

# estimate

estimate • analyze • plan • control

## So We Have Done A Cost and Schedule Risk Analysis—Now What?

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# Topics

- Three foils....
  - The Village Watchman Syndrome
  - The Lake Wobegon Effect
  - The Best of all Possible Worlds Philosophy
- Why view the world probabilistically anyway?
- Risk versus uncertainty
- Risk analysis in NASA projects
- Interpreting results of our work

# A Foil...

- In literature, a foil\* is a character who contrasts with the protagonist in order to highlight particular qualities of the protagonist
  - In some cases, a subplot can be a foil to the main plot
- So I will begin with three foils I have often used....
  - In order to make JCL look more sparkly

**SPARKLE!**

\*The word foil comes from the old practice of backing gems with foil in order to make them shine more brightly

# Foil 1: The Village Watchman Syndrome

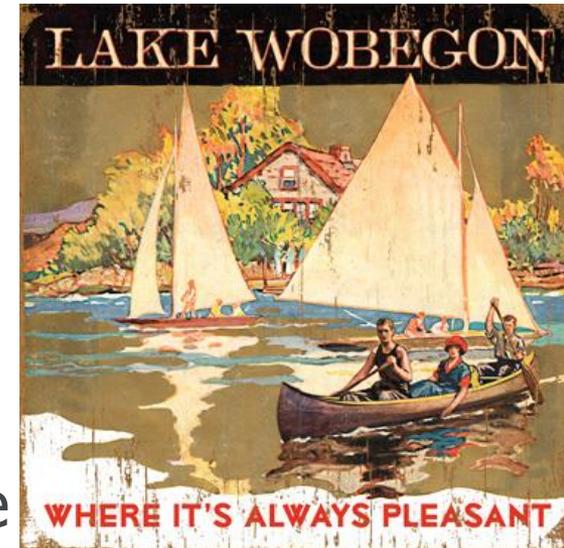
- A very detailed cost and schedule estimate sometimes only provides the illusion of accuracy
- Even EOM CADRe data is uncertain due to...
- The “Village Watchman”<sup>\*</sup> syndrome—the source of data is the village watchman “who just puts down what he damn pleases”
- All we know for sure is that the total cost of a historical mission was  $x$  and it’s total schedule duration from start to finish was  $y$
- The extent to which we break down the total cost into smaller and smaller WBS elements, we introduce inaccuracies
- Ergo, it is doubly true when we use that data to estimate a new project
- But maybe JCL will prove this wrong



A well known 1929 quote from Josiah Stamp, a British Civil Servant: "The government are very keen on amassing statistics. They collect them, add them, raise them to the  $n$ th power, take the cube root and prepare wonderful diagrams. But you must never forget that every one of these figures comes in the first instance from the village watchman, who just puts down what he damn pleases."

## Foil 2: The Lake Wobegon Effect

- Lake Wobegon, a fictional town in Garrison Keillor's NPR show, *The Prairie Home Companion* where....
  - All the women are strong
  - All the men are good looking
  - All the children are above average
- All NASA Project Managers believe themselves and their team hail from Lake Wogebon...
  - ...and thus will out perform the norm while in fact they make the same old mistakes or invent new ones
    - Knowledge transfer in organizations is a whole `nother topic
  - But maybe JCL will prove this wrong



# Foil 3: The Best Of All Possible Worlds Philosophy

- Phrase coined by the German philosopher Gottfried Leibniz in 1710 as part of his explanation of why suffering, injustice and evil co-exists with a benevolent and omnipotent God
  - It is also a pretty cool song by Kris Kristofferson
- Leibniz reasoned that God, to avoid a clockwork world, had to give humans free will
  - And a world with free will necessarily has suffering, injustice and evil
  - A suboptimum solution but the best world possible with the free will constraint
- Similarly, **the world of NASA cost analysis is the best of all possible “NASA cost worlds” we can have**
  - Because any movement toward better cost analysis moves us in the direction of fewer “new starts”
  - Said another way, good cost analysis is birth control for projects
- Since we obviously want new starts, the NASA cost world we have is the best of all possible NASA cost worlds
  - We can’t have a world with good cost analysis—nobody wants that really
  - Meanwhile, for 50 years, we have aggressively continued to pretend we are working to achieve a better world—I play the game myself regularly
  - All with little result
  - But maybe JCL will prove this wrong



# Conclusion of the English Lit 101 Part

- So we have introduced three foils that say....
  - The Village Watchman Syndrome...
    - All data is suspect
  - Lake Wobegon...
    - All project managers and their teams are suspect
  - The Best of All Possible Worlds philosophy
    - JCL is just another fad that won't change anything
- But in case CAD representatives are starting to murmur along the back wall...
  - **This briefing is going to be very pro JCL (seriously)**

**SPARKLE!**

So with foils introduced into our plot, the story can proceed.....

# Why View the World Probabilistically? (Chart 1 of 2)

- Assuming you commute to work....
  - You drive  $x$  miles one way (a deterministic variable)
  - The drive takes you  $y_1$  to  $y_2$  minutes (a random variable)
    - $y$  takes on different values each day
- Types of cost and schedule models
  - Deterministic models
  - Probabilistic (stochastic) models
    - ....and actually, our probabilistic models may still contain deterministic variables (non-random variables) for cost and schedule elements we are pretty sure aren't going to behave as random variables

# Why View the World Probabilistically? (Chart 2 of 2)



- Is the roll of dice probabilistic?
  - Not really...the dice are obeying the laws of physics and if we were sufficiently talented in Statics and Dynamics (which I took in 1968), we could ascertain the outcome of the roll of dice using physics calculations
  - Therefore a dice roll is deterministic--it only appears probabilistic because the human hand introduces variability in the technique of the roll
- Similarly, in any endeavor involving a complex set of variables that we don't fully understand, it is useful "to model" the operation probabilistically
- ...ergo modeling the cost and schedule of space flight projects might have something to offer
  - Complex systems, where lots of subsystems interact over lots of time
  - Lots of touch labor—personalities and foibles involved
  - And interrelated parts, correlation, feedback loops, exponential effects – chaotic things that we are not good at understanding
- A reverie: I believe that the first instance of NASA using probabilistic cost modeling was ca 1977 for the Satellite Power System

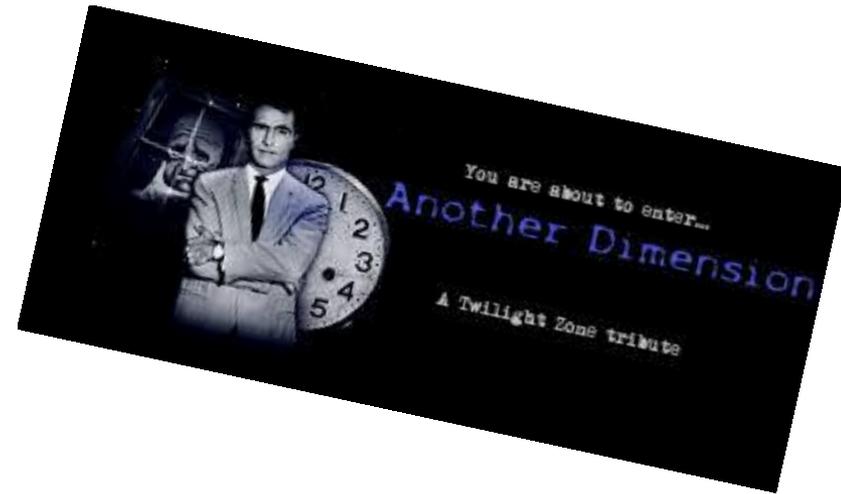
# Sources of Cost and Schedule Risk and Uncertainty



- Sources of uncertainty...
  - Noise in historical data used to build models (i.e. Village Watchman Syndrome)
  - Questionable application of models (e.g. me using spacecraft bus data to estimate launch vehicle systems—I admit being guilty)
  - Uncertainty in inputs to the cost and schedule process...
    - Optimism bias, most famously in TRLs, heritage assumptions, team expertise, etc.(the Lake Wobegon Effect)

# Risk Versus Uncertainty

- **We are now crossing over into the Twilight Zone**



# Frank H. Knight

- Frank H. Knight established the economic definition of the terms in his landmark book, ***Risk, Uncertainty, and Profit*** (1921):



- **Risk** (“Knightian risk” and “objective risk”) is present when future events occur with measurable probability
  - Example: The roll of a pair of dice—we have risk but we know the outcome is one of twelve numbers, each with  $p=1/12$ 
    - That is a risk but don’t call it uncertain
- **Uncertainty** (“Knightian uncertainty” or “subjective uncertainty”) is present when the likelihood of future events is indefinite or incalculable
  - Example: The 2009 recession: When investors realized and that Knightian uncertainty was upon them, they panicked
- While not germane to our topic here, Knight’s epiphany was that real opportunities for profit only exist in the face of genuine uncertainty
  - If a firm wants to innovate successfully, it not only has to deal with uncertainty, it must seek it out

# Risk Versus Uncertainty (Cont'd)

- Today, most academic sources parse risk and uncertainty something like this:
  - RISK is when we don't know what is going to happen, but we do know what the distribution outcomes looks like
  - UNCERTAINTY is also when we don't know what is going to happen, and we don't know the distribution
- Inching toward a (dated) project management view:
  - Risk is a loss or undesired outcome
  - Uncertainty is having too many unknown variables which do not even allow one to estimate as to what is going to happen
- But as we shall see, the uncertainty definition in the previous sub-bullet isn't quite the current NASA project management view
  - We are chipping away at the Knightian foundation here

# Risk Versus Uncertainty (Cont'd)

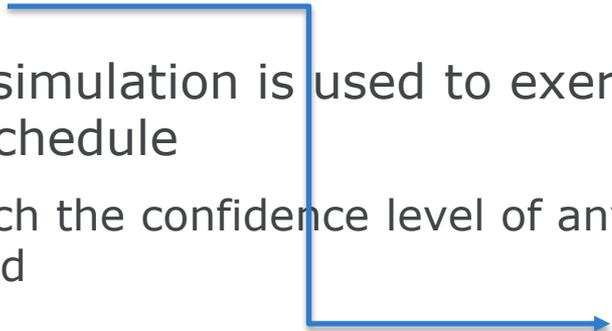


- NASA is OK with risk as the probability that an unfavorable event will occur
- And while NASA is OK with the understanding of uncertainty as indefiniteness about the outcome of a situation....
  - NASA believes uncertainty can be estimated and/or quantitatively dealt with
- Incidentally, we are in good company—such a view of uncertainty is convincingly discussed in *How To Measure Anything* by Douglas W. Hubbard\*
- And I believe Frank H. Knight would agree if Monte Carlo simulation had been invented in his time
  - Monte Carlo simulation was invented in 1946

\*How To Measure Anything; Finding the Value of "Intangibles" in Business by Douglas W. Hubbard

# NASA's JCL Process

- Generally a summarized version of the Project IMS is used as the “analysis schedule”
  - Health checks performed to debug logic flaws
- The durations of the tasks are specified as probability distributions
- Costs are mapped into the analysis schedule, also probabilistically
  - Cost separated into time dependent and time independent costs
- **The project’s risk register, with cost and schedule impacts is mapped to tasks in the IMS, also probabilistically events**
  - The 5x5 is converted to quantitative measures using the project’s RMP guidelines (such as “a likelihood rating of 3 equals a 40% probability of occurrence and a schedule consequence of 4 equals 6 months”)
- Monte Carlo simulation is used to exercise a bivariate distribution of cost and schedule
  - ...from which the confidence level of any given cost, schedule pair can be indicated



Hang on to this thought

# Risk Registers—Chart 1 of 2

- A risk register is a term used by projects to describe a central repository for all risks identified by the project
  - Each risk includes information such as risk probability, impact, counter-measures, risk owner etc.
- Some typical items on NASA project risk registers
  - Instruments mass may exceed bus capability
  - Instruments power may exceed bus capability
  - Launch vibration/acoustics environment may exceed design limits
  - Flight software late delivery
  - Software integration complexity
  - Shortage of skill [x]
  - TRL advancement of [critical part] on critical path
  - Parts quality issue uncovered
  - Critical path complexity due to multiple partners
  - Radiator contamination during IACO
  - EMI test may uncover problems
  - Congress may not provide budget

# Risk Registers—Chart 2 of 2

- Does the risk register include the real risks?
  - More often they seem like a list of the known engineering challenges that the engineers are gleefully looking forward to working
    - Are they risks or is it more akin to a to-do list\*
  - The real risks are of course the unknown-unknowns and how do we enumerate these?
    - Consult a soothsayer?
- I suggest we should examine the history of analogous missions and enumerate actual risks that have occurred
  - Furthermore I suggest that the scatter in CERs and SERs is the “cosmic background radiation” evidence of unknown risks
  - All we really have to do is construct CER/SER prediction intervals and budget cost and time to something around the 50 percent confidence level
    - Probably a little higher to offset optimism in CER/SER input variables
- Oh, sorry...I just fell off the officially licensed JCL bandwagon on this chart

\*I think I stole the “to-do list” one-liner from Barbara Stone-Towns

## Hubbard's "The Failure of Risk Management..."\*



- Hubbard has some better thought out criticisms of the risk register approach...
  - Assigned scores tend to cluster around the mid-low high range—score compression
    - On a 5 point scale, 75% of all responses are 3 or 4 such that changing a score from 3 to 4 or vice-versa can have a disproportionate effect on classification of risks
  - Scores implicitly assume that the magnitude of the quantity being assumed is directly proportional to the scale-- score of 2 implies that the risk is twice as large as it would be for a score of 1
  - Scoring techniques presume that the factors being scored are independent of each other—no correlation
  - And there are others...see his book
- Instead of risk matrices, Hubbard suggests probabilistic models
  - Involves building probabilistic models of risk events
  - Probabilities can be based on historical data, empirical observation or even intuition

\*The Failure of Risk Management and How To Fix it by Douglas W. Hubbard

# Hulett's Risk Driver Method

- Focuses on the really important risks in the project risk register
- Requires an understanding of root causes of cost and schedule duration uncertainties
  - At a root level of detail that the risks are  $\sim$ independent
  - Correlation is handled structurally (e.g. risks are tied to each activity they impact)
- For each risk...
  - The probability that the risk will occur
  - The range associated with the impacts if the risk does occur expressed as multiplicative factors on specific cost and/or schedule activities in the cost informed analysis schedule

# Some Final Thoughts on Interpreting JCL (Chart 1 of 3)



- There are convincing arguments for JCL...
  - In the literature (by Hubbard, Hulett, others)
  - In expert model building (Booz Allen, Tecolote, etc.)
  - In other NASA support contractors (Reed)
  - A host of NASA and NASA support contractors JCL practitioners
  - Several enthusiastic CAD cheerleaders (“Give me a J, give me a C....”)
  - Very importantly, the NASA PM community has bought into JCL
  - Also very importantly, NASA has made significant progress in communicating to OMB and the Hill the purpose and sanctity of UFE (thanks to Doug Comstock and maybe others)

# Some Final Thoughts on Interpreting JCL (Chart 2 of 3)



- JCL shouldn't really be thought of as an optimal methodology for obtaining more accurate cost and schedule estimates of NASA projects
  - If that was all we were interested in doing there are far simpler ways to do that
    - In my opinion (not universally shared) by estimating nearer the top of the WBS with good analogies)
  - And while we are on the subject, because JCL has so many moving parts, all final JCL cost and schedule results should be checked with a high level analogy based estimate "prior to going to press"
    - If the analogy estimate and the JCL estimate differ by a significant amount, this must be reconciled

## Some Final Thoughts on Interpreting JCL (Chart 3 of 3)

- I submit that that the cost and schedule estimate produced by JCL is a trivial feature
- What is far more important....
  - JCL forces us to lay out the work in an IMS (and it's stepchild, an analysis schedule)
  - It requires that we logic link all the activities and debug the schedule
  - It requires that we "inform" the schedule with cost and understand time dependent and time independent activities
  - JCL necessitates that we give risk and uncertainties far more thought than NASA has traditionally done (at least in the project planning phase)
  - And it gives us the tool to assign those risks to project activities, specifying the cost and schedule impacts
  - And once JCL illuminates for us, the impacts of risks, it also provides a tool to assess risk mitigation plans
  - It is important to maintain the JCL through the project lifecycle because project management will adjust the project plan as a consequence of dealing with risks

# Conclusions and Recommendations (chart 1 of 3)

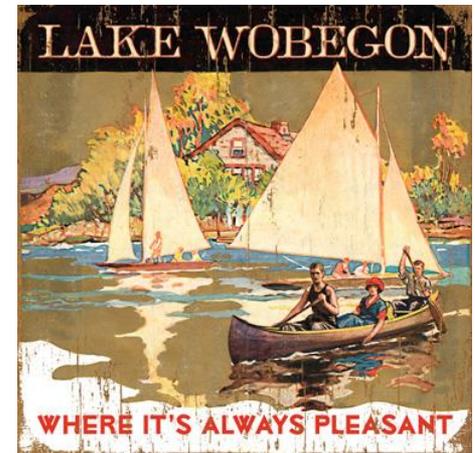
- Additional research is needed on...
  - A schedule duration database should be developed
  - Time dependent and time independent cost
- In other words, defeat the Village Watchman Syndrome of bad data



# Conclusions and Recommendations (chart 2 of 3)

- While not really the responsibility of the cost/schedule community, risk register methods should be improved
  - Consider using the risks from analogous completed missions
  - In other words, help Project Managers realize the normality\* of their team and do things like improve risk registers

\*Compared to other NASA teams



# Conclusions and Recommendations (chart 3 of 3)

- JCL final results should be checked with high level analogy estimates of both cost and schedule
- The CAD should track results of JCL in terms of actual cost and schedule outcomes
  - In other words, prove the fallacy of thinking that we already have the Best of All Possible Worlds



- JCL seems to be the right tool at the right time for NASA!

SPARKLE!

# Supporting Material

Drag the icon below to the desktop  
of the projecting computer

