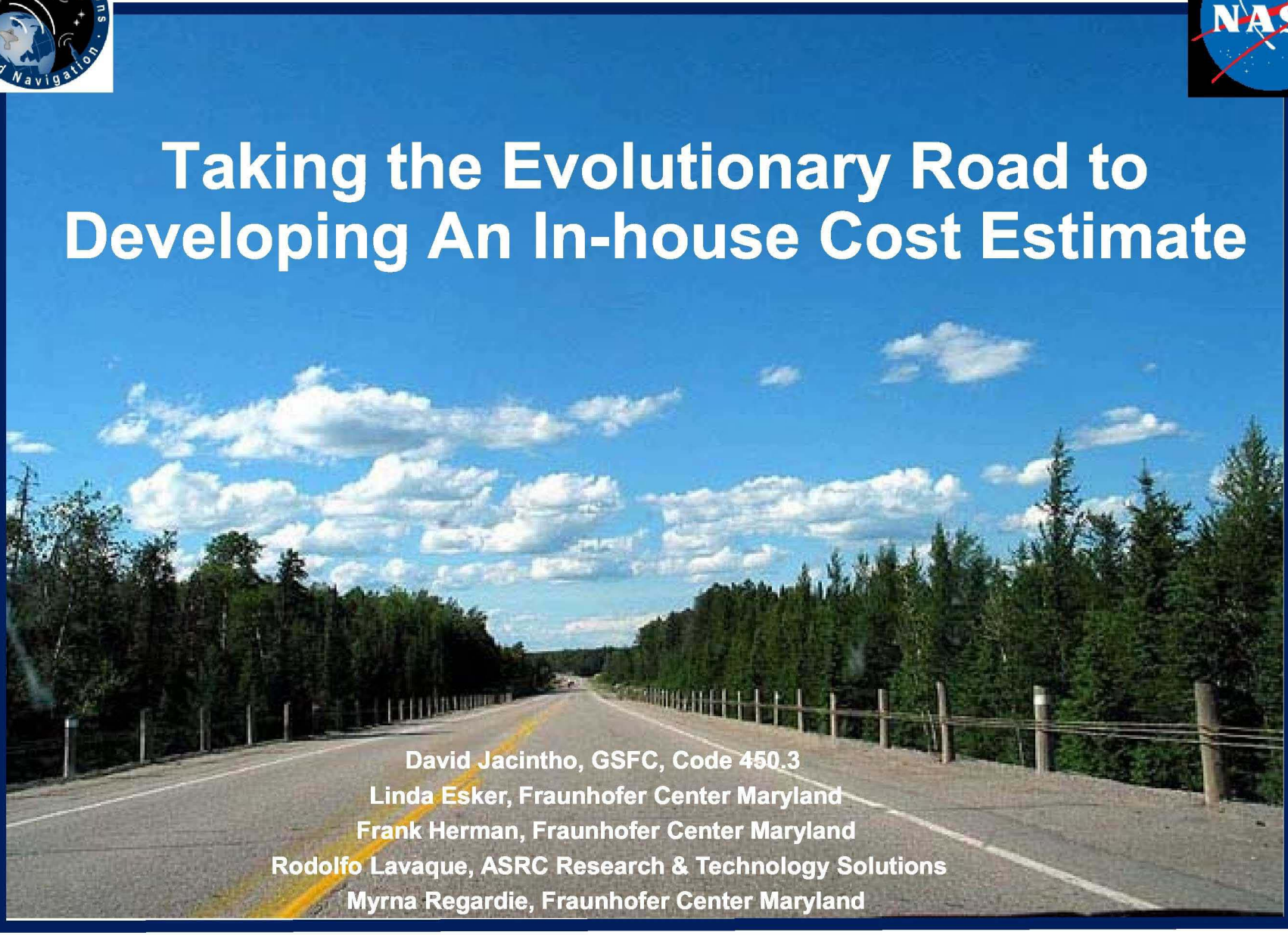
Taking the Evolutionary Road to Developing An In-house Cost Estimate



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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:

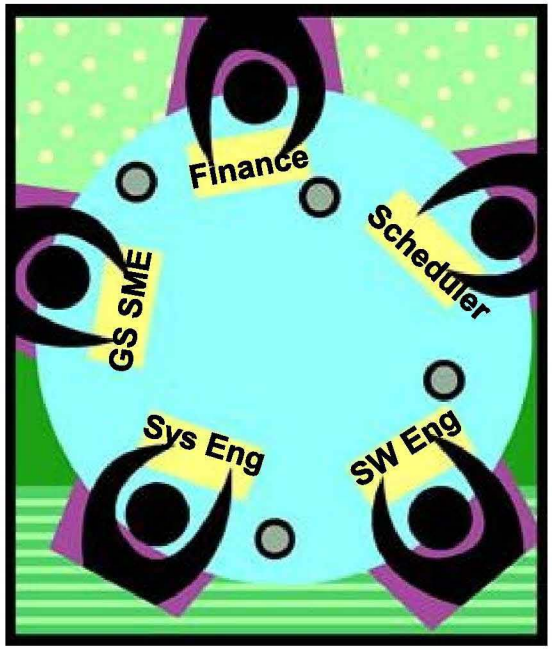
1. **Assist in visualizing SGSS requirements**
2. **Establish services and activities the project will need**
3. **Provide insight into challenges and complexities that a contractor will face in meeting the requirements**
4. **Provide context & framework for how requirements are provided to industry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

IHCE Presentation Scope:

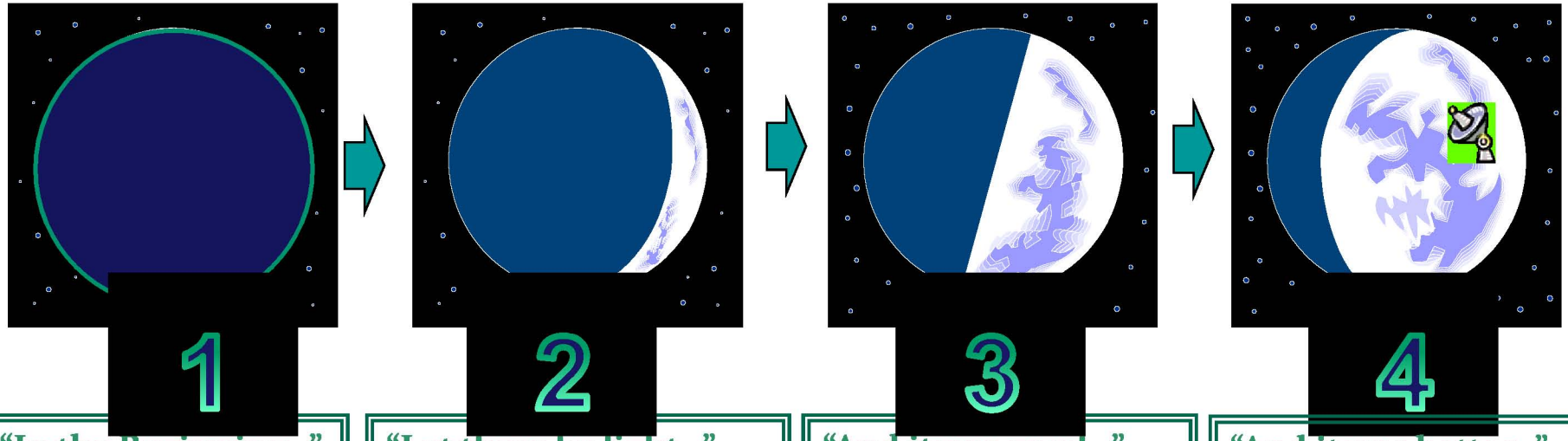
Project Concept Through Contract Award

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



"In the Beginning..."

- Forming the concept

"Let there be light..."

- Maturing the project's architecture and requirements
- Defining a project lifecycle & WBS
- Defining the estimation process and models

"And it was good..."

- Iterating on the architecture, schedule, models, and estimate
- Evaluating options and "what ifs"

"And it was better..."

- Formalizing IHCE Confidence

Lessons Learned

Lessons Learned

Lessons Learned

IHCE Phase 1

Strategy: Formulate concept

Challenge: Create initial estimate with minimum information

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

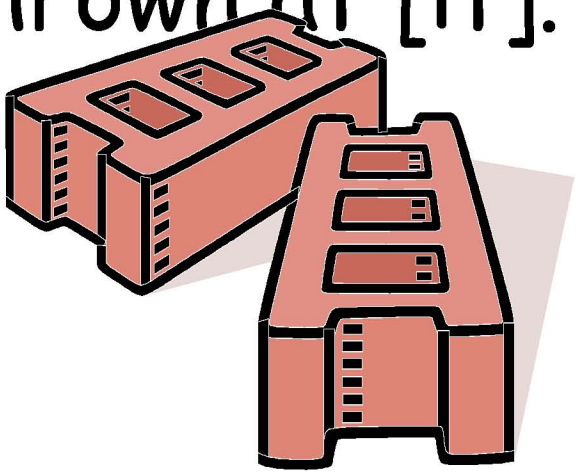
Lessons Learned

- **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**

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

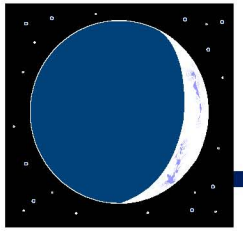
Phase Start: Immature requirements; notional architecture beginning to evolve; some changes to project team

- **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**

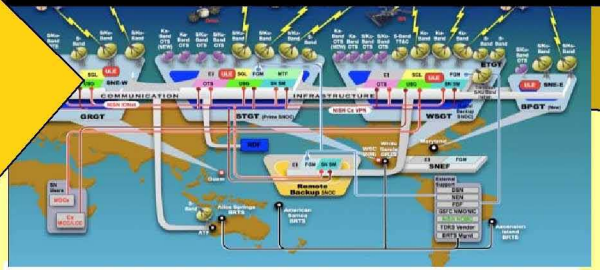


IHCE Phase 2

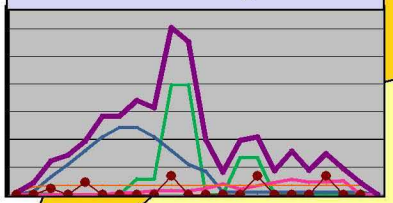
- **Areas of Focus:**
  - Schedule:
    - Introducing a schedule – understanding when equipment would be needed
    - Considering whether development & transition would be feasible within time constraints
  - SW:
    - Improving the understanding of the SW needed
    - Stabilizing requirements to refine 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

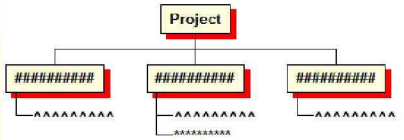
Notional System Architecture



Labor, Material, Cost Phasing

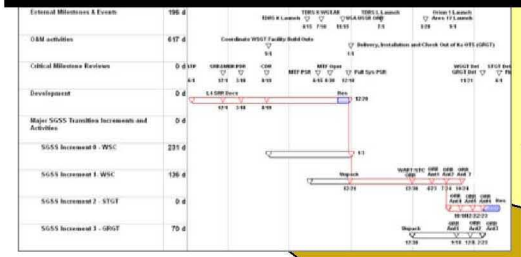


WBS (By Notional Architecture)



IHCE Model

Project Lifecycle Schedule



RESOURCES

Hardware
- Antenna
  - Antenna part 1
  - Antenna part 2
- Computers
  - Server
  - Workstation

Software
- Software item 1
- Software item 2

Engineering tasks
Integration Tasks
Transition tasks

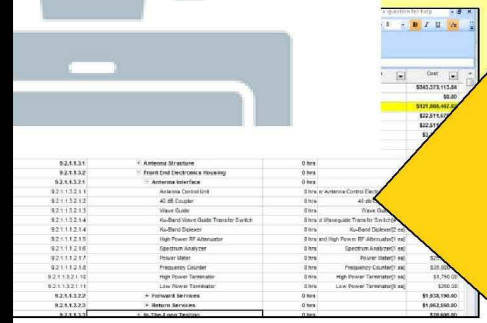
→ Items, Costs

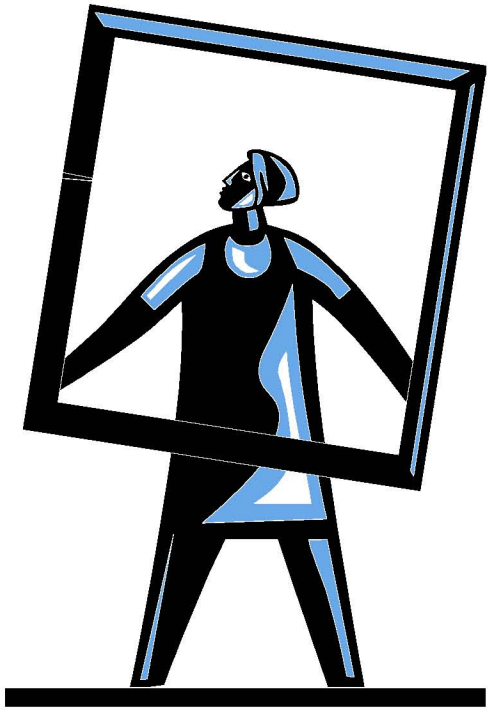
SLOC → COCOMO Model → Effort, Duration

→ Effort

Master Resource Sheet of

- Hardware
- Software
- Engineering Effort
- Integration Effort
- Transition Effort





"It is the framework which changes with each new technology and not just the picture within the frame-

Marshall McLuhan

IHCE Phase 3

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

Challenges:
Honing the estimate; Avoiding diversions

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

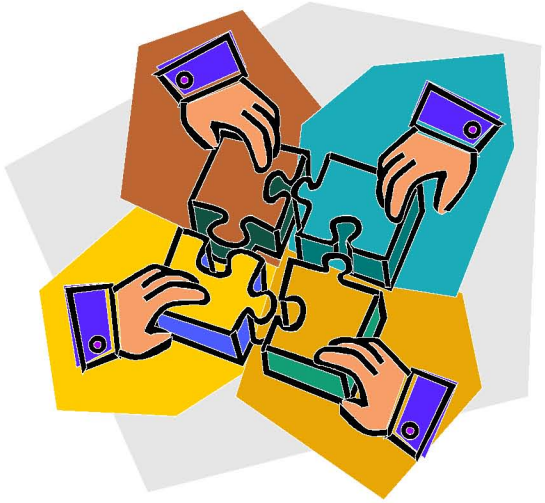
Lessons Learned

- 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

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

"A[n *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

Strategy:
Examine IHCE Cost Risks

Challenge:
Understand Confidence in IHCE

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**

Decisions:
Project has confidence with expected range

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


Yea, though I walk through the valley of the shadow of death, I will fear no evil - PS 23:4

Summary/Key Take-Aways

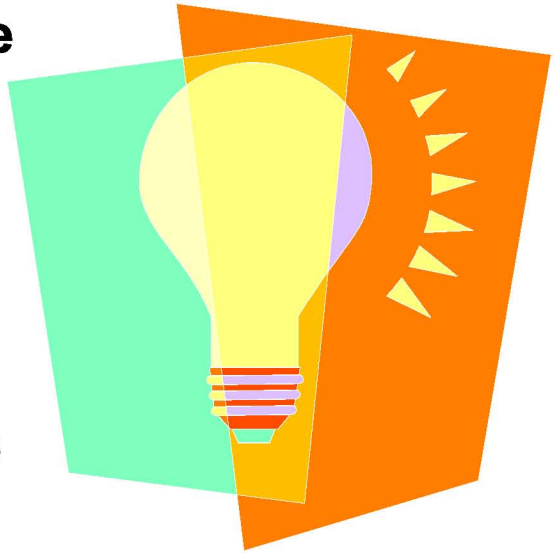
➔**Start early: Plan for iterations of the IHCE**

- 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

Attractions Next Intersection:

- **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