Taking the Evolutionary Road to Developing An In-house Cost Estimate

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Agenda

• Project Overview

• IHCE Group

• IHCE Phases

• Summary / Key Take-Aways

• What’s Next / Attractions
Project Overview

Project:
Space Network Ground Segment Sustainment (SGSS)

Purpose: Implement a new modern ground segment that will enable the NASA Space Network (SN) to deliver high quality services to the SN community for the future.
The In-House Cost Estimate (IHCE)

IHCE:
Cost estimate developed within the project to estimate government and contractor project costs to support a budget request

Goals of IHCE:
1. Assist in visualizing SGSS requirements
2. Establish services and activities the project will need
3. Provide insight into challenges and complexities that a contractor will face in meeting the requirements
4. Provide context & framework for how requirements are provided to industry through an RFP

IHCE Presentation Scope:
Project Concept Through Contract Award
In-House Cost Estimate (IHCE) Group

- **Make-up:**
  - Members from the entire project, not just financial estimation team
    - Systems Engineering
    - SW Engineering
    - Finance
    - ...
  - Expertise from many professional backgrounds
  - Contractors from different competing companies with varying approaches
IHCE Phases

1. Forming the concept
   - Maturing the project’s architecture and requirements
   - Defining a project lifecycle & WBS
   - Defining the estimation process and models

2. “Let there be light...”
   - Iterating on the architecture, schedule, models, and estimate
   - Evaluating options and “what ifs”

3. “And it was good...”
   - Formalizing IHCE Confidence

4. “And it was better...”

Lessons Learned

PM Challenge 2011--SGSS In-house Cost Estimate (IHCE)
IHCE Phase 1

Phase Start: Blank page; immature requirements; forming team; gathering historical data; top-down approach

- Concept studies performed to develop Notional Architecture
- Estimate used:
  - General Parametric models
  - Expert judgment
  - COCOMO
  - Spreadsheets
- **HW:** Developed MEL (Master Equip. List)
- **SW:** Used analogies/LOC
- **Percentages used to estimate many areas:**
  - Management
  - Contingency, Reserve & Inflation
  - Spread of Labor, HW, SW by FY
  - Other Element unknowns

Decision: Next use bottoms-up approach for greater accuracy

Lessons Learned
- False starts can be expected – recovery is key
- Team covering many areas necessary to make progress
- Take advantage of everyone’s skills
- Be sure to handle conflict

Challenge: Create initial estimate with minimum information

Strategy: Formulate concept
IHCE Phase 1

• Areas of Focus:
  – Examining use of a commercial parametric model/tool
  – Working on a clear definition/agreement and how to proceed and implement the project
  – Understanding the scope fully and being careful at this stage not to promise too much
  – Paying attention to details—it's not too early to begin understanding SW and HW requirements
  – Managing fluctuation in team composition

• Key Accomplishments:
  – Established initial estimate and framework foundation for next iteration
  – Identified gray areas
    • Understood what we knew and what we didn’t know
“A successful [IHCE] is one [that] can lay a firm foundation with the bricks others have thrown at [it].”

Adapted from a quote by David Brinkley
IHCE Phase 2

Strategy:
Use bottoms-up approach; define models; HW/SW by arch

Challenge:
Establish sound basis for good estimate

Phase Start: Immature requirements; notional architecture beginning to evolve; some changes to project team

- Migrated approach from parametric overlay to bottoms up
- Established physical notional architecture to organize costs
- Approach helped drive engineer thought process
- Estimate used:
  - Expert Judgment
  - Analogous estimation - some historical data
  - COCOMO for SW effort & duration
  - Parametric models
- % still used to estimate
  - Management (based historical data)
  - Contingency, Reserve, Inflation, & unknowns
  - Spread of Labor, HW, SW by FY

Decisions:
Pursue 2 independent paths (dev., deploy.); focus on things missing

Lessons Learned
- Interviews time-consuming, but critical for good data
- Hybrid of bottoms-up & parametric modeling works best
- Involvement of entire team is important
IHCE Phase 2

• Areas of Focus:
  – Schedule:  • Introducing a schedule – understanding when equipment would be needed
    • Considering whether development & transition would be feasible within time constraints
  – SW:  • Improving the understanding of the SW needed
    • Stabilizing requirements to refine the SW estimate
  – HW:  • Adjusting for HW quantities and costs as requirements fluctuated
  – Getting Engineers' buy-in and participation
  – Using percentages only for unknowns

• Key Accomplishments:
  – Successfully enhanced model using a blended parametric models & bottoms up approach
Iterative Development of the IHCE Model

Notional System Architecture

WBS (By Notional Architecture)

RESOURCES
- Hardware
  - Antenna
    - Antenna part 1
    - Antenna part 2
  - Computers
    - Server
    - Workstation
- Software
  - Software Item 1
  - Software Item 2
- Engineering Tasks
- Transition Tasks

Items, Costs

SLOC COCOMO Model

Effort, Duration

Effort

Project Lifecycle Schedule

Master Resource Sheet of
- Hardware
- Software
- Engineering Effort
- Integration Effort
- Transition Effort

Labor, Material, Cost Phasing
"It is the framework which changes with each new technology and not just the picture within the frame."

Marshall McLuhan
IHCE Phase 3

Phase Start: Matured requirements & team; near complete notional architecture

- Incorporated inputs from Trade Studies and independent cost estimate
- Aligned cost structure, schedule, WBS, and notional architecture
- PM worked with all technical teams to understand basis of estimate (BOE)
- Loaded Resources by skill level & labor rates
- Spread HW/SW/Labor Costs by FY based on schedule
- Only PM remained %
- Enhanced IHCE model to allow:
  - Many different views (architecture elements, high cost drivers)
  - Investigation of options ("what if" a ground station were eliminated?)

Decisions: Ready to go; freeze IHCE for RFP

Lessons Learned

- BOE review sessions need a strong driver
- The better the IHCE fidelity the more useful for "holes" & "what ifs"
- Working as a team creates buy-in and project team is much smarter

Strategy:
Use 2 separate Teams (dev. & deploy.); merge results

Challenges:
Honoring the estimate; Avoiding diversions

PM Challenge 2011—SGSS In-house Cost Estimate (IHCE)
IHCE Phase 3

• Areas of Focus:
  – Identifying a good ground system model on which to base confidence in the estimate
  – Ensuring Implementation schedule is realistic
  – Understanding changing expectations and being flexible to deal with change
  – Dealing with competing priorities for completing the work
  – **SW:** Filling voids in analogous systems by using SW SMEs to provide sizing information
  – **HW:** Using a notional system to obtain sufficient information for an IHCE and trying to avoid over engineering the perfect system

• Key Accomplishments:
  – Met goals of project:
    • IHCE for RFP; presentation to HQ; basis for budget
“An IHCE is complete when it starts working for you, rather than you working for it.”

Adapted from a quotation by Scott Allen
IHCE Phase 4

Phase Start: RFP Released; IHCE frozen; fewer distractions

Performed Risk Cost Analysis
- Focused on high cost drivers
  - Optimistic
  - Most likely
  - Pessimistic estimate
- Used triangular distribution and Monte Carlo to simulate confidence ranges
- Compared dispersions with expected ranges
- Detailed resource items enabled analysis of procurement long lead items & phasing

Lessons Learned
- A solid IHCE enables developing confidence levels and understanding where the estimate falls within the levels before contract start
IHCE Phase 4

• Areas of Focus:
  – Assessing and ensuring confidence in IHCE
    • Identified high, medium, and low values for the elements of the notional architecture – ensuring sufficient detail was used as a basis
    • Leveraged details in IHCE model to look at the higher cost drivers of each major area of architecture
      – Identified optimistic, most likely, and pessimistic estimate
      – Assessed dispersion values as a means to evaluate expected estimate, including varying the dispersion values to provide confidence level

• Key Accomplishments:
  – Thorough IHCE to support budget process
  – Achieved a good level of confidence at early stage of the project
Confidence

Yes, though I walk through the valley of the shadow of death, I will fear no evil. -Ps 23:4
Summary/Key Take-Aways

**Start early:** Plan for iterations of the IHCE
- The project estimate will need to go through phases as more information is learned
- Use the estimation process to support the maturation of the project concept, requirements, and schedule
- Use each iteration as a base to grow and get to step

**Use Teamwork:** Involve representatives from all project organizations in the cost and schedule estimation process
- It makes the team much smarter as a project
  - Manager needs to work closely with the element leads
  - Project team learns much more about architectural elements outside of an individual’s areas of expertise
- It helps the technical team focus on what needs to be done and realize how technical decisions can impact the project
- It makes the basis of estimate visible to all—not hiding anything
- May need some team dynamics training
Summary/Key Take-Aways

**Involve Leadership:** Need someone to drive the activities who is not the expert but can ask the tough questions
- Helps engineers to think outside their specific areas and be able to explain it to others

**Be Adaptable/Flexible:** There will be some false starts and changes
- Until there is a clear definition/agreement on how to proceed and implement the project, you will need to change and adapt
- Be sure your cost estimation tools are flexible
  - Need to handle what is known about the project at early and also later phases of the evolution
  - COTS may not match all your needs—a hybrid approach works well
Summary/Key Take-Aways

Ensure Confidence: Don’t promise things too soon
- Can set an unrealistic or aggressive timeframe
- Let the process dictate how long the development should be

Facilitate Communications: A detailed IHCE helps present progress and evolution
- Open and objective format facilitates collaboration
- Helps budget and procurement process
- Shows where the project still has unknowns
- Detailed IHCE allows for multiple “what if” costing/tradeoff scenarios
  - IHCE organized by architecture makes it easier to see the pieces and examine trade-offs
Hope to show how close the estimates are to what was bid and actuals
• Scenic views as well as road hazards are ahead
  • Project beginning to accelerate
Questions

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Acronyms

BOE – Basis of estimate
COCOMO – Constructive Cost Model
COTS – Commercial Off-the-Shelf
FY – Fiscal year
GS – Ground Segment
HQ - Headquarters
HW - Hardware
IHCE – In-house cost estimate
LOC – Lines of code
MEL – Master equipment list
PM – Project manager; project management
RFP – Request for proposal
SGSS – Space Network Ground Segment Sustainment
SME – Subject Matter Expert
SN – Space Network
SW – Software
WBS – Work Breakdown Structure