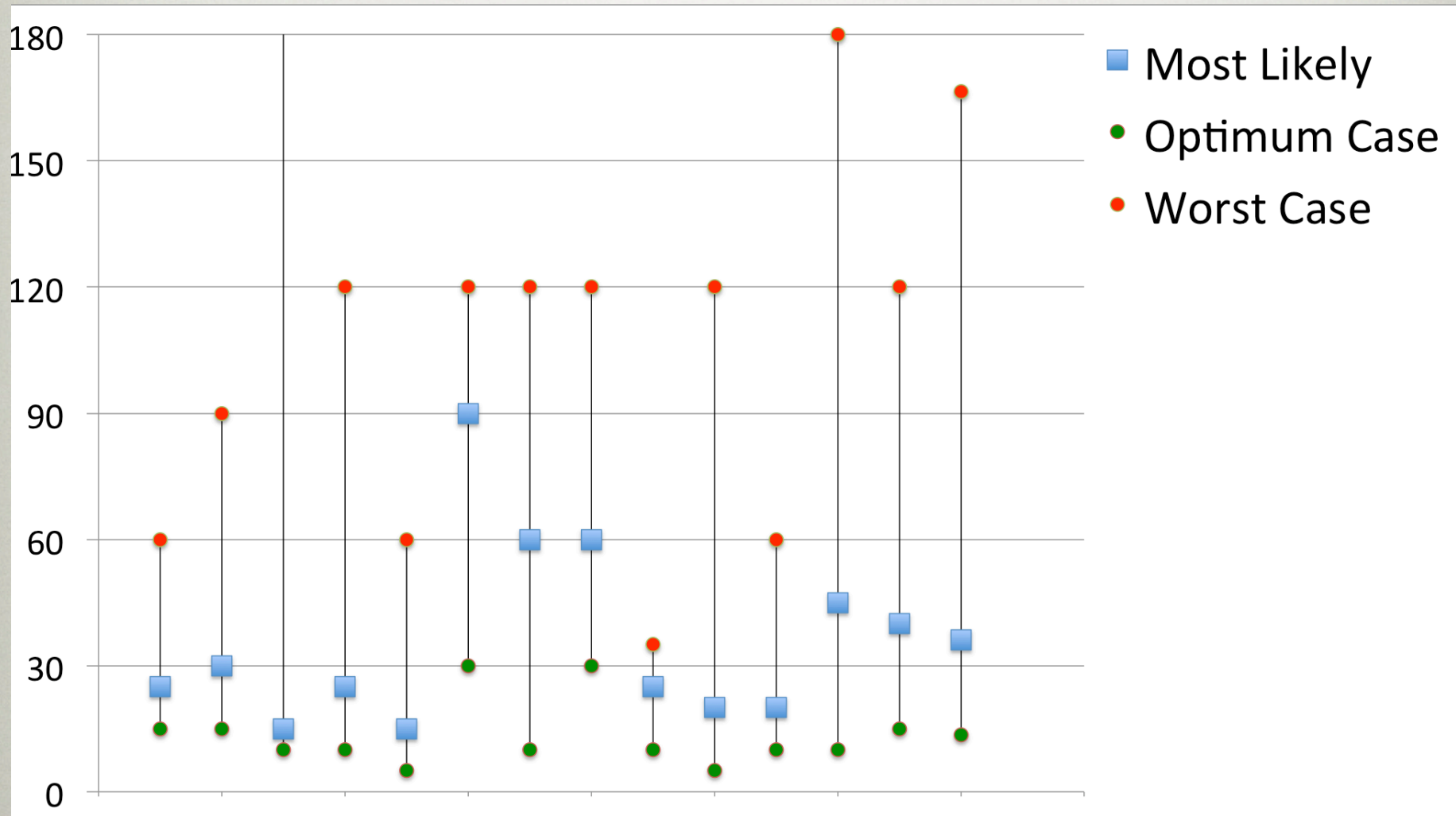
MILESTONES

- Mark significant events in a project's life
- May be part of WBS
- Milestones take no time, do not influence schedule
- Start and finish of project may be milestones
- May mark input from one party / phase to another
- May represent significant events not represented by summary task or work package
- Show major progress points

MILESTONES EXAMPLE

milestone	updated (Sep. 2008)	proposal (May 2007)	passed?
PhD student starts	March 2008	March 2008	yes
Design Review	February 2009	November 2008	
AIT finished	November 2009	July 2009	
Instrument shipped to the USA	January 2010	November 2009	
First light at SOLIS	March 2010	February 2010	
Start of regular data collection at SOLIS	July 2010	June 2010	
Thesis defense PhD student	April 2012	April 2012	
Minimum instrument lifetime achieved	Jun 2020	May 2020	

OPTIMISTIC ESTIMATES



OPTIMISTIC ESTIMATES

Average estimates from practicum 3:

- Optimistic case: 13 minutes
- Pessimistic case: 167 minutes
- Most likely case: 36 minutes
- $(\text{Optimistic} - \text{Pessimistic}) / 2$: 90 minutes

PERT ANALYSIS

- Program Evaluation and Review Technique (PERT)
- Widely known, rarely used
- 3 Estimates:
 - Optimistic, best case (O)
 - Pessimistic, worst case (P)
 - Most Likely, single estimate outcome (M)
- Most estimates are closer to optimistic than pessimistic
- More realistic estimate: $R = (O+4*M+P) / 6$

SCHEDULING

1. Take Work Breakdown Structure
2. Specify person / vendor who will accomplish each work package / task and ask how much time it takes
3. Establish task dependencies between and among tasks
4. Determine completion dates for each task
5. Add this information and assumptions to plan
6. Create overall schedule

TASK DEPENDENCIES













For each work package ask

- When could it begin?
- When must it begin?
- When could it finish?
- When must it finish?
- Where does it lead to?
- What would be delayed if it slipped?

DETERMINE TASK DEPENDENCIES

- Task dependencies only exist between work packages (summary tasks consist of work packages)
- Task dependencies only reflect sequence constraints (A must be done before B)
- Schedules are typically made by assuming that task must be completed before successor task can start















TASK DEPENDENCY EXAMPLE

ID		Task Name	WBS	Duration	Predecessors
1		Polarimeter	1	87 days	
2		Modulator Package	1.1	82 days	
3		FLC	1.1.1	28 days	
4		controller	1.1.1.1	1 day	
5		determine center wavelen	1.1.1.2	2 days	
6		requirements	1.1.1.3	3 days	4,5,10
7		quotes	1.1.1.4	1 day	6
8		purchase	1.1.1.5	2 days	7
9		test	1.1.1.6	3 days	8
10		achromatic design	1.1.2	2 days	
11		half-wave plate	1.1.3	1 day	
12		rotation mechanism design	1.1.4	5 days	
13		rotation mechanism manufactu	1.1.5	2 wks	12
14		temperature controller design	1.1.6	5 days	7
15		temperature controller manufac	1.1.7	2 wks	14
16		Polarization compensator	1.2	79 days	
17		specifications	1.2.1	2 days	
18		mechanical design	1.2.2	2 wks	
19		mechanical fabrication	1.2.3	2 wks	18
20		Polarizing Beamsplitter	1.3	76 days	
21		specifications	1.3.1	2 days	
22		optical design	1.3.2	3 days	21
23		purchase beamsplitter	1.3.3	2 days	22
24		purchase prisms	1.3.4	2 days	22
25		mechanical design	1.3.5	1 wk	
26		mechanical fabrication	1.3.6	2 wks	25
27		AIT	1.3.7	1 wk	23,24,26
28		Polarization calibration	1.4	60 days	
29		requirements	1.4.1	3 days	
30		design	1.4.2	2 wks	
31		fabrication	1.4.3	2 wks	30
32		fiber-fed focal plane	1.4.4	1 day	

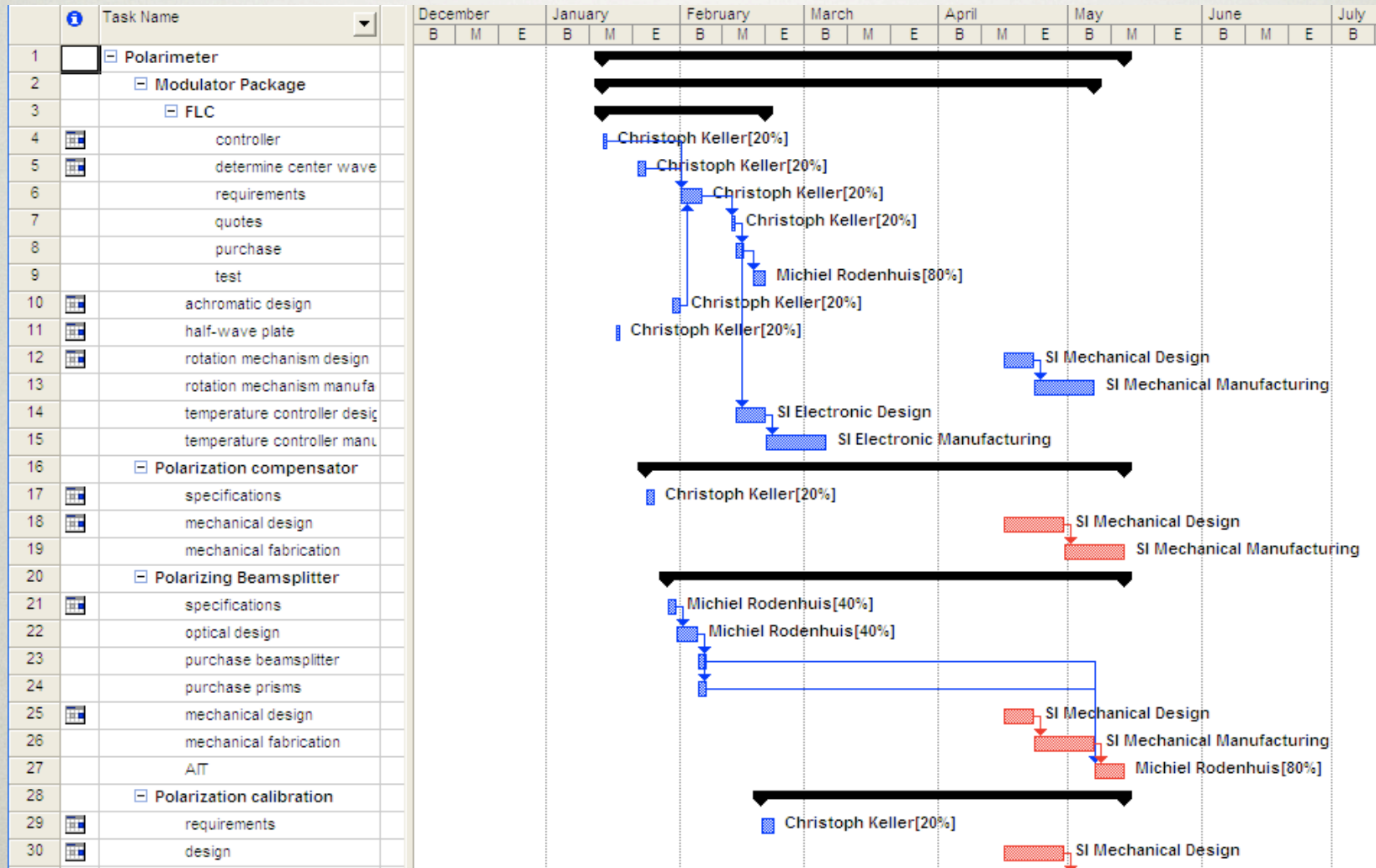
LABOR ESTIMATE VS DURATION

- People not available 100% of time
- People not 100% efficient
- Decisions can take significant time to get to
- Orders placed quickly, but delivery can take long time
- Labor estimate = time it takes somebody working 100% on task to finish it
- Duration estimate = time that passes on the clock until task is finished

EXAMPLE RESOURCE ASSIGNMENT

	 Task Name	WBS	Duration	Resource Names	Predecessors
1	 Polarimeter	1	87 days		
2	 Modulator Package	1.1	82 days		
3	 FLC	1.1.1	28 days		
4	 controller	1.1.1.1	1 day	Christoph Keller[20%]	
5	 determine center wave	1.1.1.2	2 days	Christoph Keller[20%]	
6	requirements	1.1.1.3	3 days	Christoph Keller[20%]	4,5,10
7	quotes	1.1.1.4	1 day	Christoph Keller[20%]	6
8	purchase	1.1.1.5	2 days		7
9	test	1.1.1.6	3 days	Michiel Rodenhuis[80%]	8
10	 achromatic design	1.1.2	2 days	Christoph Keller[20%]	
11	 half-wave plate	1.1.3	1 day	Christoph Keller[20%]	
12	 rotation mechanism design	1.1.4	5 days	SI Mechanical Design	
13	rotation mechanism manufa	1.1.5	2 wks	SI Mechanical Manufacturing	12
14	temperature controller desig	1.1.6	5 days	SI Electronic Design	7
15	temperature controller manu	1.1.7	2 wks	SI Electronic Manufacturing	14
16	 Polarization compensator	1.2	79 days		
17	 specifications	1.2.1	2 days	Christoph Keller[20%]	
18	 mechanical design	1.2.2	2 wks	SI Mechanical Design	
19	mechanical fabrication	1.2.3	2 wks	SI Mechanical Manufacturing	18
20	 Polarizing Beamsplitter	1.3	76 days		
21	 specifications	1.3.1	2 days	Michiel Rodenhuis[40%]	
22	optical design	1.3.2	3 days	Michiel Rodenhuis[40%]	21
23	purchase beamsplitter	1.3.3	2 days		22
24	purchase prisms	1.3.4	2 days		22

GANTT CHART



EXAMPLE SCHEDULE CHECK

“The E-ELT construction time of 6-7 years is comparable to the construction time for an 8m-class telescope. No 8m-class telescope was constructed in significantly less time. However the construction process for the E-ELT is far more complex than for an 8m-class telescope. The amount of material involved is an order of magnitude greater, there is extensive machining of very large components which can only be performed on-site, and there is much less opportunity to find and correct problems during factory preassembly, which will be limited.”

From 42-m E-ELT Phase B Design Review at
http://www.eso.org/sci/facilities/eelt/docs/E-ELT-PhaseB-BoardReport_ExecSummary.pdf

WORK SMARTER, NOT HARDER?

- Sponsors may assume 'padding' in plan
- Get pushed to do things faster, cheaper, and better
- Plan based on careful analysis, established planning approaches
- Try to resolve discrepant views and have
 1. Convinced sponsor and have support for plan
 2. Adjust plan based on helpful insights
 3. If you agree to the impossible, it will still remain impossible

CASH FLOW PLAN

- Determine when money is going to be spent
- Requires both cost estimates and schedule
- Can be easily calculated
- Often an issue in scientific projects because funding agencies will only provide equal payments per period
- Project sponsor may have to play the bank

CASH FLOW PLAN EXAMPLE

	Year 1	Year 2	Year 3	Year 4	Year 5
Personnel					
Postdoc (5 years ,vacant)	55000	55000	55000	55000	55000
PhD student A (4 years, vacant)	38000	39000	39500	40000	0
PhD student B (4 years, vacant)	0	38000	39500	40000	39000
Equipment etc.					
Equipment	112000	86000	83000	16000	5000
Consumables	5000	5000	5000	5000	5000
Workshop/Conference	0	0	35000	0	0
Travel	10000	10000	10000	10000	10000
Cash Needed	220000	233000	267000	166000	114000
Cash Available	189200	189200	189200	189200	189200
Cash Needed - Available	30800	43800	77800	-23200	-75200

FINAL REMARKS

- Accurate estimates take time and cost money
- Lessons from past improve forecasts of future
- Compare estimates with actual performance to improve future estimates
- Know when to use which method
- Know how much accuracy is required for certain decision
- Forces outside of project control often responsible for wrong estimates