1.040 Project Management

Spring 2009

Project Organization II

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Based on Lectures Given by Dr. Nathaniel Osgood in 2005

Fred Moavenzadeh
Civil and Environmental Engineering
Massachusetts Institute of Technology

Project Organization

I. Project Delivery Systems (most common)
   - Design / Build
   - Others
   - Summary

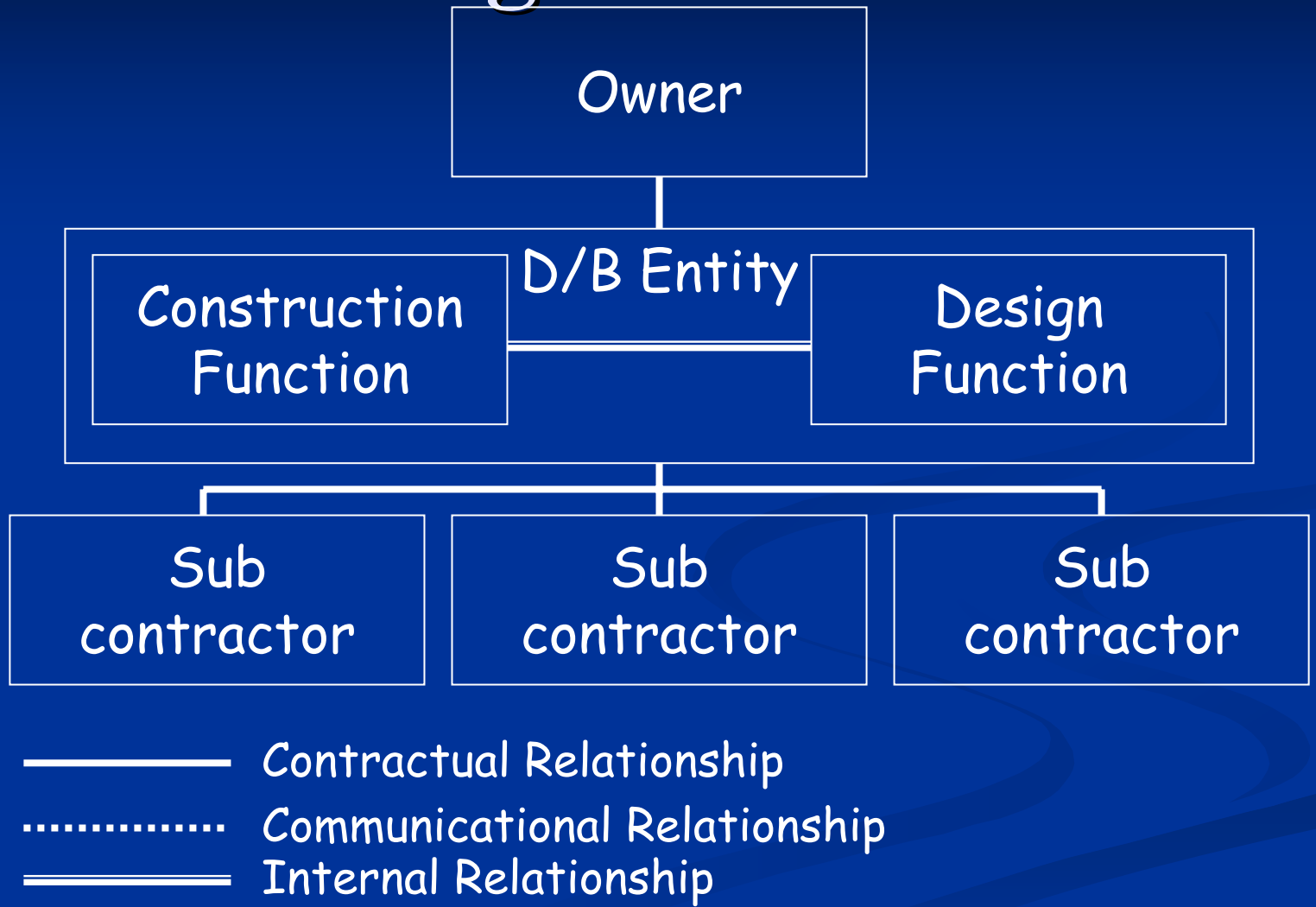
II. Payment Schemes
   - General points
   - Lumpsum
   - Cost plus fixed fee/% price
   - Unit price
   - Guaranteed maximum price

III. Award Methods
   - General points
   - Negotiation
   - Bidding

Part I

- Project Delivery

Design-Build



How To: Design / Build

- Owner
  - Develops early design (to communicate needs)
  - Hires a design/build firm that will complete both design and construction
- This firm can be a design/build firm but also a joint-venture firm for this specific project
- DB company may hire subcontractors
- Work solicited via RFP (honorarium, phased)
- Can be good for complex projects – but need phased design to shield parties from risk

Back to the Future…

- Dominant method early in US history
- Recent drivers
  - Time pressure (desire to fast track)
  - Shortcomings of tightly defined architect role
    - Constructability issues
    - Limited A/E oversight of construction
  - Downsizing of US corporations (outsourcing design)
  - Desire for single source of responsibility

Advantages DB

- Allows Fast Tracking
- May be good for some complex projects
  - Close coordination within team
  - Institutional knowledge build up
- Single source of accountability
- Owner need not mediate or be exposed to designer/contractor conflicts
- Easier incorporation of changes caused by field conditions

Disadvantages DB

- Lack of fiduciary relationship with designer
  - Risk of DB sacrificing *design* quality to protect profit
  - Owner must assume responsibility for quality assurance
- Pricing not possible at the beginning
- Demands sophisticated owner (construction, quality, oversight of submittals, negotiation,…)
  - Must stay on top of design so don't get surprise
- Can be bad for many complicated projects
  - Very important for owner to be closely involved to specify important and complex aspects of design
- Package: Can't pick or get rid of individual team members (e.g. individual subcontractors)

Design-Build Disadvantages II

- Need to make sure design goals stay foremost
  - Often contractor's interests within DB dominate
- Fewer checks and balances
  - Problems may be hidden until late (no A/E watch)
  - May take direction that owner does not really want
  - Design-build firm can give high quote for changes
    - Responsible for everything!
- If fast tracked, changes can lead to
  - Rework
  - Iteration
  - Delays

Public Use Challenges

- Regulatory hurdles
  - Federal use allowed
    - Federal Acquisition Reform Act of 1996 allowed
  - Many states still do not allow
    - Special permission may be granted for formal request
- Major opposition from
  - Architectural lobby
  - Unions

Bridge Designer/Engineer

- Serves as bridge between
  - Owner
  - Design-build team
- Performs preliminary design before DB team hired
  - E.g. up to 30% design
- Monitors development of design and construction
  - Fiduciary with owner

DB Selection Considerations

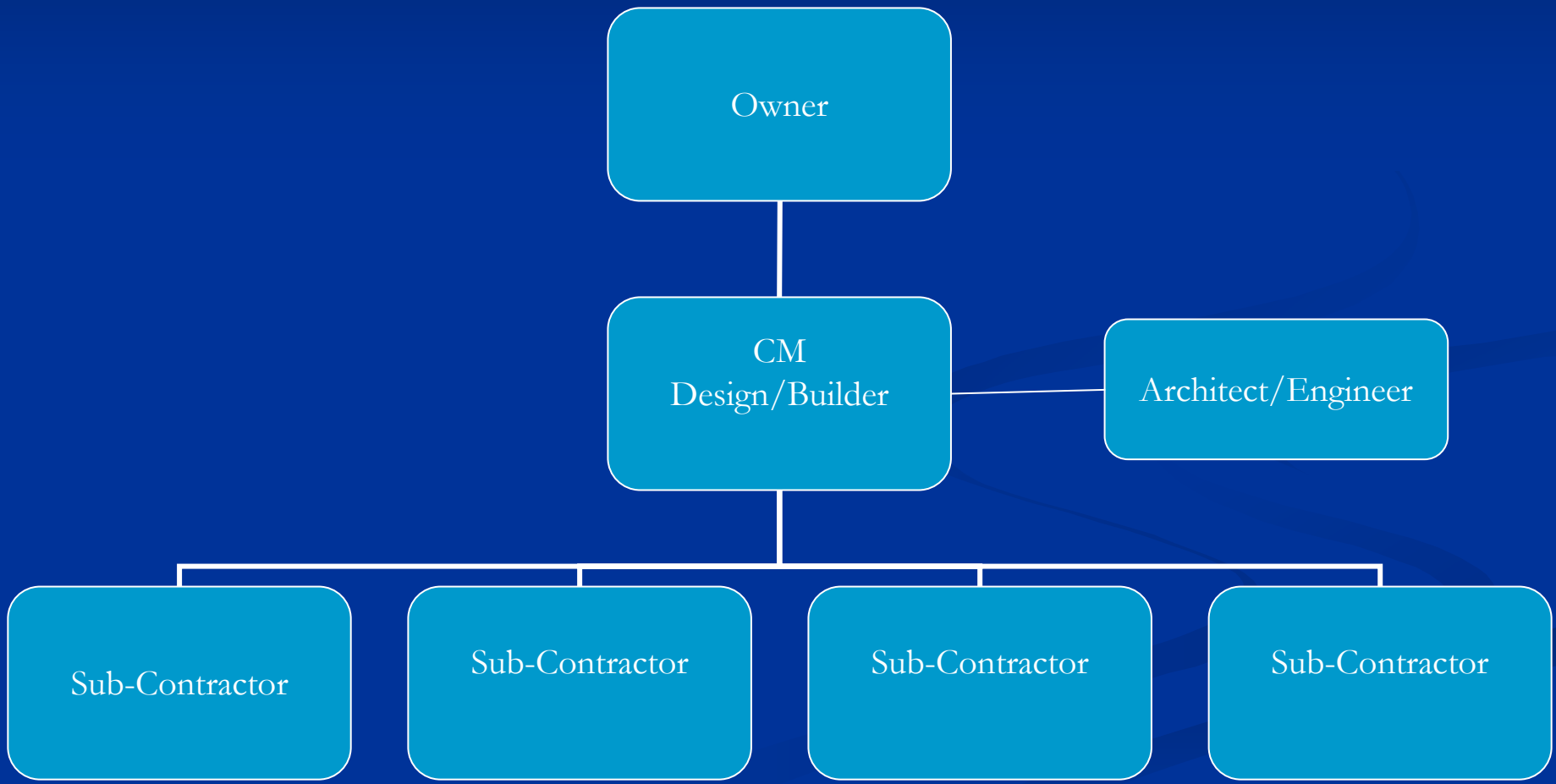
- Timing tension for when to recruit DB firm
  - Earlier recruitment:
    - Hard to judge – like beauty contest
  - Later recruit: Less benefit from DB
    - E.g. Lower ability to fast-track
    - Limit creativity (closer to GC)
- Often have segmented pricing (cost-plus design, fixed price or GMP construction)
- More comprehensive selection process typical
  - Design/Price/Schedule/Team
  - Design competitions undertaken

Example Design-Build: I15

- Originally slated as DBB, but made DB to fast-track
  - Hard deadline due to 2002 SLC Olympic Games
- $1.3B joint venture (Kiewit lead company)
- US DOT as owner agency
- Bidded project (with rights to use unsuccessful)
  - Unsuccessful bidders became subcontractors
- Reputation foremost
  - 200 Subcontractors
  - Few reviews
- Finished 5 months ahead of schedule

Modified CM Design/Build: Design Subcontracted

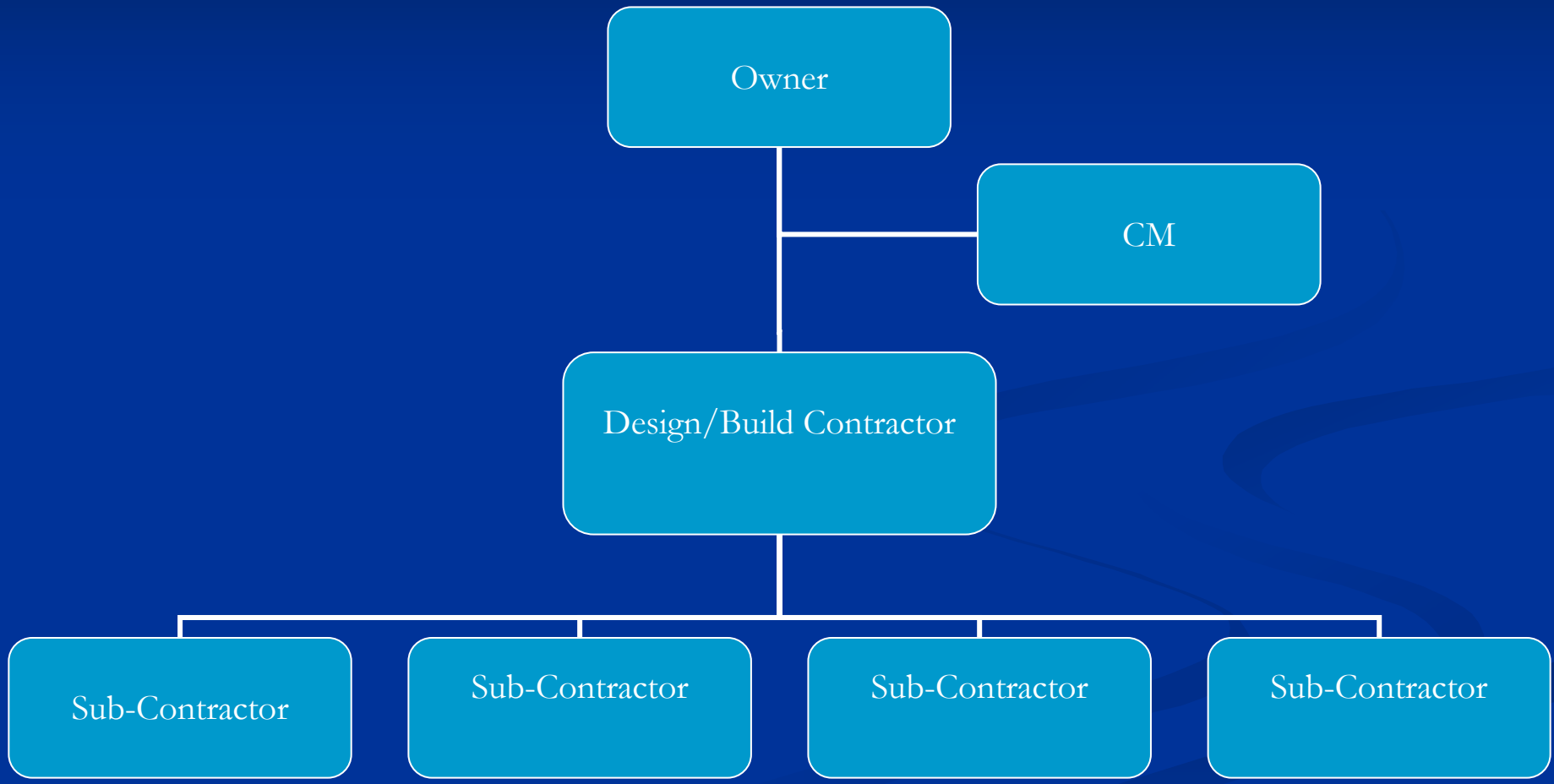
(CM Serves as Design/Builder and Subcontractors Design)



[Howell et al., 1998]

CM Oversight Design/Build

(CM Provides Agency Oversight on Owner's Behalf)



[Howell et al., 1998]

Other Delivery Methods

- Turnkey (Like DB but Contractor Financed)
  - Very common in residential housing
  - Gives owner time to raise money during construct.
- Design-Build-Operate-Transfer (BOT)
  - Long-term financing (vs. DBO)
  - Can compete on size, transfer time, etc.
  - Have different guarantees needed to entice
- Multiple Primes
  - Phase construct.,hand-pick team,sophisticated owner
- Owner/Agent (owner does part of design)

Type of Relationships Among Participants

	Owner-A/E	Owner-Contr.	A/E-Contr.	Owner-CM	CM-A/E	CM-Contr.
DBB	K	K	C	–	–	–
PCM	K	K	–	K	C	C
CMR	K	–	–	K	C	K
D/B	K*		I	–	–	–

K: Contractual Relationship
C: Communication Relationship
I: Internal Relationship
*: Contractual Relationship between the Owner and the D/B Team

Advantages of the 3 Most Common Delivery Methods

Type of contracts	Traditional Approach	Design Build	Construction Management
Advantages			
Legal and contractual precedent	X		
Cost determined before contract commitment	X		
Fast-tracked construction allowed		X	X
Minimum owner involvement	X	X	
Cost benefit from competition	X		X
Negotiation with quality contractor for unique expertise		X	X
Allow adjustment to new conditions without changing agreement		X	X
Single firm control of design/construct process		X	

Adapted from Gould and Joyce, 2002

Disadvantages of the 3 Most Common Delivery Methods

Type of contracts	Traditional Approach	Design Build	Construction Management
Disadvantages			
Design does not benefit from construction expertise	X		
Design construction time is the longest	X		
Adversarial relationship owner/designer vs contractor	X		~X
Contract agreement affected by changes	X		~X
Few checks and balances		X	
Cost control occurs late in project		X	
Contract amount may be complicated by continual contractor negotiations	X		~X
Contract agreement affected by unforeseen conditions	X		~X

Modified from Gould and Joyce, 2002

Issues with Bids

- Low bidders can be unreliable
  - Prequalify aggressively!
- To allow for fast-tracking may bid early (30%)
- Don't try to force delivery from low bid
- Growing Frequency: innovative bidding method
- Pressure for lowest bid can create
  - Cutting corners
  - Low-quality personnel
  - Bad feelings

Part II

- Payment Schedule

Payment Schemes

- Extremes

Payment method:	Reimbursable	Fixed Price
Product Type:	**Service**	**Commodity**
Award method	Solicit based on Reputation and agree via Negotiation	Bidding

Key Idea Here: Risk Sharing

- Different parties have ability to manage or tolerate different types of risk
  - Owner (or big contractor) often better: Geotechnical risk, weather risk
  - Contractor better: Risk of slow teams, equipment quality, procurement, quality of supervision
- Divide risks within an agreement to
  - Save money on contract price
  - Provide incentive to contractors to finish early, in budget, good quality

Fundamental Ideas

- Contractors are often highly risk averse
  - Recall risk premiums: Contractor willing to "pay" owner (charge less for contract) if owner takes on risk – if have to
- For risks that contractor *can't* control, may be willing to pay a risk premium to owner to take over
  - Contractor here will lower costs if owner assumes certain risk (essentially, paying the owner a risk premium)
- For risks that contractors *can* control, cheaper for a contractor to *manage* risk than to pay a risk premium

Fundamental Ideas II

- Structure contract so that
  - Risks contractor can better handle are imposed on contractor (i.e. contractor will lose $ if don't control)
    - To be competitive, will have to *manage* these
  - Risks owner can better handle are kept by owner
- "'Risk can be better handled by A vs. B" here means that the risk premium that would be charged by the A for taking on this risk is smaller than would be charged by B

Fundamental Balance

- Impose *high* enough risk incentive to get contractor do job efficiently – within the specifications of the contract
  - E.g. Incentive to finish on time, incentive to stay within budget
  - E.g. better team assignment, equipment provision, mgmt
- Impose *low* enough risk to have reasonably low bid
- Impose according to contractor ability to tolerate

Derivative Results of Risks I: Accountability/Monitoring

- Consider parties A and B in an agreement
  - A is contractor; B is owner
- The greater the risk on party A
  - The more incentive on party A to manage this risk
  - The less incentive on party B to manage this risk
  - More incentive on A to monitor the relevant factors so B can't claim the risk is responsible for a problem
  - More incentive on B to make sure that A's means of risk *management* falls within the agreement
    - E.g. that not "cutting corners" or otherwise cheating to shield from risk

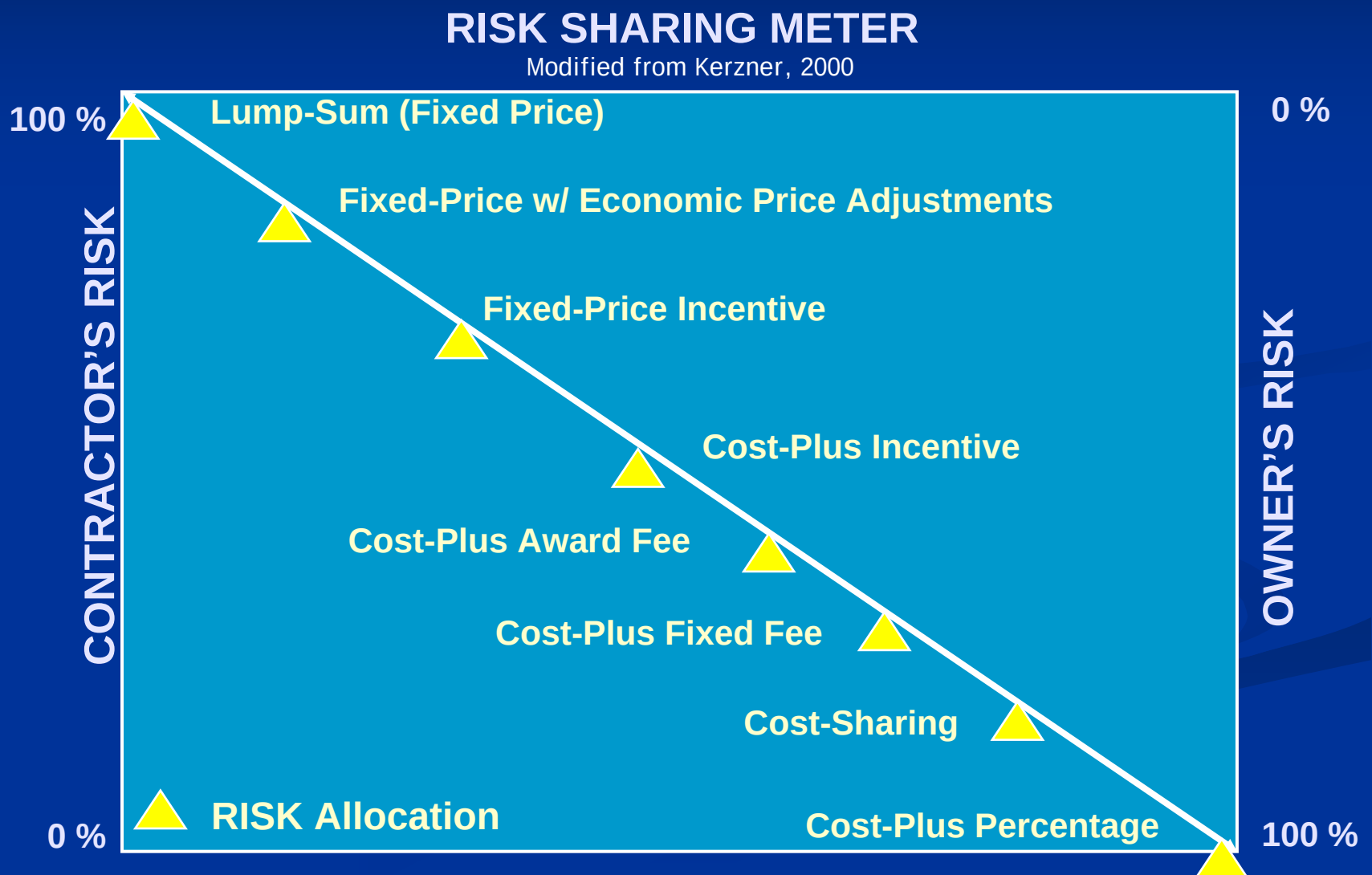
Derivative Results of Risks II: Impact on Construction Timing

- Both parties must agree on cost to move forward
- In general, more risk on one party, less that party is willing to move forward
- More risk on contractor, the longer will delay construct.
  - Given uncertainty, contractor will charge more up front
  - Owner doesn't want to pay a huge amount up front
  - As uncertainty is lessened in design, prices converge
- Owner can expedite – by paying higher price (risk premium) to contractor or by shouldering risk
- Remember; delay can have major costs – but so can wrangling over change orders!

Note on Change Orders

- Changes contract (cost/schedule/scope/etc.)
- Can lead to costs beyond contract specification
- Anticipated costs incorporated in "contingency"
  - Often 1-3% on top of agreed upon price
- Often only paid for additional direct costs
  - Big problem if disruption in work
- Source of very large risk

Contractual Risk Allocation



Cost Versus Price for Lump Sum

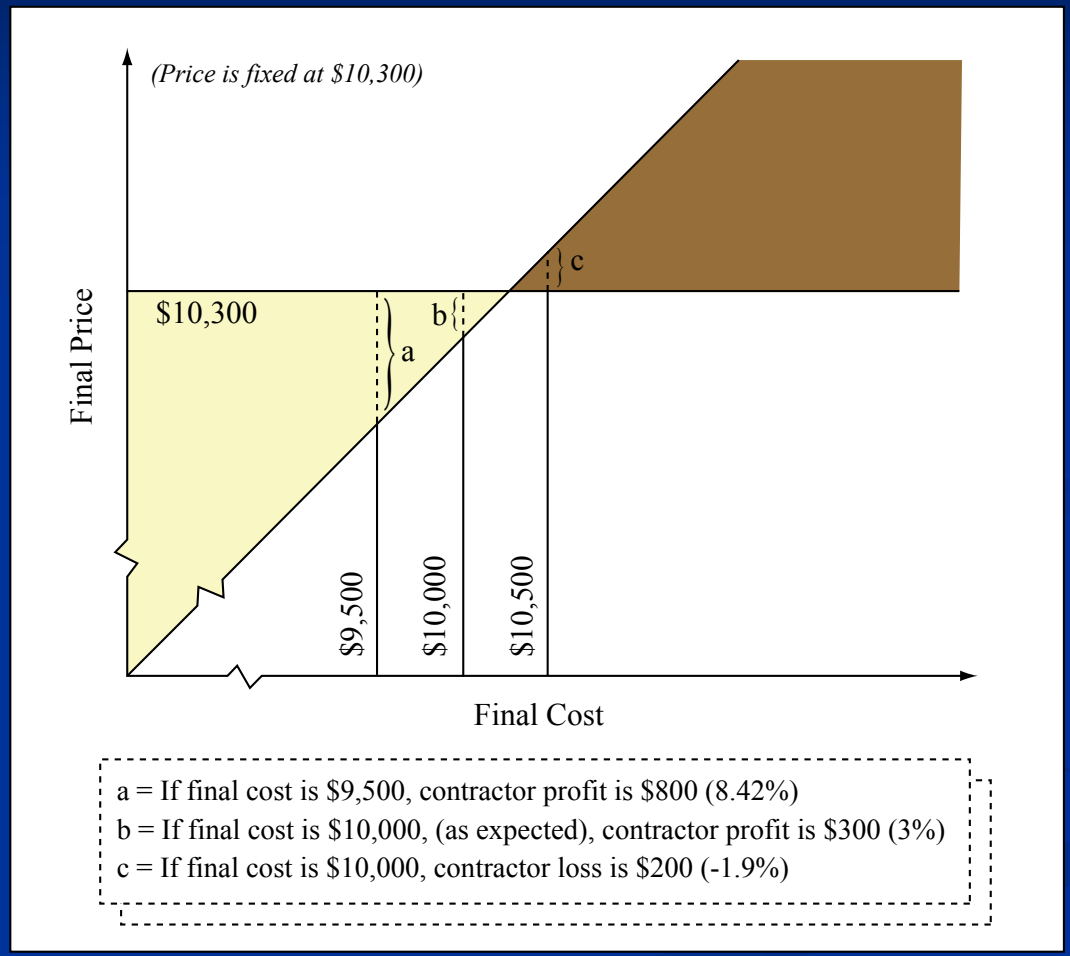


Image by MIT OpenCourseWare.

Macomber, 1989

Lump Sum ("Fixed Price")

- Contractor required to achieve the project at the negotiated contract value
- All risk of cost, schedule fall on contractor
- The owner knows the actual cost of the project before it begins
- Minimizes risk for the owner if the project is well estimated, contractual documents accurate and project clearly defined
- High incentive for contractor to finish
  - Early (so can move on to other jobs)
  - Low cost (so can make a profit)

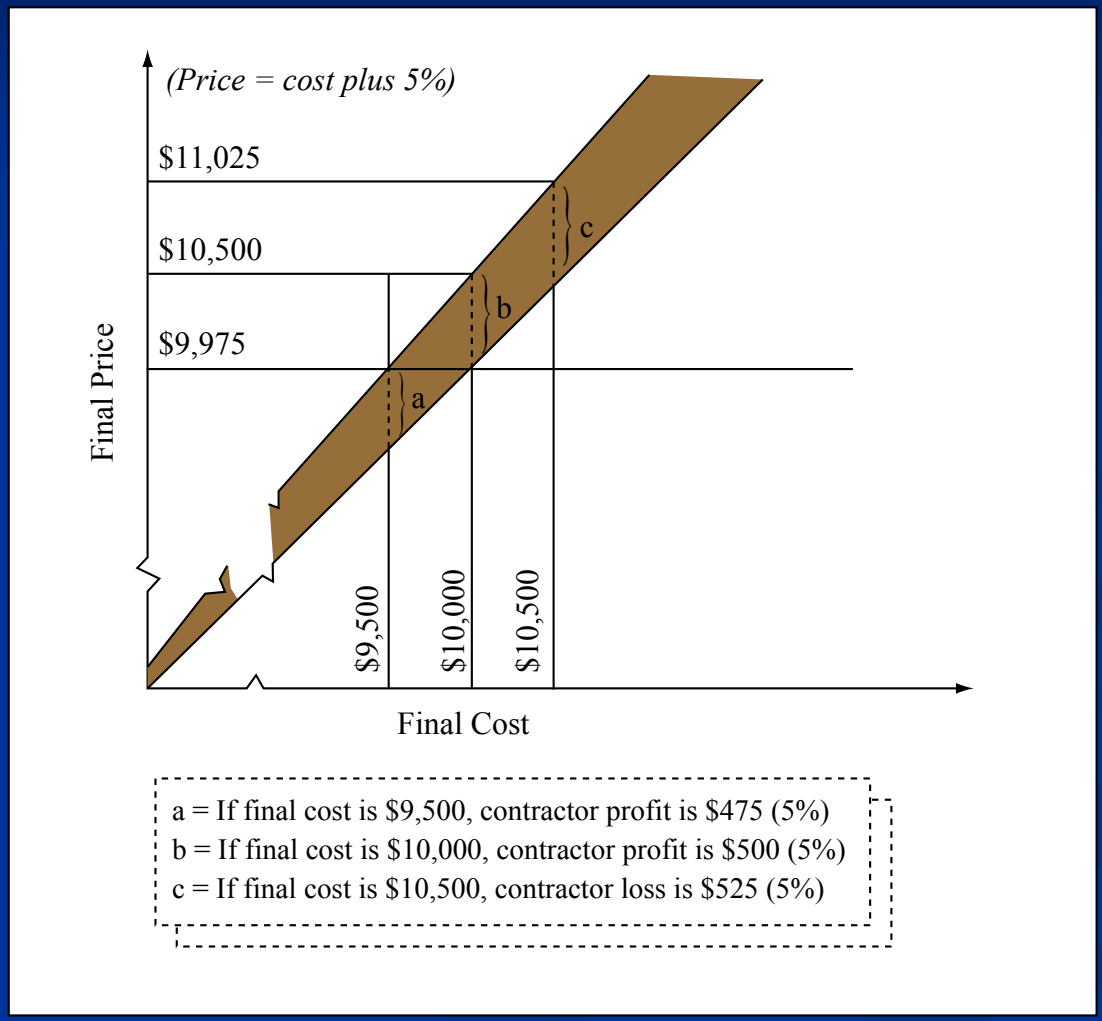
Lump Sum

- Required for many public projects
- Good for some well-defined projects
  - Good price competition in commodity metric
- Bad for ill-defined projects
  - Adversarial relationship over responsibility and payment for of changes
- High contractor risk means typically start late
- *Very different from typical meaning of "Fixed fee"!*

Ways to Save Money: Effect on Owners

- Helps: Efficiency within construction
  - Best teams
  - Appropriate equipment
  - Careful management
  - Quality workmanship (to avoid risk of rework)
- Hurts: Cutting corners, distortion, charge orders
  - Substitution of materials
  - Distortion of quantities used
  - Distortion of progress

Cost Versus Price for Cost Plus



Macomber, 1989

Cost Plus Fixed %

- Owner is paying the actual cost plus a fixed percentage
- Contractor agrees to do his best efforts to achieve the work
- Contractor shoulders very little risk
- Typically select contractors based on reputation and comfort (*service* rather than commodity)

Cost Plus + Fixed %: Advantages

- Maximum flexibility to the Owner
  - No fighting over change orders – contractor gets paid for any extra work required
- Permits to collaborate at the early stages of the project
  - Minimal negotiation time
  - Minimal fear of commitment by contractor
- Only have to pay for what actually costs
  - If manage closely, can *save money* vs. fixed-price

Cost Plus + Fixed %: Disadvantages

- Owner shoulders all risk
  - Little incentive to reduce costs and overtime salaries can even increase costs
  - Cost unknown until contract completes
- Owner needs to oversee construction closely
  - Speed up slow crews
  - Identify management problems
- Contractors have incentive to grow scope, price
- Terrible with turnkey delivery type!

Applicability

- *Requires sophisticated owner to manage*
- Uses if the pricing could not be performed in any other way and if it is urgent
  - Emergencies (civil, military)
- Ill-defined, risky scope
  - e.g. historic building renovation with unknown cond.
  - Unknown technologies
- Either scope or construction method unknown
- Confidential projects (limit public knowledge)

Cost Plus Fixed Fee ("Fixed Fee")

- Cost may vary but the fee remains firm
- The fee is independent of the duration of the project
- Like Cost + fixed % except some shared risk
  - Less time risk: High incentive to finish early
  - Less risk of contractor growing size of project

Unit Price Contract

- Agreement on the price charged *per unit* between the contractor and the owner
- Interesting example of risk sharing
  - Owner: risk for uncertainty in quantity
  - Contractor: risk for unit price (efficiency, procur)
- Contractor overhead must be integrated in the units price
- Necessity of an owner presence on site to measure the actual quantities
- Typically renegotiate if quantity 20% off
  - Quantity influences price b/c economies of scale

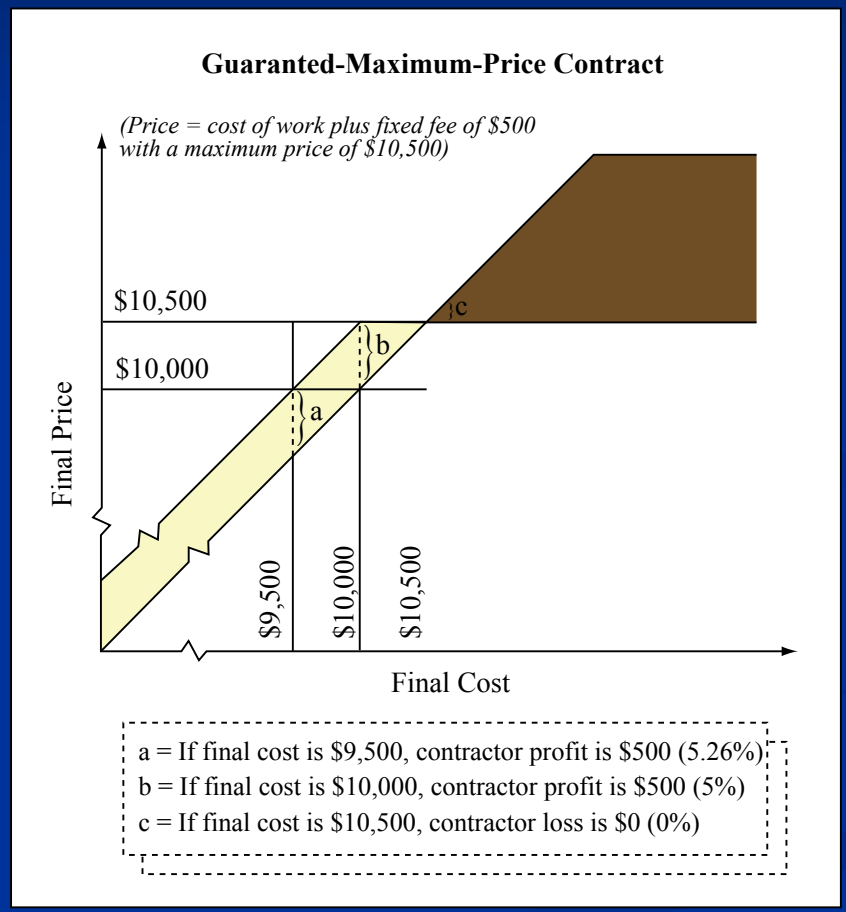
Unit Price Contract

- Highly dependent on the accuracy of the estimation of the quantities given by the Owner/Designer
  - Risk of unbalanced bidding
    - If contractor believes actual quantity will differ, case increase and/or decrease the unit price
    - Contractor can make profit because payment is based on actual quantities but he can also lose money in the same way
  - A contractor can be excluded if its bid is very unbalanced
  - The total cost for the owner can be greater than planned

Example: Pile Driving

- Too risky to just charge fixed price
  - Geotechnical uncertainties make length of piles uncertain
  - Piles can be highly expensive
- Risk allocation
  - Price risk more under contractor control (efficiency, crew and equipment selection): to contractor
  - Length out of contractor control: to owner
- Owner must precisely monitor length used

Cost Versus Price for GMP



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Guaranteed Maximum Price or GMP

- Variation of the Cost Plus a Fee but GMP can be a cap on *direct costs*
- After a certain point, the "floor" or "ceiling", the contractor assumes any additional costs
- Often *start* in cost plus fixed fee and then impose GMP at e.g. 90% design
- Best: GM Shared Savings: Below Guaranteed Maximum, savings shared (60-40% or sliding)
- Very good for turnkey, well-defined scope

GMP: Advantages

- Permits easier financing
- Can fast-track
- Owner keeps savings below GMP
- Often can get started quickly on construction
  - Particularly if contractor already involved w/design
- Contract may be higher than for fixed price b/c design often not complete when contract set

GMP: Disadvantages

- Contractors may still spend lots
- Owner must monitor contractor spending
- Can be fights over what is direct vs. indirect cost
  - i.e. what must fall below GMP
- Bad if unclear scope after GMP agreed to (must renegotiate)
- Just as for CPFF, quality may be sacrificed whereas without GMP, cost and/or schedule would have increased

Relative Costs of Construction Contracts

- E= contractor's original estimate of the direct job cost at the time of contract award
- M = amount of markup by the contractor in the contract
- B = estimated construction price at the time of signing contract
- A = contractor's actual cost for the original scope of work in the contract
- U = underestimate of the cost of work in the original estimate (with negative value of U denoting an overestimate)
- C = additional cost of work due to change orders
- P = actual payment to contractor by the owner
- F = contractor's gross profit
- R = basic percentage markup above the original estimate for fixed fee contract
- Ri = premium percentage markup for contract type i such that the total percentage markup is (R + Ri), e.g. (R + R1) for a lump sum contract, (R + R2) for a unit price contract, and (R + R3) for a guaranteed maximum cost contract
- N = a factor in the target estimate for sharing the savings in cost as agreed upon by the owner and the contractor, with 0 N 1.

Chris Hendrickson, 2000

Original Estimated Contract Prices

Type of Contract	Markup	Contract Price
Lump sum	M = (R +R1)E	B = (1 + R + R1)E
Unit price	M = (R + R2)E	B = (1 + R + R2)E
Cost plus fixed %	M = RA = RE	B = (1 + R)E
Cost plus fixed fee	M = RE	B = (1 + R)E
Guaranteed max cost	M = (R + R3)E	B = (1 + R + R3)E

Adapted from Chris Hendrickson, 2000

Owner's Actual Payment with Different Contract Provisions

Type of Contract	Change Order Payment	Owner's Payment
Lump sum	$C(1 + R + R1)$	$P = B + C(1 + R + R1)$
Unit price	$C(1 + R + R2)$	$P = (1 + R + R2)A + C$
Cost plus fixed %	$C(1 + R)$	$P = (1 + R)(A + C)$
Cost plus fixed fee	C	$P = RE + A + C$
Guaranteed max cost	0	$P = B$

Adapted from Chris Hendrickson, 2000

Contractor's Gross Profit with Different Contract Provisions

Type of Contract	Profit from Change Order	Contractor's Gross Profit
Lump sum	C(R + R1)	F = E - A + (R + R1)(E + C)
Unit price	C(R + R2	F = (R + R2)(A + C)
Cost plus fixed %	CR	F = R (A + C)
Cost plus fixed fee	0	F = RE
Guaranteed max cost	-C	F = (1 + R + R3)E - A - C

Adapted from Chris Hendrickson, 2000

Principles of Incentive Contracts

Additional profits are possible by lowering cost

Customer and contractor share cost savings

- OWNER PAYS 80 % OF OVERRUN
- CONTRACTOR PAY 20 % OF OVERRUN
- PROFIT IS $1500 LESS CONTRACTOR'S 20 %

EXAMPLE

TARGET COST: $20,000
TARGET FEE: $1500
SHARING RATIO: 80/20 %

- OWNER KEEPS 80 % OF OVERRUN
- CONTRACTOR KEEPS 20 % OF OVERRUN
- PROFIT IS $1500 PLUS CONTRACTOR'S 20 %

Note: limitations may be imposed on price or profit

Kerzner, 2000

Conclusion

- When market is not very good, clients insists on fixed price bids whereas when the project offers are numerous, it is more difficult to obtain those conditions
- The contract type choice must depend on:
  - The accuracy of the estimation
  - The ultimate cost know since the beginning or at least the maximum
  - The desired risk
  - If quick completion of work is wanted

Part III

- Award Methods
- Contract Selection

Award Methods: Contractor Selection

- Extremes

Bidding

- Variants
  - Low bid
  - Multi-parameter bidding
    - Low bid plus arithmetic combination of other factors
    - Low bid divided by ranking of other factors
- Fixed price low bid is win-lose
- Typically associated with lump-sum contract
- Prequalification critical

Bidding Tradeoffs

- Time provided to bidders to review documents
  - Too long: Construction delayed
  - Too short:
    - Bids low-quality because too little time to review contract docs (incorporate high risk premium or unrealistically low)
    - Few bidders willing to participate
- Bid count
  - Too many bidders: Scare away best contractors
  - Too few bidders: Bid not competitive

Bidding Tradeoffs

- Advantages
  - Can get good price
  - Transparency
- Disadvantages
  - Can set up win-lose situation
  - Competitive pressures can eliminate profit from bid
    - Try to make up with change orders, cutting corners
    - Can lead to combative relationships
  - Insufficient consideration of design before pricing

Bidding Metrics

- Most common: Price alone
- Bidding "cap": Bid on how far can go with set amount of money
- Multi-parameter bidding (increasingly popular)
  - Consider non-price items (time, quality, qualification)
  - A+B Additive measures
    - Price+($/day)*days (common for retail), Price+qualification+design rank, price+design rank,…
  - A/B (e.g. B scoring along some metric: Design, etc.)

Issues with Bids

- Low bidders can be unreliable
  - Prequalify aggressively!
- To allow for fast-tracking may bid early (30%)
- Don't try to force delivery from low bid
- Growing Frequency: innovative bidding method
- Pressure for lowest bid can create
  - Cutting corners
  - Low-quality personnel
  - Bad feelings

Bidding Process

- A/E oversight typical
- Publicity (specifies qualification requirements)
- Provide bid documents
  - Typically include fair cost estimate, sample contract
- Answer RFIs
- Pre-bid conference
  - Explain scope, working conditions, answer questions, documented in writing)

Public vs. Private Bidding

- Public Bidding
  - Must be publicly advertised (posting in newspapers, public building, etc.)
  - Qualification occurs after submission of bids
  - Typically 60 day period in which can submit bids
- Private Bidding
  - May be by invitation only
  - Qualification occurs before submission of bids

Dealing with Way-Out Low Bids

- Forcing collection from unrealistically low bids is dangerous
  - Construction highly contentious, poor morale
    - Risk of extreme corner cutting
  - Default is possible
    - Disruption
    - Insurance companies fulfilling performance bonds very difficult to work with

Subcontracting Bids

- GCs push subs for lowest possible price before GC bids
  - GC not obligated to use sub who gave bid
- Can lead to serious predatory behavior
  - Bid shopping (before *and* after GC wins bid)
  - Bid peddling (unsolicited calls from subs to GCs after GC wins bid)
- Some owners/states require listing of chosen subs at bid time or assign based on sub-bidding

Qualifications

- Common items for qualifications
  - Bonds/Insurance (bid, performance, payment)
  - Safety record
  - Reputation
  - Financial strength
  - Total/Spare capacity
  - Licensing
  - Background in type of work
  - Experience in local area/labor market
  - Management system (QA, planning, estimation, control)
  - Interest, adaptability shown

Negotiation

- Typically selected based on reputation, qualifications
- Typically used for two cases
  - Very simple
    - Use trusted, familiar party
  - Very complex/big
    - Get contractor involved in design, start work early
- Requires relatively savvy owner
  - Evaluate proposals, monitor performance
- Important even for DBB for post-bid changes

Negotiation Considerations

- Can get win-win because of differences in
  - Risk preferences
  - Relative preferences for different attributes
- Goal is to find a pareto optimal agreement
- Key skill in negotiation: Ability to find win-win options

Negotiation Tips

- Try to maintain clear sense of reservation price
  - Price or conditions under which will accept offer
- Want to adopt some objective basis for position
  - Without this impersonal criteria, other party can take disagreements personally as arbitrarily demands
- Discuss multiple issues at once
  - Permits trading off issues flexibly
- Formal exposure good–but experience gives edge

Negotiation Tips 2: Major Sins of Negotiation (Thomson, 2001)

- Leaving money on the table: Failing to identify and use win-win opportunities
- Settling for too little: Unnecessarily large concessions
- Walking away from the table: Rejecting terms that are favorable, often due to pride
- Settling for terms worse than existing alternative: Pressure to reach some deal leads to opportunity less attractive than opportunity cost