

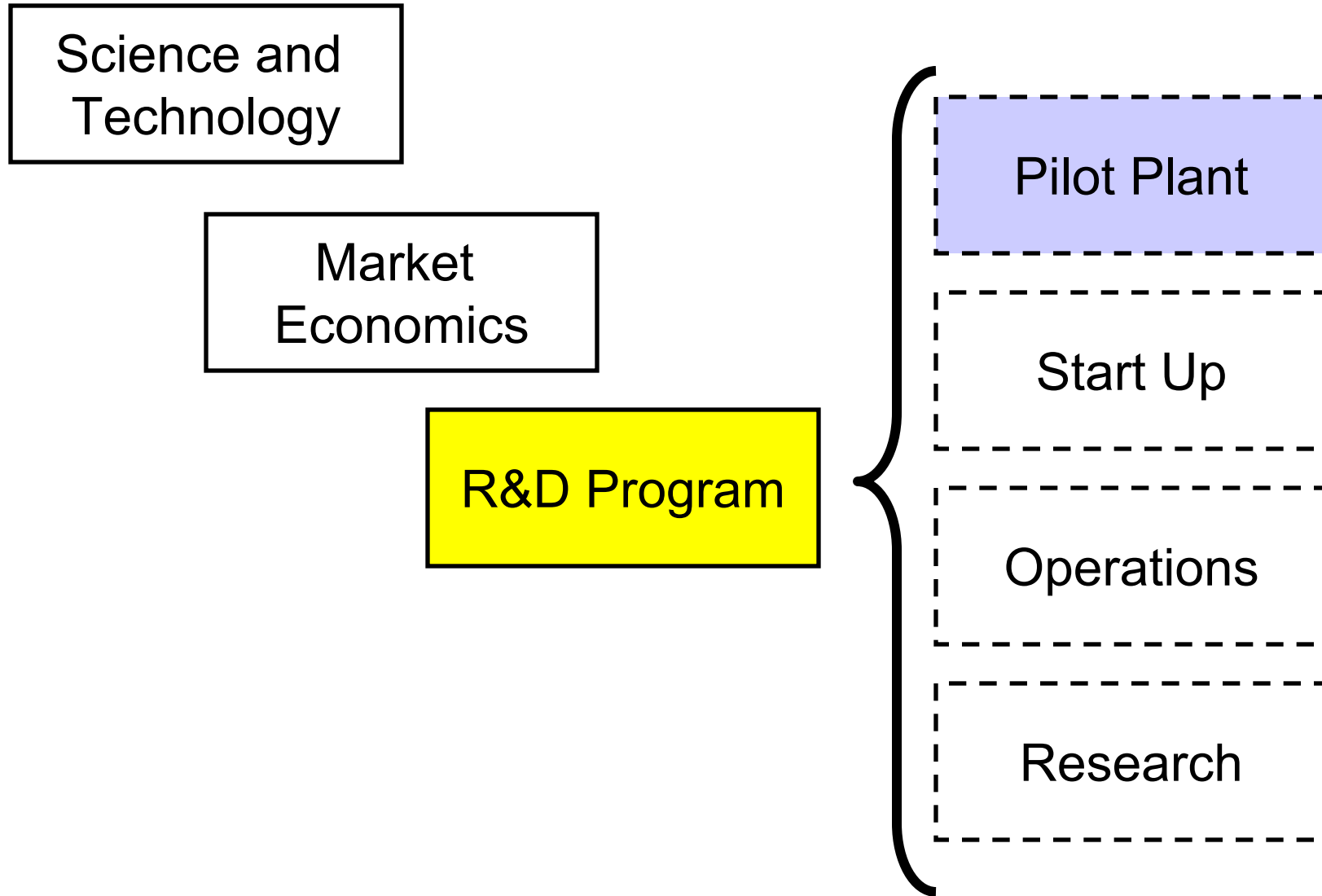
The Effect Of Pilot Plant Cost
Estimates On Research
Economics

Richard P Palluzi
ExxonMobil Research
& Engineering Company

Introduction

- The costs to design, construct and start up the pilot plant(s) or laboratory equipment to conduct an R&D program has a large effect on the economics and hence, the decision
- The effect of errors or uncertainty in the equipment estimates are often a key factor in reaching the decision.

Factors Influencing An R&D Decision



R&D Program Evaluation

- Most programs are evaluated in stages
 - Conceptual → Final
- Pilot plant requirements and design information start out ill defined and only sharpen as the process continues
- Multiple cost estimates usually required

Cost Estimates

- Many are based on inadequate information
- Often result in
 - Significant estimating inaccuracy and uncertainty
 - Difficulty in a final decision
 - Inadequate funding
 - Premature cancellation
 - Costly over runs

Types of Cost Estimates

- Conceptual
- Screening
- Preliminary
- Detailed
- Definitive

Conceptual

- Earliest cost estimate
- Little if any project definition
- Very limited design work completed
- Little if any hazard analysis and risk assessment

Conceptual (cont'd)

- Quick to develop (days)
- Rarely accurate ($\pm 50-300\%$)
- Skewed to producing under estimates
- Prone to overly optimistic/simplistic assumptions
- Any schedules are usually wildly unrealistic

Screening

- Commonly produced when competing alternatives are identified
- Limited project definition usually restricted to major areas of difference
- Analysis overly focused on perceived differences
 - Design
 - Hazard analysis

Screening (cont'd)

- Fast to develop (days → weeks)
- Good relative costs but potentially poor absolute costs
- More prone to personal bias
- Relatively inaccurate ($\pm 30-100\%$)
- Schedules remain very poor

Preliminary

- Generally developed following first adequate project basis
- Typically first estimate based on a documented design basis
 - Often cursory and/or incomplete
- Hazard analysis may overly focus on major areas of concern
 - Resulting in overlooking less apparent problems

Preliminary (cont'd)

- Some effort to develop (weeks → months)
- Requires supporting calculations and design work
- Accuracy varies widely with level of definition, supporting design work and review and estimator experience ($\pm 20-50\%$)

Detailed

- Developed after detailed design is complete
- Design basis complete and documented
- Almost all design work complete
- Hazard analysis complete
- Significant cost surprises after this point are rare
- Schedule begins to be valuable

Detailed (cont'd)

- Time consuming mostly due to need to complete design work and basis first (months)
- Significant increase in accuracy ($\pm 15-30\%$)
- First truly realistic schedule

Definitive

- Normally based on contractor bids on detailed design
- Often skipped to save time and effort
- Design basis complete, documented and frozen
- All design and hazard analysis completed

Definitive (cont'd)

- Significant time to complete (months)
- Highest accuracy (10-20%)
- Performs to expectations if there is adequate control of change
 - Can be a problem if the program definition or project design basis was faulty or incomplete

Guidelines to Improve Estimates

- Document all estimate basis completely and thoroughly
 - Identify all assumptions and allowances
- Conduct a rigorous review of the estimate basis
 - Cold eye reviews are recommended
 - Pilot plant/research experience is critical
 - Challenge everything!

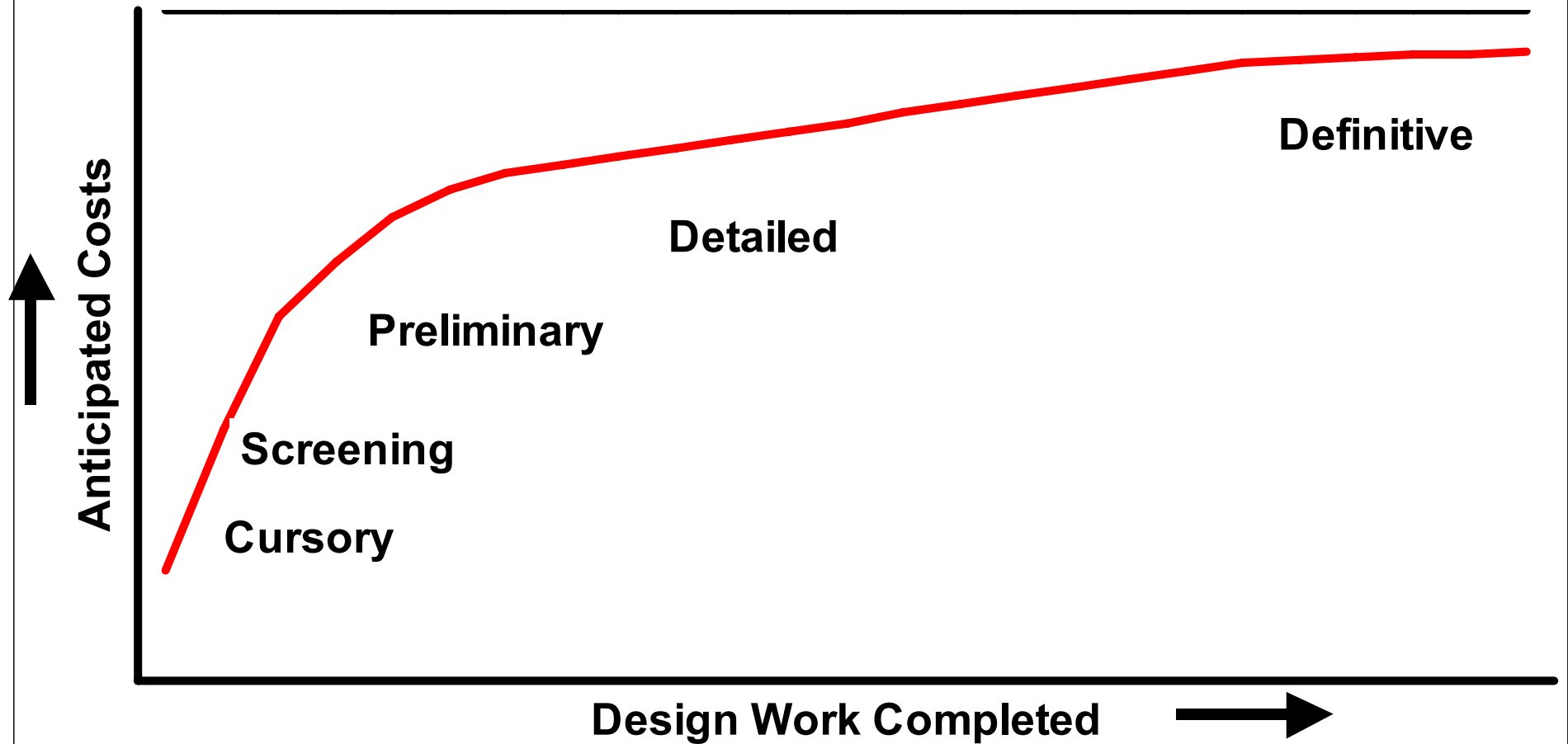
Guidelines to Improve Estimates (cont'd)

- Try to validate any components of the estimate
 - Particularly for conceptual, screening and preliminary estimates
- Watch out for personal/organizational bias
 - Particularly in conceptual and screening estimates

Guidelines to Improve Estimates (cont'd)

- Ensure adequate design work and hazard analysis is applied to all parts of the estimate
 - Inadequate work results in perceived lower costs
- Use the most experienced pilot plant estimators available

Anticipated Costs Over A Typical Pilot Plant Estimating Cycle



Guidelines to Improve Estimates (cont'd)

- Do not skip the detailed estimate
- Ensure that adequate hazard analysis is performed at each stage of the design
- Carefully evaluate the data supporting the design
- Allow adequate time and resources
- Ensure each stage has adequate contingency

Contingency

- An allowance for historically predictable but currently unidentified costs (entropy)
- A measure of estimating uncertainty (errors and omissions)
- An allowance for issues and problems identified as the design progresses (design definition)

Typical Contingency Levels

Cursory	50% to	100%
Screening	30% to	60%
Preliminary	20% to	50%
Detailed	10% to	30%
Definitive	5% to	15%