Project Management

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James Webb Space Telescope

$~~4~~ >5 billion over budget, ~~four~~ seven years past schedule: Meet Northrop's problem program

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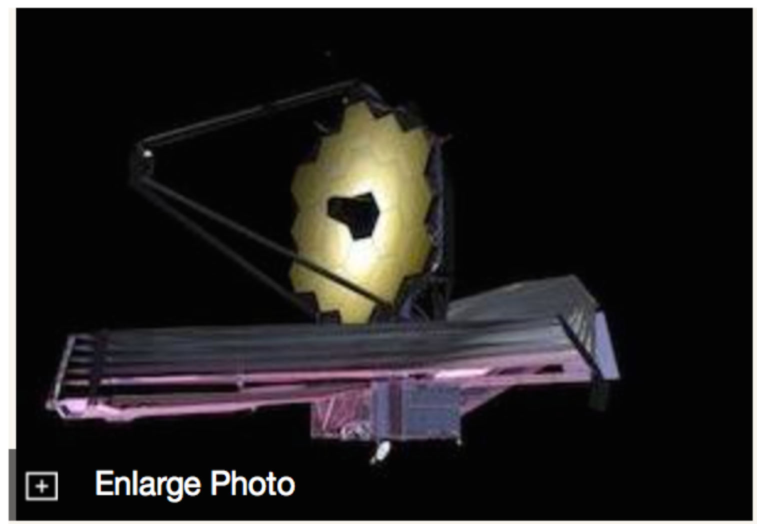
More than a decade after a prime contract was awarded for the development of the Hubble Space Telescope's successor, NASA's largest science project remains on shaky ground.



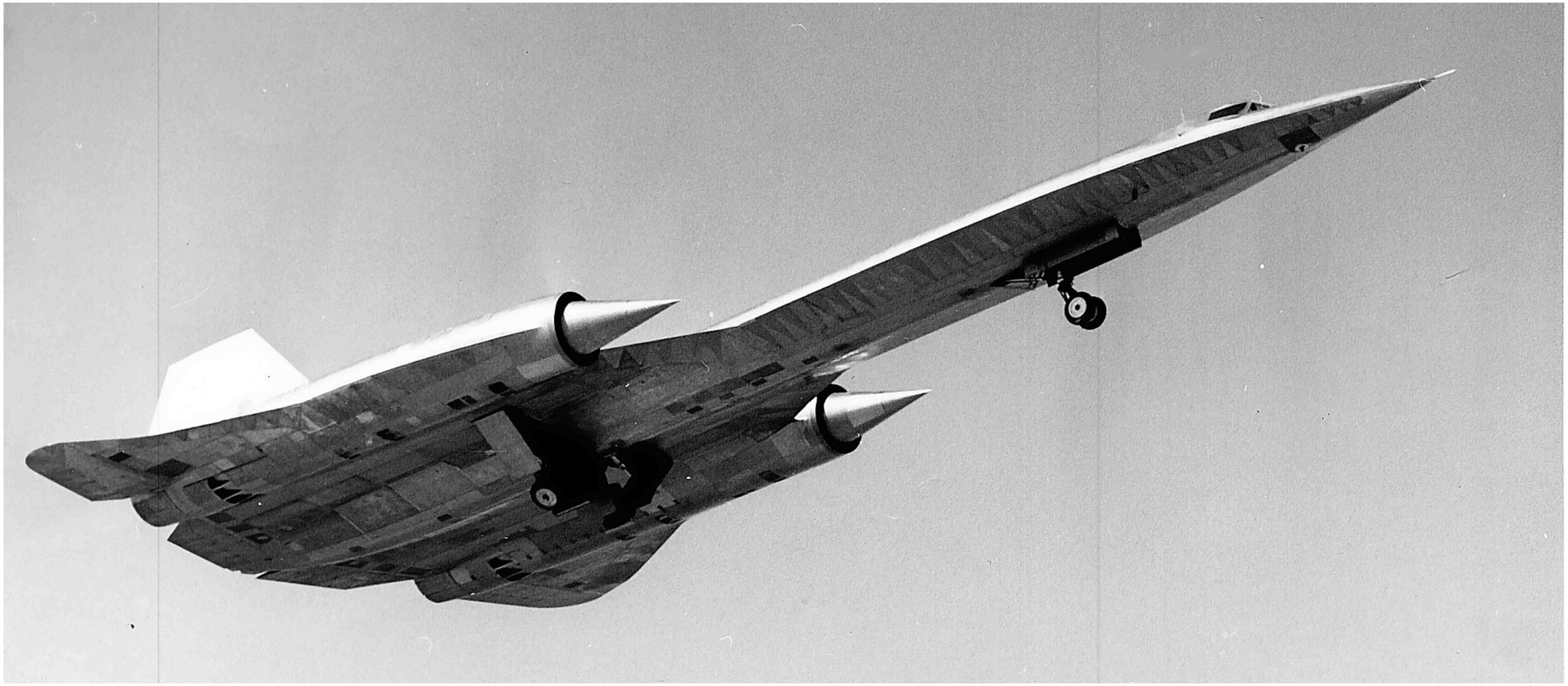
NASA

Clarence L. “Kelly” Johnson

XP-80, first US jet fighter: Skunk Works designed, built XP-80 in 143 days, 7 days less than required

CIA A12

- First flight within 2 years, 12 delivered, >2× over budget
- Mach 3.2 in 1963, declassified in 1996
- SR-71 officially achieves Mach 2.9 in 1976



Projects & Processes

<u>Projects:</u>

1. Are only done once
2. Have a beginning and a specific end
3. Produce something unique

<u>Processes and Operations:</u>

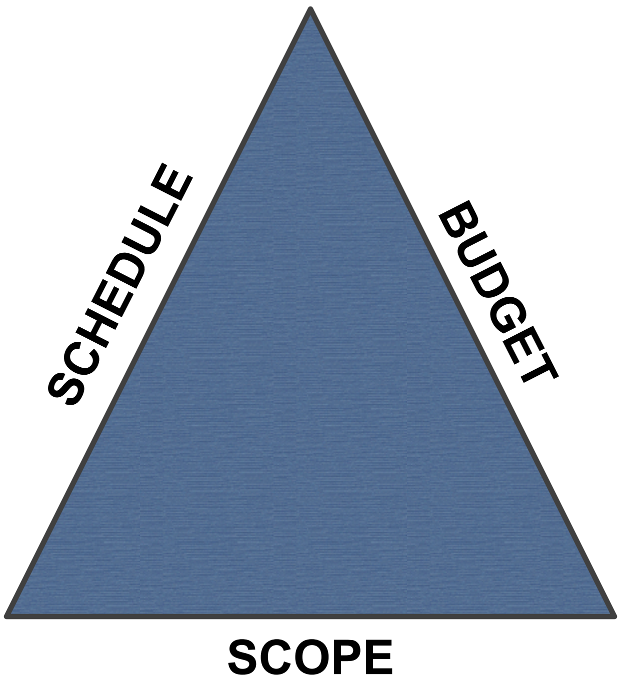
1. Repetitively produce same product or service
2. Have no predetermined end
3. Produce similar or identical products

Projects/Operations require different skills and approaches

Project Management

- Science: Methods, techniques, structures to manage complexities of unique, temporary work
- Art: Politics, interpersonal skills, creative decisions, intuition not to be underestimated
- Science of project management
  - is prerequisite to practicing the art
  - provides foundation for leadership
- Success in leading projects can be learned

Project Management Triangle

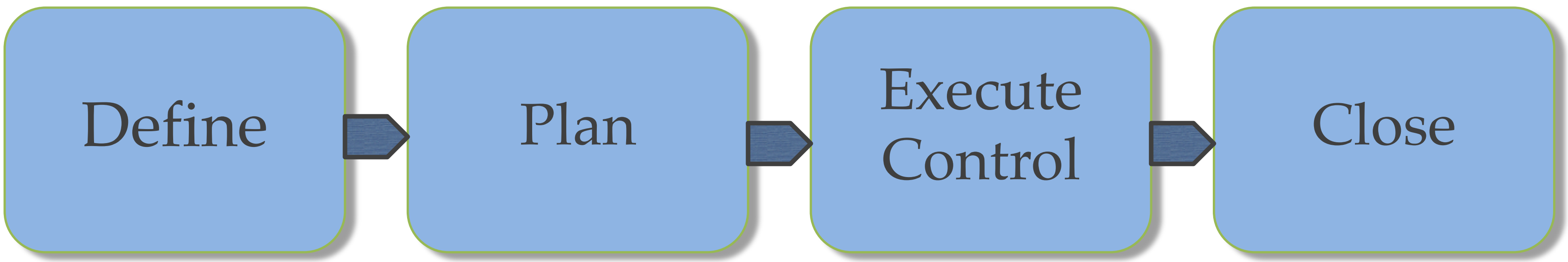


3 constraints often compete:

- increased scope -> increased time and cost
- tight time constraint -> increased costs and reduced scope
- tight budget -> increased time and reduced scope

Project Management provides tools & techniques to organize work and meet constraints

Project Life Cycle



Project Management tasks:

1. Define project
2. Plan project execution
3. Execute project, track progress, adjust plans
4. Close project

1. Project Definition

- Define
  - scientific purpose
  - scientific requirements
  - constraints
  - success
  - authorities and responsibilities
- Establish project management processes

Scientific Requirements

- Science rational leads to science objectives or science drivers
  - I would like to understand the origin of the solar cycle
- Measurements required to achieve science objectives, in astronomy often key observations
  - Line-of-sight magnetic field averaged over 1arcsec^2 with sensitivity of 1Gauss
- Requirements must be **S**pecific, **M**easurable, **A**greed, **R**ealistic, **T**ime-based

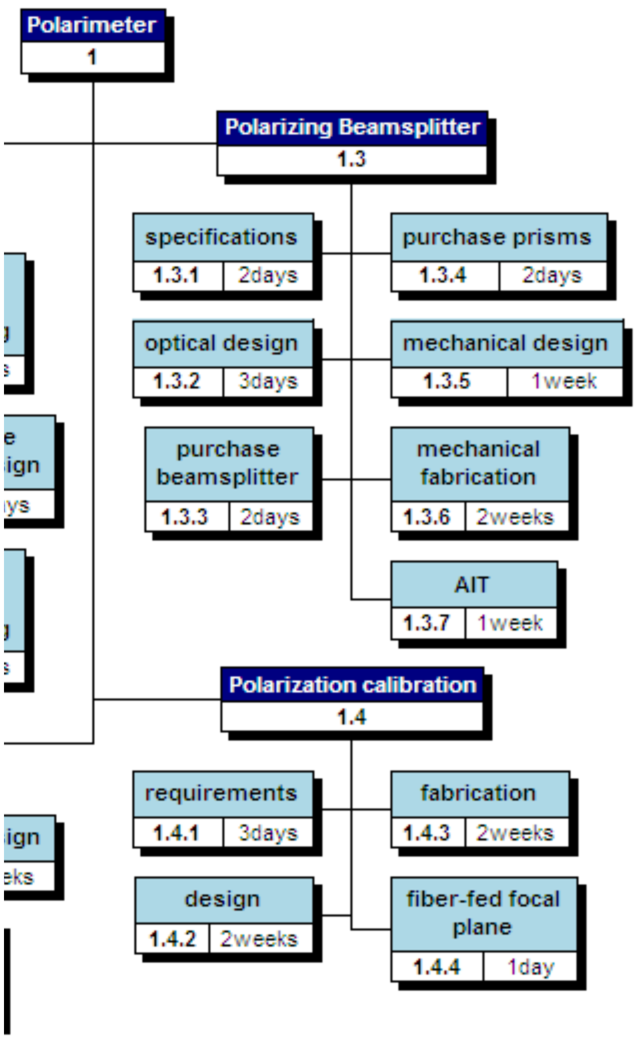
Good or Bad Requirements?

- SR-1: JWST shall be capable of making astronomical observations at wavelengths from 0.6 to 27 micrometers.
- SR-3: JWST shall have coronagraphic imaging capability over the wavelength ranges 2 to 27 micrometers.
- SR-32: The JWST science mission lifetime, after commissioning, shall be a minimum of 5 years.
- SR-33: Propellant shall be sized for 10 years of operation after launch.

2. Project Plan

- Explains how project goals will be met given the constraints
- Estimates for budget, effort, schedule
- Risk assessment and mitigation
- Communications plan
- Change Control process
- Plan becomes ***baseline*** to track project against

Work Breakdown Structure (WBS)



- Decomposition of project into manageable units (≥ 1 day, ≤ 2 weeks)
- Understand whole project by understanding all parts
- Family tree of all project work required to deliver the final product or service

Estimates (1)

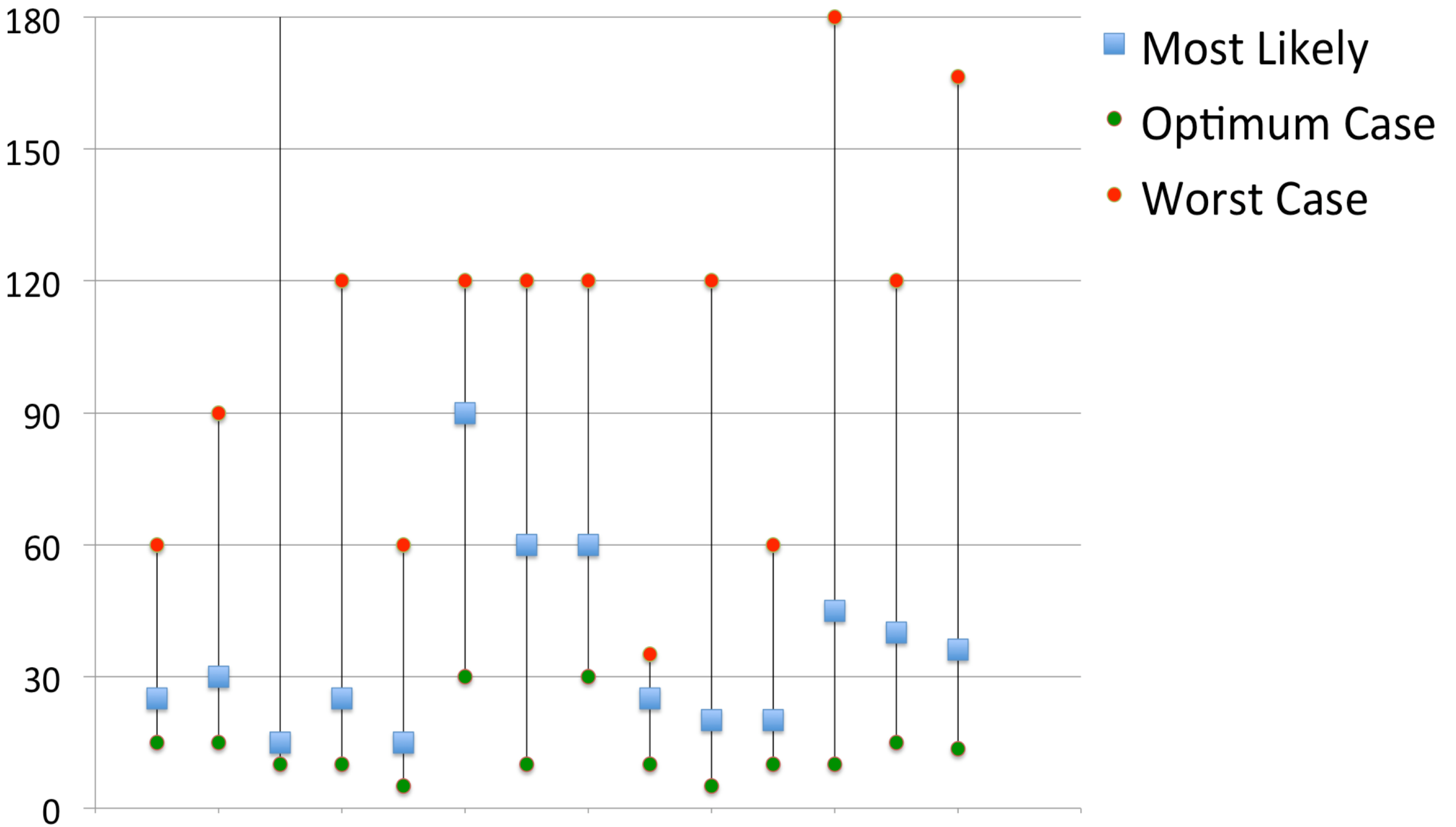
- Forecasts of cost, effort and schedule
- *Ballpark estimate* (SWAG)
  - Very fast, easily wrong by factor of 2 or more
- *Rough Order of Magnitude* (ROM)
  - Extrapolation from previous projects
  - Often good enough to start project
- *Parametric Estimate*
  - Equation based on past, completed projects
  - Example: €500 per m^3 for residential house in NL

Estimates (2)

- *Top-down estimate, b*ased on similar, past projects
  - Fastest, least accurate method

  "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." (from: www.eso.org/sci/facilities/eelt/docs/E-ELT-PhaseB-BoardReport_ExecSummary.pdf)
- *Bottom-up estimate*
  - Estimate each work package individually
  - Sum up all estimates for total project estimate
  - Most expensive, most accurate

Optimistic Estimates



Scheduling

1. Based on Work Breakdown Structure
2. Specify person/vendor who will accomplish each work package and time it takes
3. Determine dependencies between tasks
4. Determine completion dates for each task
5. Add this information and assumptions to plan
6. Create overall schedule (software can do it)

Contingency

- Must cover risk of underestimating cost and unforeseen problems
- Rules of thumb:
  - >100% during definition
  - >50% during design
  - >20% for construction
- Hide contingency for funding agencies that do not allow contingency

Risks

- *Risk* = any uncertainty in project
- Not everything will go according to plan
- Ask: “What could go wrong in this project?”
- *Risk Management* = systematic, disciplined approach to increase likelihood of success
- Risk management ≠ hiding the risks behind complex constructions

Risk Management

Risks defined by 3 variables

- **Event** that disrupts project
- **Probability** that event will happen
- **Impact** that event will have on project

1. Identify events by asking "what if" questions
2. Sort according to some criteria
3. Mitigate (reduce) high, moderate risk events
4. Ignore low risk events

Risk Mitigation Example

risk	likeli hood	impact	ran k	mitigation
spectrograph design	6	8	**48**	- learn from experts - reduce spectral resolution at edges of spectral range
calibration not precise enough	3	10	**30**	- test on prototype - more manual calibrations
influence of temperature variations on FLC	6	5	**30**	- test on prototype - thermal measurements - thermal isolation - thermal control
pointing too critical	4	7	**28**	- improve hardware/software
degradation of liquid crystal components	8	3	**24**	- regular checks - spare parts
alignment too critical	3	7	**21**	- alignment plan high priority - use tapered fibers - use precision translation stages
camera read-out too slow	3	5	**15**	- accept reduced polarimetric sensitivity
stiffness requirements too critical	3	3	**9**	- move spectrograph to fixed position

3. Project Control

- Regularly assess progress and compare to plan
- Progress measurements identify problems early:
  - Problems are still small
  - Still time to catch up
- Validate estimates
- Communicate progress
- Deviations from plan must lead to
  - Corrective actions
  - Adjustments of plan

4. Close Project

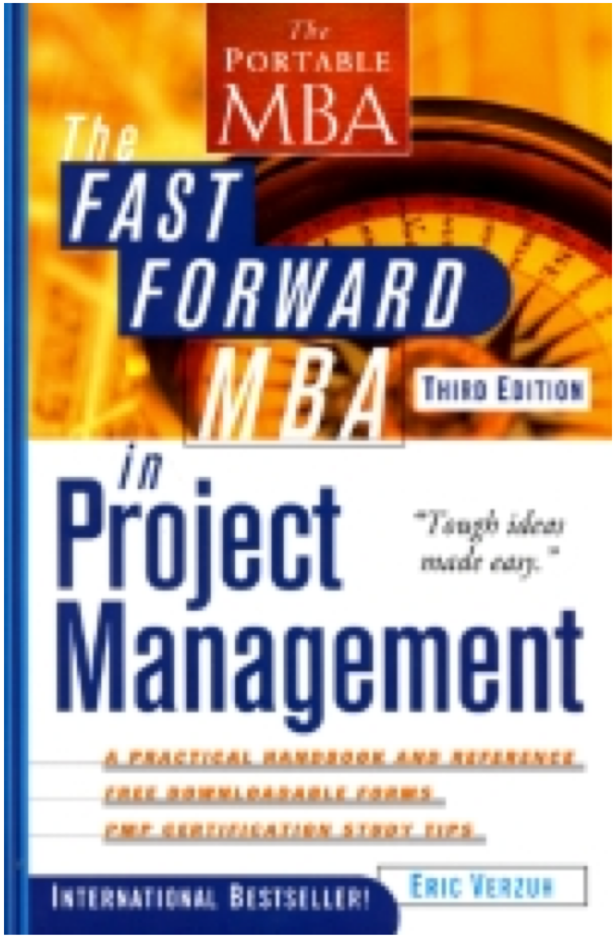
- Deliver
- Lessons learned
- Celebrate
- Happy team ready to do next project

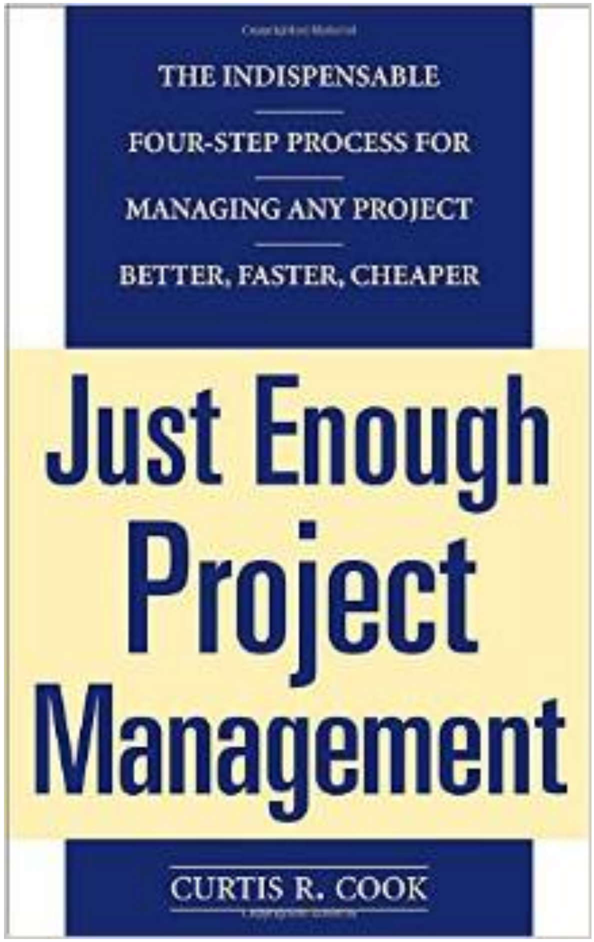
Keys to Successful Projects

1. Agreement among all on goals of project
2. Plan can be used to measure progress
3. Constant, effective communication
4. Controlled scope
5. Management support

- Just Enough Project Management
- Don't forget the people!

Books etc.





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