Improve Project Cost Estimates

Why estimates aren't accurate and what to do about it

Dr. David Ullman & David Persohn, Robust Decisions Inc.
Arthur Chmielewski, NASA/JPL New Millennium Program
Larry Leach, Advanced Projects Inc.

Copyright Robust Decisions

Presentation Overview

- Goals of study at JPL
- Current state of estimation accuracy
- A taxonomy of causes
- JPL study results
- How to improve overruns

Copyright Robust Decisions

Study Goals

1. Understand the causes of inaccurate estimates
2. Study the causes at JPL
3. Recommend methods for estimation improvement

To achieve these we:

- Interviewed all cost estimators in 3 JPL space experiments of which: 1 launched, 1 cancelled, 1 awaiting launch
- Developed a taxonomy of causes based on literature and study data
- Performed additional surveys

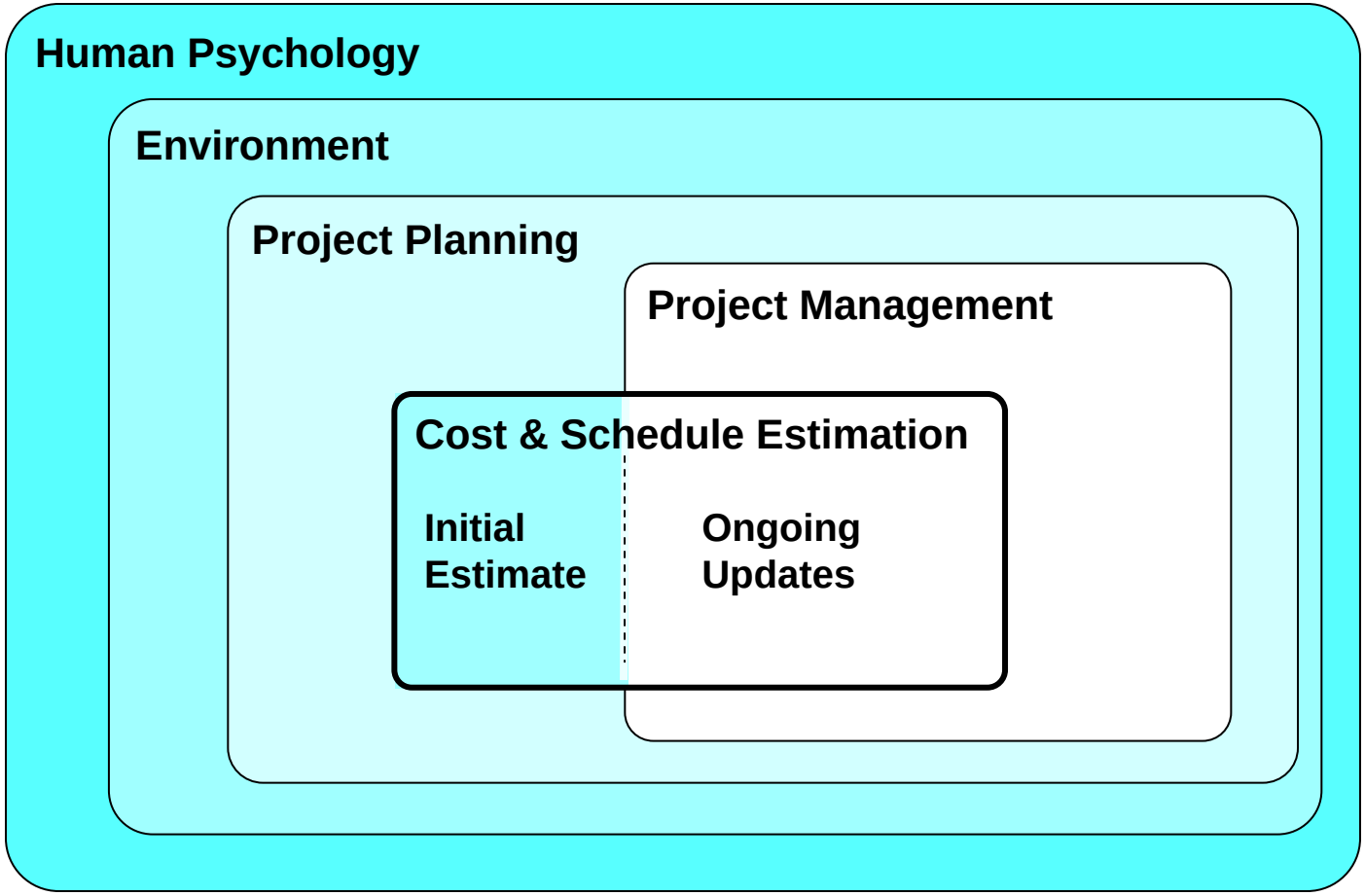
Copyright Robust Decisions

Current Estimation Accuracy

Mission type	Average Overrun	Missions Included
Flagship (> $800M)	31%	Spitzer, MER
Medium size (< $300M)	19%	Cloudsat, Deep Impact, Genesis, Grace, Stardust
Instruments (< $150M)	34%	TES, EMLS
System Technology Experiments (< $150M)	81%	DS-1, ST5, ST7
Small Technology Experiments (<$10M)	315%	In-STEP (11 experiments), Microgravity (26 experiments)

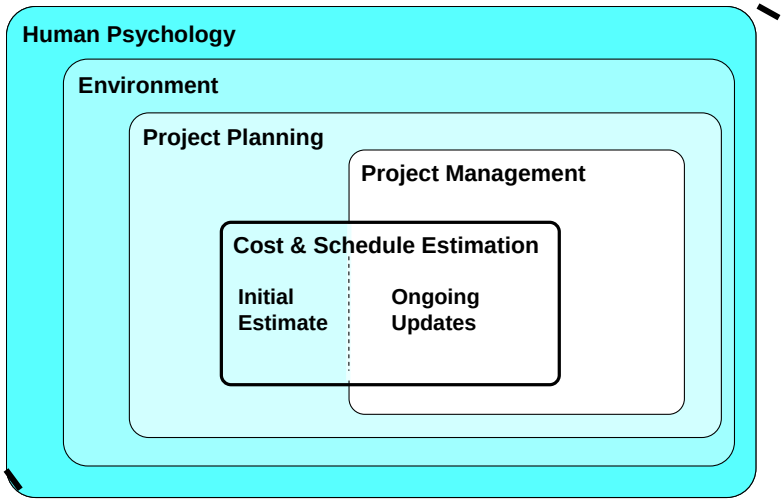
Copyright Robust Decisions

Inaccuracy Components



Copyright Robust Decisions

Human Psychology Component



Human Psychology

- No accounting for estimation uncertainty
- Anchoring effects
- Conflict between needs and accuracy

Copyright Robust Decisions

Human Psychology: Uncertainty

Manager: *"How long will it take to do thermal vacuum testing?"*

Engineer: *"Oh, 5 weeks"*

What does "5 weeks" convey?

- The average time is 5 weeks – 50% of the time it will take longer, 50% shorter
- He is 75% sure can be done in 5 weeks
- He is 90% sure can be done in 5 weeks
- Something else

Copyright Robust Decisions

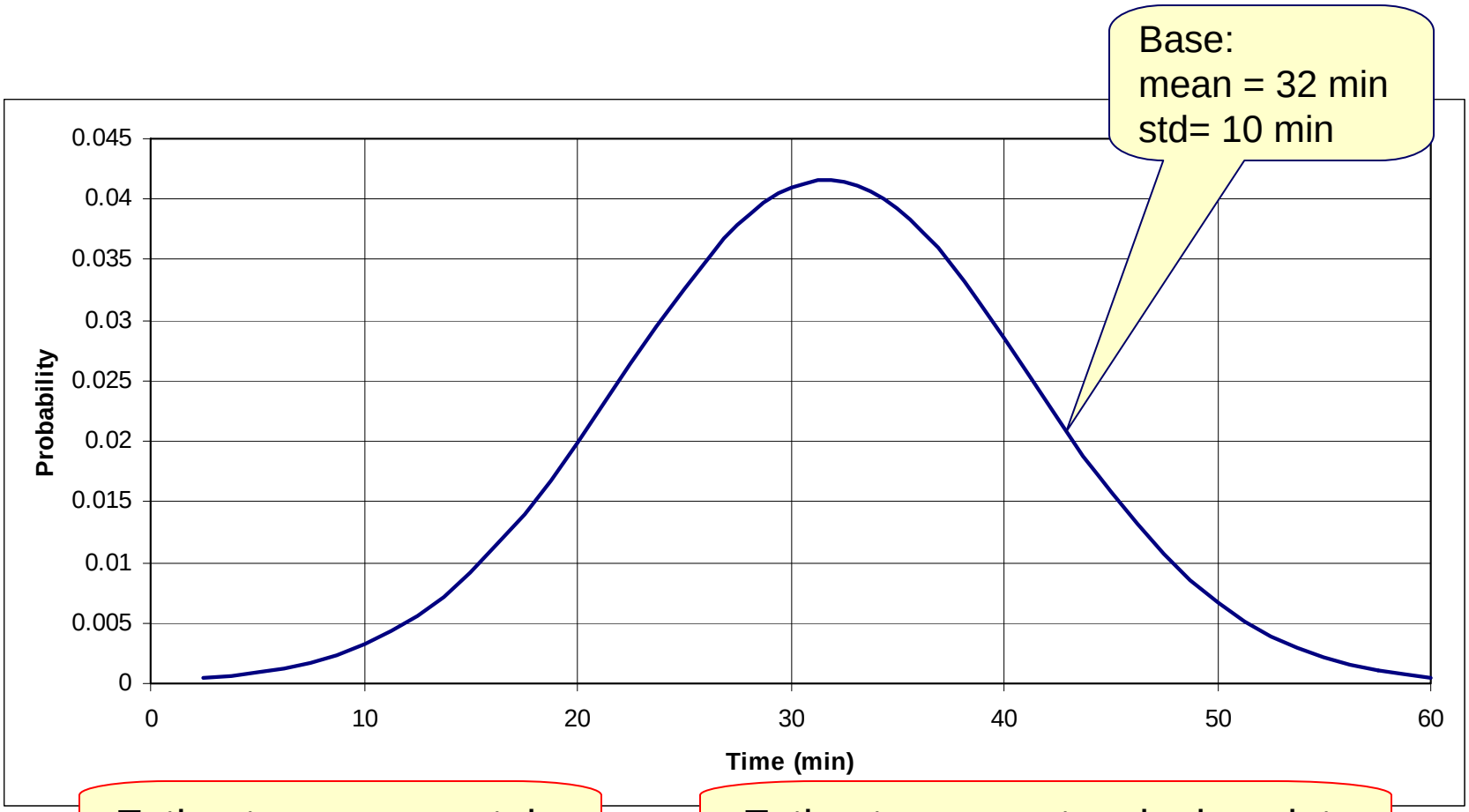
Human Psychology: Experiment

We gave 200 people a simple test asking them how long it will take to clean up a stack of dirty dishes. We gave them a detailed list of the dishes. We asked each person one of 5 different questions.

The first question, asked to 1/5 of our sample: *Estimate how many minutes it will take you to clean up the kitchen?*

Copyright Robust Decisions

Human Psychology: Some Results



Estimates are uncertain

Estimates are not a single point

Estimates more than one standard deviation from the mean (outliers) have been removed from the raw data in the results shown.

Copyright Robust Decisions

Human Psychology: Experiment

Other subjects were asked either:

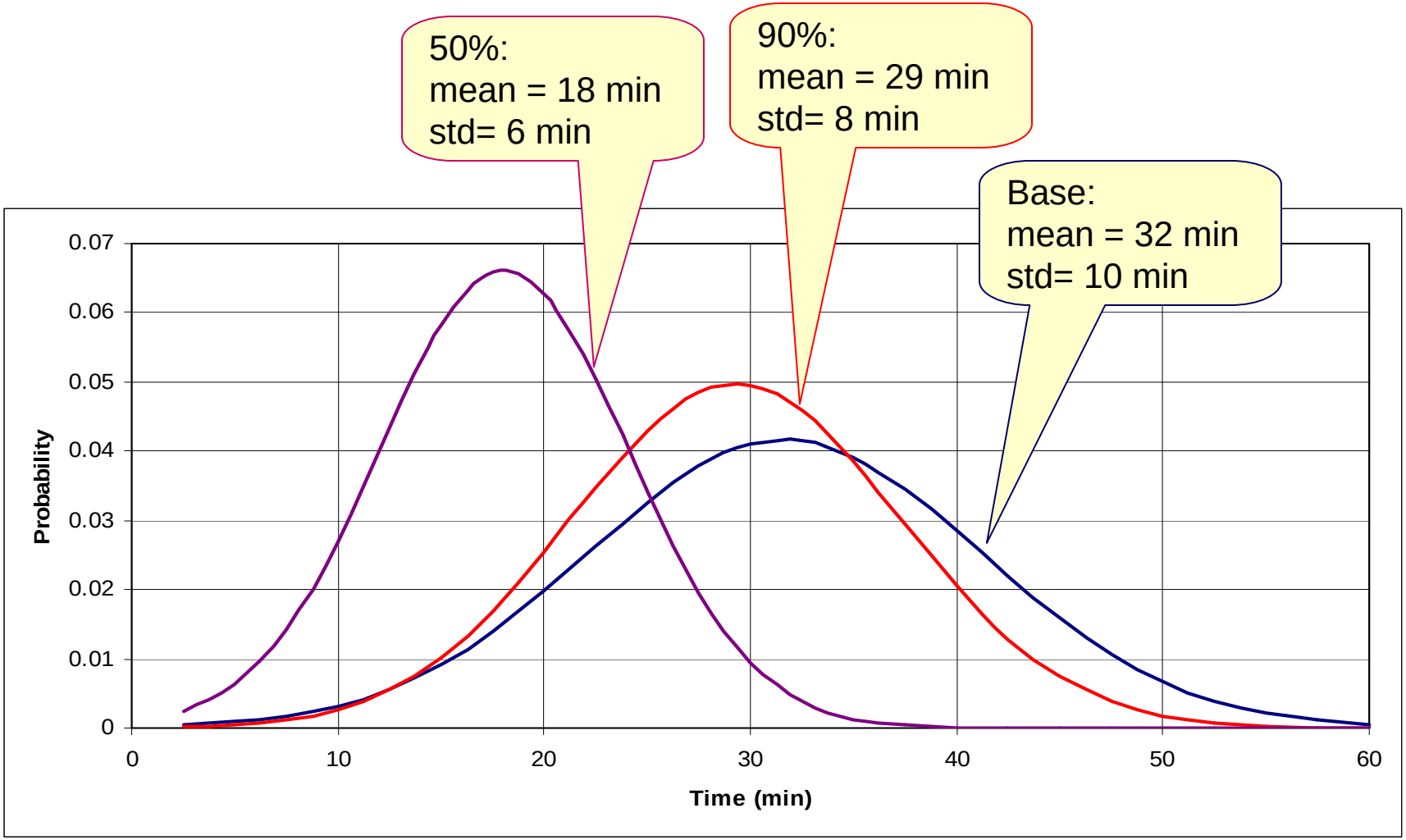
- *Estimate how many minutes so that you are 50% sure you will be finished cleaning up the kitchen?*

or

- *Estimate how many minutes so that you are 90% sure you will be finished cleaning up the kitchen?*

Copyright Robust Decisions

Human Psychology: The Results



Copyright Robust Decisions

Human Psychology: Anchoring

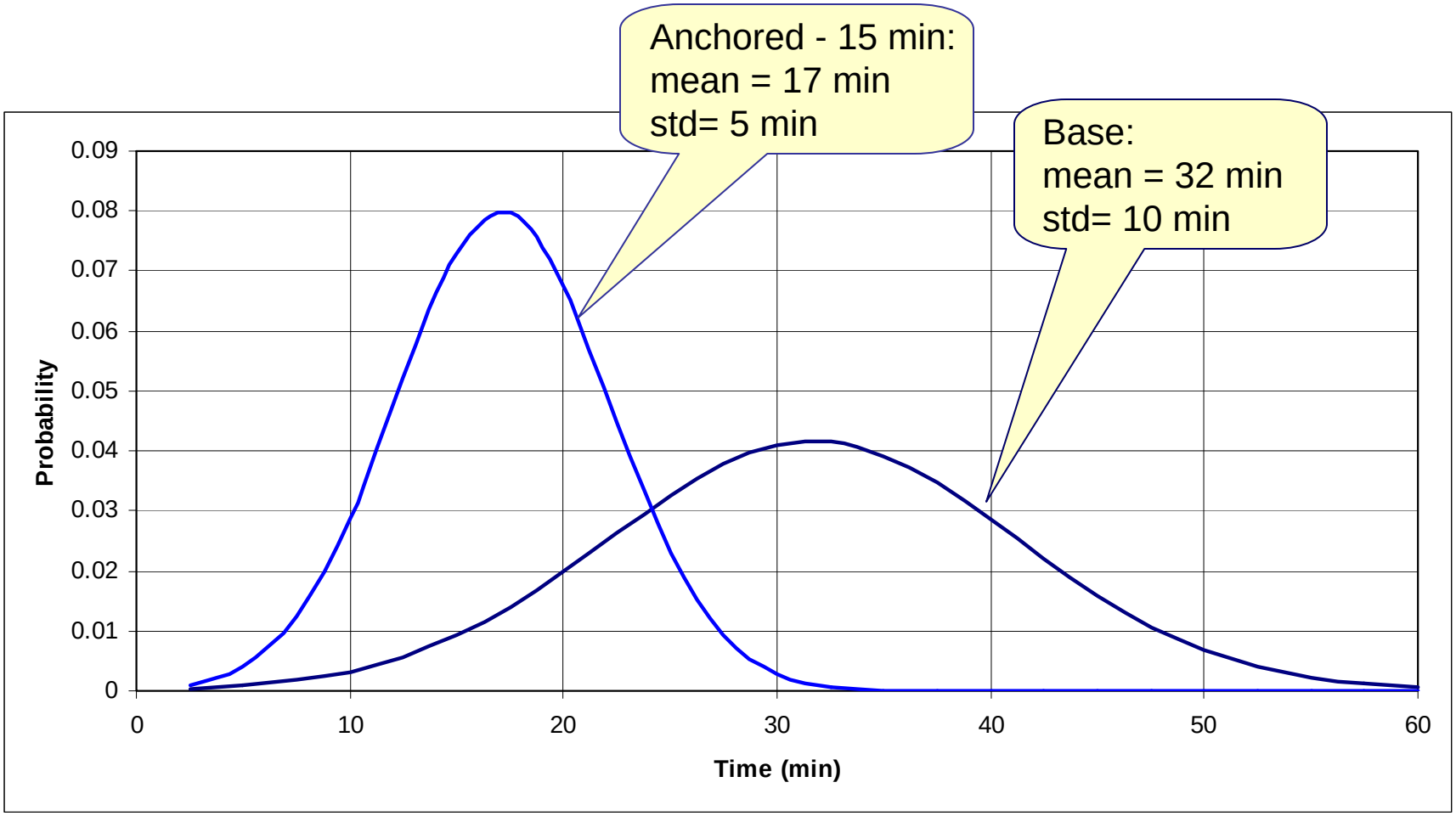
Another group was asked was:

- *Your partner has told you that the kitchen needs to be clean in 15 min. Estimate how many minutes you think it will take you?*

- Loading a question with a value will "anchor" people to that value, a well known psychological phenomenon
- Self-anchoring happens when an estimator is asked to provide a preliminary number ("you can refine it later")
- JPL "grass roots" estimates anchored by management "top down"

Copyright Robust Decisions

Human Psychology: The Results



Copyright Robust Decisions

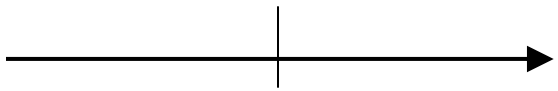
Human Psychology: Interpretation

- Results depend on how you ask the question
- The variation of each estimate is about the same as the estimate itself
- Dishwashing experts had similar results
- All of these estimates are equally (in)correct, it depends on who does the dishes
- Human psychology has a profound impact on estimates whether for the kitchen or, even more so, for thermal vacuum testing

Copyright Robust Decisions

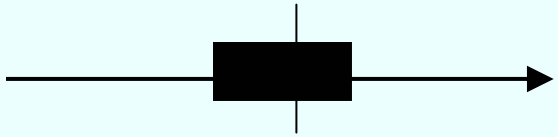
Human Psychology: Conflict between needs and accuracy

Estimated uncertainty is reduced artificially because:



Management wants a single value

- Management needs small uncertainty for planning regardless of reality
- Large uncertainty is seen as lack of knowledge
- Large uncertainty scares sponsor



Estimated uncertainty

The honest reality

Copyright Robust Decisions

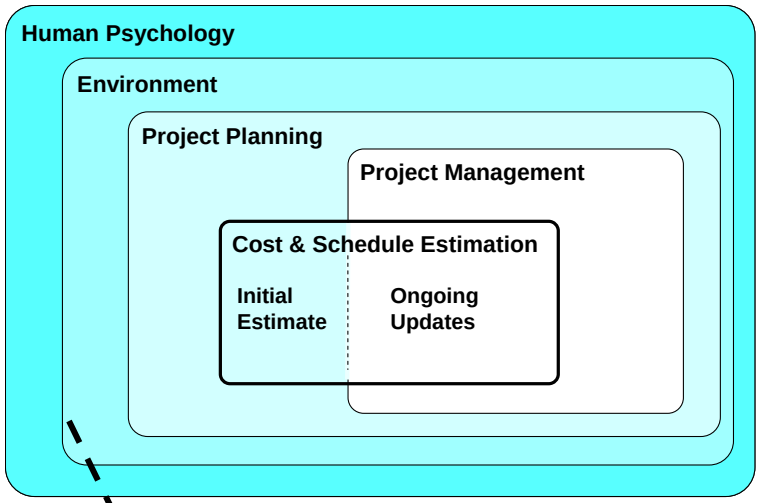
Human Psychology: Conclusions

In spite of psychological limitations, still need to make the best possible estimates

- Need training to elicit best possible estimations
  - Account for uncertainty
  - Not anchor
  - Have a methodology to gain the best possible estimates
- Need to manage the disconnect between the desire for "accurate" estimations and the reality
- Need planning and management methods to compensate for human limitations and uncertainty

Copyright Robust Decisions

Environment Component

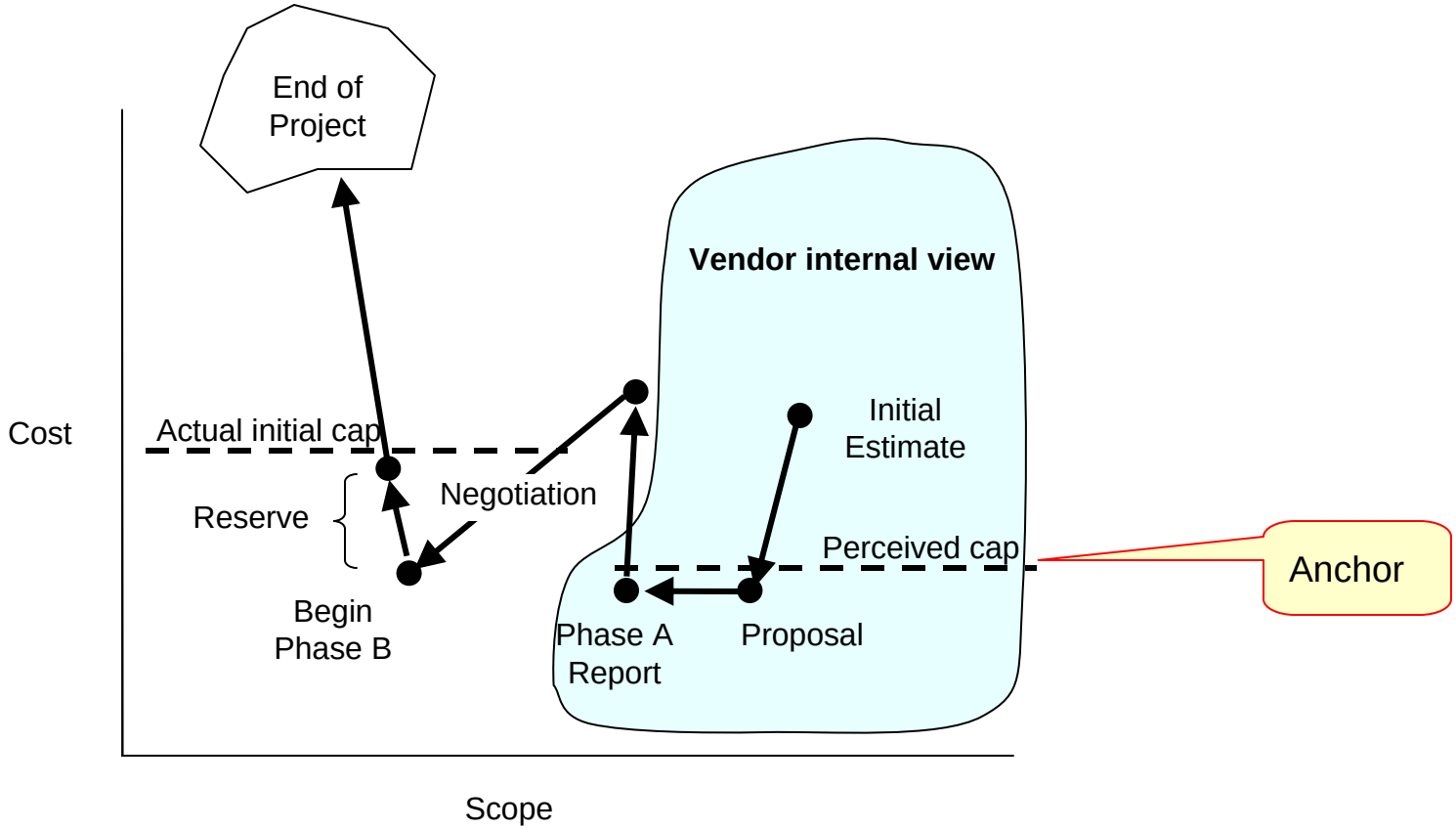


Environment

- Projects follow “W” curve
- Cost growth expected
- Non-robust, political, non-efficient decisions made
- Estimation not considered core competency
- Organization complexity results in poor communication
- Too many non-value added reviews

Copyright Robust Decisions

The Project "W"



This "W" pattern is repeated over and over. This leads to a basic truth…..

Copyright Robust Decisions

A "Truth"

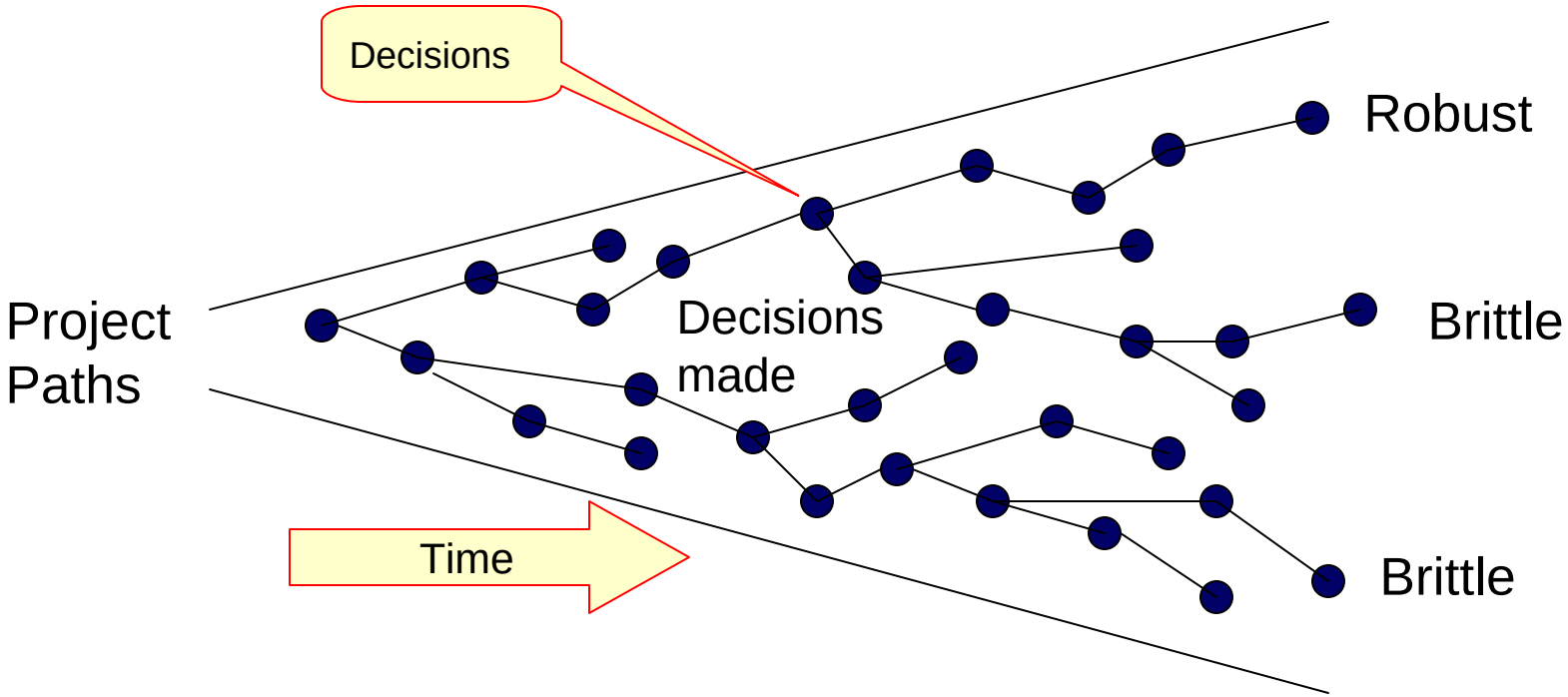
If an organization repeatedly shows the same behavior, then it is designed to give that behavior. Thus, most organizational structures are unintentionally designed to yield missed estimates.

Two choices:

- Live with it and patch to compensate for it (current approach).
- Actively try to change the organization and its methods, tools and operating processes.

Copyright Robust Decisions

Robust Decisions



Robust Decisions will:

- Look good a year later
- Resistant to uncertain estimations
- Spread buy-in and accountability
- Give guidance about what to do next to make the best possible decisions with measured satisfaction and risk

Copyright Robust Decisions

Decision Situations

- Concept selection
- Project management
- Portfolio management
- Product development
- Proposal evaluation
- Strategic planning
- Trade studies
- Hiring & evaluations

Copyright Robust Decisions

Robust Decisions

- Methods and software (*Accord*) currently in use at HP, Boeing and others
- Research on methods funded by NSF, DARPA, USAF, NASA
- Methods and tools help teams of people make the best possible decisions with uncertain, incomplete and evolving information.

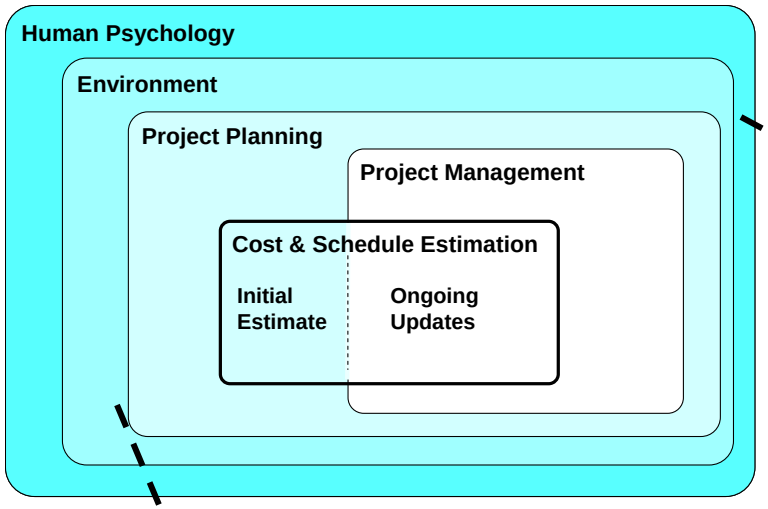
Copyright Robust Decisions

Environment: Conclusions

- Understand why environment generates "W" behavior and generate methods to resolve it
- Use Robust Decision methods to make the best use of uncertain information, integrate all stakeholders and make the best possible decisions

Copyright Robust Decisions

Project Planning Component



Project Planning

- Poor ability to measure technology readiness
- Inconsistent methods for managing risk
- Funding and management not consistent with technology challenge

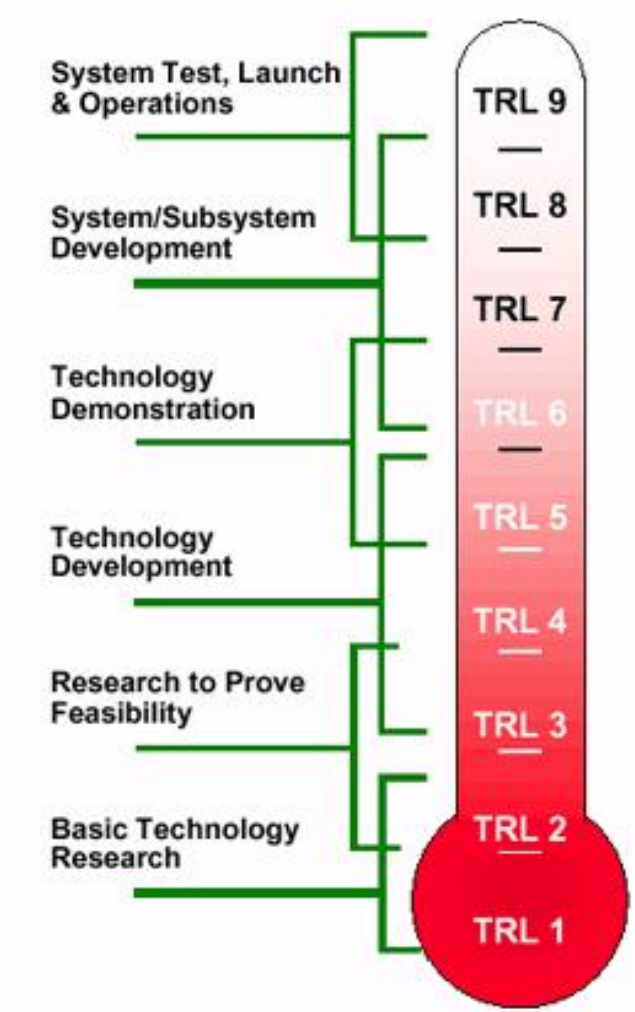
Copyright Robust Decisions

Technology Readiness

TRLs (Technology Readiness Levels) are a measure of the starting point for technology development projects.

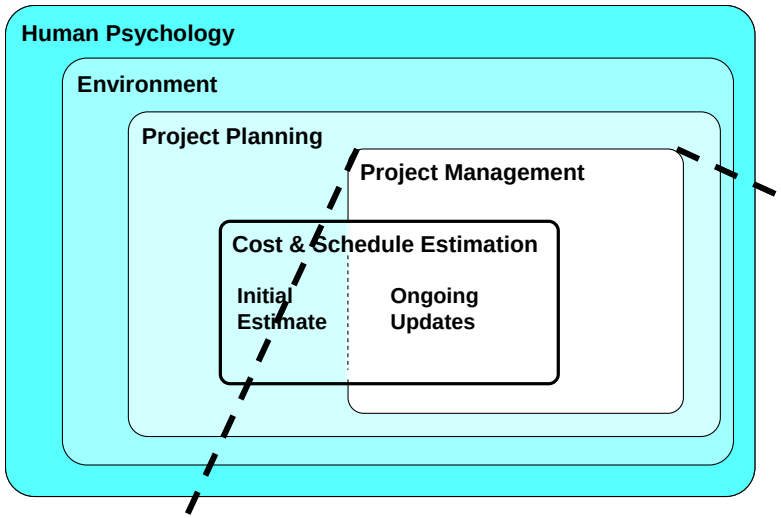
- Miss-assessment dooms estimate, yet TRLs are only estimated in an ad-hoc fashion
- TRLs need to be assessed using the best possible methods for managing uncertain information

If TRLs are not accurately assessed then it is hard to know where the project is starting and a consistent estimation methodology is needed.



Copyright Robust Decisions

Project Management Component



Project Management

- Current methods not best suited for technology development projects
- Change management challenging
- Disagreement on project assessments

Copyright Robust Decisions

Current methods not suited

Earned value and other current management methods are not designed to work with the reality of limited and uncertain estimates.

In fact, EV can exasperate the ability to work with uncertain estimates

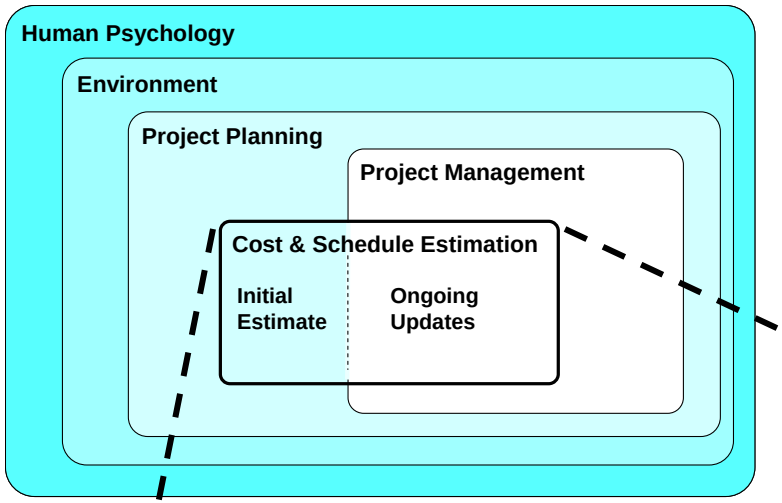
Copyright Robust Decisions

In a recent USAF study, the first author found that companies using Critical Chain Project Management methods benefited by:

- Basing schedules on uncertain estimates
- Projects on time - schedule focused
- People no longer afraid to expose problems
- People now work on critical tasks
- Less confusion
- Meetings focused on problems and how to fix them
- Forced organization to decide what is most important

Copyright Robust Decisions

Cost and Schedule Estimation Component



Cost and Schedule Estimation

- Poor estimation practice
- Poor tools to support estimation
- Poor estimator practice

Copyright Robust Decisions

Overall Summary

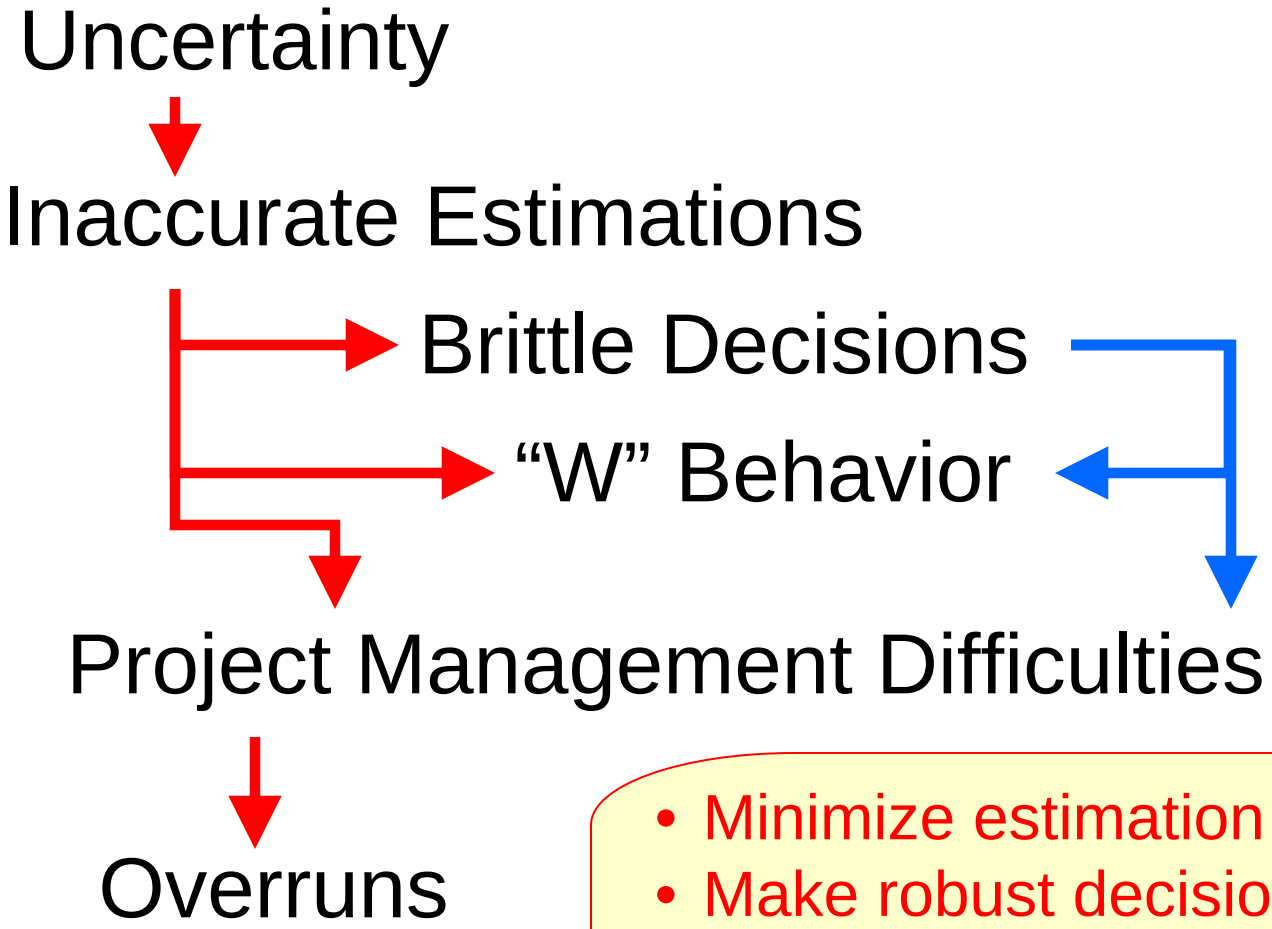
Cost and schedule overruns are NOT ONLY AN ESTIMATION PROBLEM. They are a system problem, a complex interaction between:

- Human psychology
- Organization and culture
- Project planning
- Project management

All of which suffer from poor uncertainty and decision management

Copyright Robust Decisions

Suggested Fixes



- Minimize estimation uncertainty
- Make robust decisions - immune to remaining uncertainty
- Use project management methods designed for uncertainty

Copyright Robust Decisions

Questions?

Dr. David Ullman

ullman@robustdecisions.com

Copyright Robust Decisions