Case Studies: A Common Language Between Engineers and Managers

10th Annual NDIA Systems Engineering Conference

DeWitt T. Latimer IV, dlatimer@usc.edu
http://www.robotics.usc.edu/~dlatimer
Center for Systems and Software Engineering
http://csse.usc.edu
Robotics Embedded System laboratory
http://robotics.usc.edu
Viterbi School of Engineering
University of Southern California

Overview

- Background
  - Communication Facilitation
  - Engineering training and education
  - Manager training and education
- Possible Discourse Problems
- Example Case Studies
  - Surface Assessment Robot
  - Autonomous Helicopter
- Observations & Pitfalls Experienced

Background

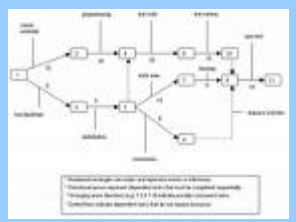
- Review communications basics – where would discourse about cases help?
- Review education and training of engineers and managers to establish a baseline of what each community is comfortable communicating

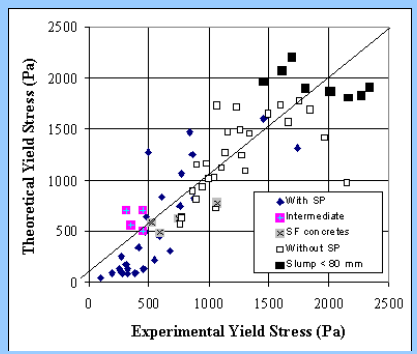
Communication starts with understanding.

- R. Kline

Has this happened to you?

"What's wrong with this picture?"





$$\text{logit}\,[\Pr(y_{cij})] = A_{ci} + \gamma_1{}^{T} z_{cij} + \beta_{(dog)}\,(X_{cj} - \overline{X_c})_{(dog)} + \beta_{(nodog)}\,(X_{cj} - \overline{X_c})_{(nodog)} + e_{cj}, \quad [1]$$

where

$$\left(X_{cj} - \overline{X_c}\right)_{(dog)} = \begin{cases} X_{cj} - \overline{X_c} & \text{if } dog = 1 \\ 0 & \text{otherwise} \end{cases}$$

and

$$\left(X_{cj} - \overline{X_c}\right)_{(nodog)} = \begin{cases} X_{cj} - \overline{X_c} & \text{if } dog = 0 \\ 0 & \text{otherwise} \end{cases}.$$

Managers

?

Engineers

Communication Stages

- Receive : Largely a physical (sound) or technical (email) phenomenon
- Attended : Did the recipient pay attention to the message (raise to their consciousness, open the email)?
- Understood : Did the recipient form the desired mental concepts?
- Responded : Did the recipient confirm understanding or was the recipient able to act on the understanding?
- Remembered : Did the recipient commit the facts to memory?

Engineering Training and Education

- Emphasis on models, accuracy, precision, and addressing uncertainty as a statistical quantity
  - Gather data from many projects/cases to integrate into models
  - Apply the data collected to enhance models
  - Learn rules of how to accurately apply models to projects
- Emphasis of engineer training is the concept of “due care” in the generation of products - accepting that sometimes things “just happen”

Management Training and Education

- Most programs heavily involve case studies that illustrate quantitative models in action
  - The cases provide “grounding” as to where the models are valid and how to utilize them
  - Indeed, a tenant from many management students is that models may be easily invalidated by moving to a different set of environmental factors
    - And there are case studies to illustrate this
- The focus on management training is to identify, prevent if possible, and report on things that may disrupt the manager's span of interest

Discourse

- My experience
- Anatomy of a disagreement

Discourse

From my experience...

- Managers want to know if the model truly represents the problems they are about to encounter, or that the model gives them information about how to handle the problems without wasting resources
- Engineers prefer problem-relevant models in which they have experience and desire to use them in the fashion in which they've been trained

Discourse (2)

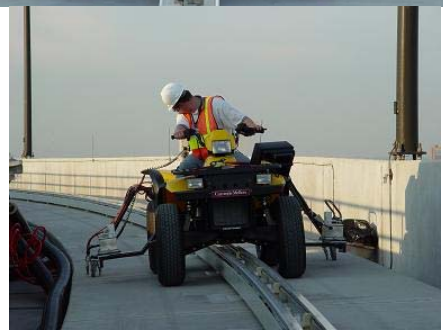
- Conflict arises when the engineer and manager are in disagreement – e.g. “Can we produce a system at the 20% confidence effort estimate?”
- Different views of the data is a possible cause
  - Manager believes that the uncertainty is the management trade space
  - Engineer believes the uncertainty is the inherent variation in performing the tasks
- Both may be correct!! How do we begin a rational discourse?

Example Case Studies

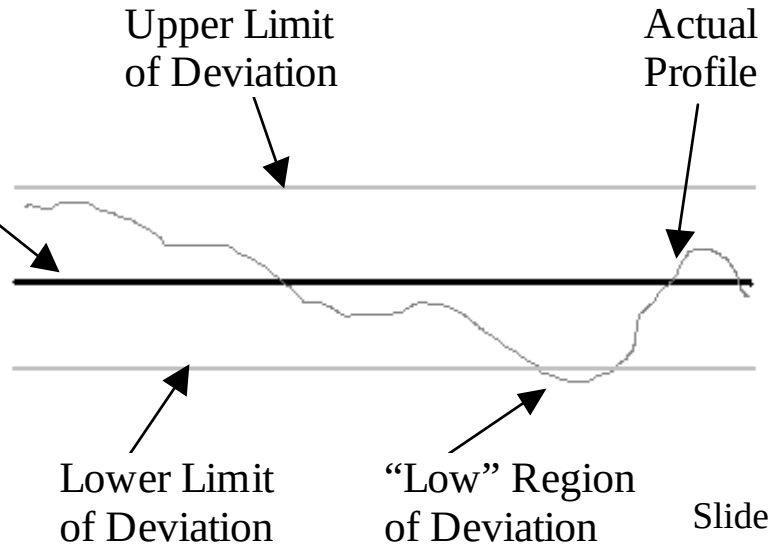
In the following two cases, we will cover two examples of where schedule for production of a robotic system failed to achieve a usable system on time

- Surface Assessment Robot – met all stated requirements, unstated requirements cause system to fail to integrate with all stakeholders
- Global Hawk – short engineering / manufacturing design phase led production problems

Surface Assessment Robot



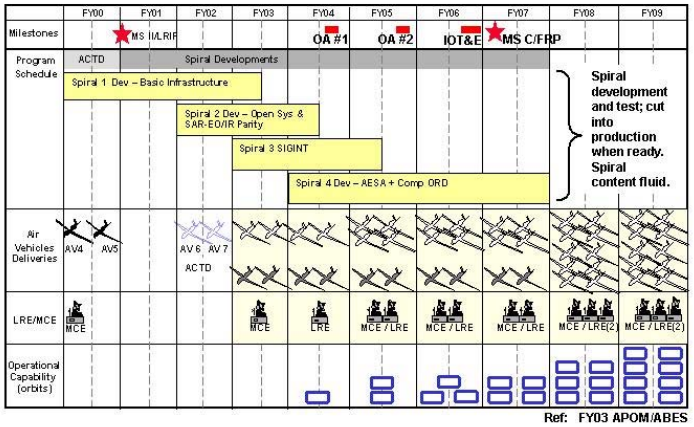
- System detects and marks deviations from the smoothness standard in road surfaces
- Project involved numerous precedented technologies in construction assessment
  - Unprecedented nature of fully taking an engineer out of the loop created requirement development risk
  - Cost/schedule given were sufficient only for a precedented system that could be acquired in a single pass (non-evolutionary)



Global Hawk

- System carries remote sensing payloads under guided flight autonomy command of remote operator

Transformation Program



Ref: FY03 APOM/ABES

- Engineering analysis for production system was limited due to believe that research prototype was ready for production
- Schedule created on belief that engineering analysis was “close”
- Result: inability to meet full rate production goals

Observations

- Reaction when using cases as the basis to discussion between engineers and managers
- Example outcomes of managers engaging and investing in engineering decisions flowing out from case study dialog
- Strengths and weaknesses

Observations

- Managers who were later exposed to these cases engaged to address the root causes
  - Many proposed additional forward looking models
  - Many engaged on setting estimation parameters in constructive effort models
- Managers began to see where the “trade-space” was outside of the confidence intervals
  - Expressed understanding of the inherent risk in various parameterized descriptions of the environment

Observations

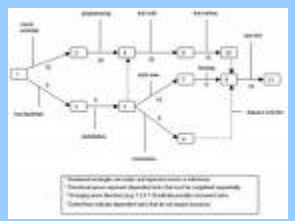
- Using the surface assessment robot case, managers brought up how strategic alignment should be linked to various effort model settings
- Using the Global Hawk UAS case, managers mentioned the importance of having reliable assessment metrics for maturity of engineering *products* in addition to the *processes*
  - Identified the lack of ability to assess reuse
  - Identified the lack of upfront investment to ensure work products could be reused and need to invest to make up for the shortfall

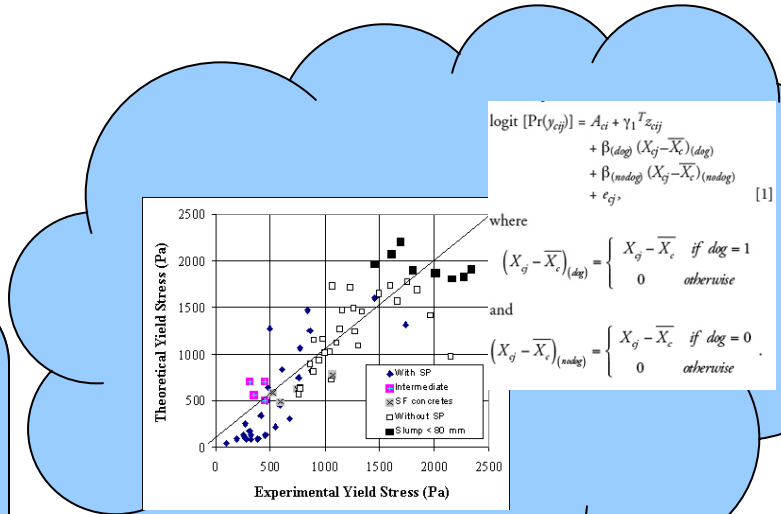
Observations

Case Studies typically do not have “schoolhouse” answers - this is their strength and weakness

- Strength – the case describes the breadth of what happened and the environmental/political factors
- Weakness - the case doesn't tell you what to do if you aren't doing the *exact* same thing in the *exact* same situation and time

Cases as a Common Language





Managers

Engineers

Pitfalls

Two pitfalls I have encountered when using cases to support engineering positions with management

- I want more cases to support your position...
- We have to use the model based result, even if it doesn't make sense!

... and what can be done about these pitfalls

Pitfalls (1)

"That's only one (two, three...) case that supports your model, now give me more cases!"

- Likely that you may only be conversant in a few cases relating to any one set of circumstances
- This may be done if someone is engaging in *selection bias* for which cases they consider for when forming their theory of the solution
- Remember, calibrated models are the integration of many observations, where each observation is a case explained in the parameters of the model!

Pitfall (2)

"The model says something we didn't expect, we have to use the results because its the model"

- "Expect" is based on understanding of this specific project in progress and similar historic cases
- Model may be leveraged beyond its calibration or model parameters do not enable discrimination between cases with different outcomes
- People should examine some relevant case to see how well the model is calibrated to this problem or look for other factors that could impact the result

Review

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  - Communication Facilitation
  - Engineering training and education
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- Experiences Using Case Studies in Discourse
- Example Case Studies
  - Surface Assessment Robot
  - Autonomous Helicopter
- Observations & Pitfalls Experienced

Take Away

The goal is effective communication through engaged listening and speaking. Motivating cases may be one avenue to appropriate understanding and responses in multidisciplinary teams.

Backup Slides

Additional Sources of Case Studies

Defense Acquisition History Project

http://www.army.mil/cmh/acquisition/research/fa_casestudybib.html

AFIT Case Studies web page

http://www.afit.edu/cse/cases.cfm

The Risks Digest

http://catless.ncl.ac.uk/Risks/

Systems Engineering Handbook

Available from INCOSE.org

Technical Project Management Textbooks

one example: Kermer, “Software Project Management: Readings and Cases”, McGraw Hill, 1996

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About the Author

Capt DeWitt Latimer IV, USAF is currently assigned as a PhD Student to the Air Force Institute of Technology and working towards a PhD in Computer Science at the University of Southern California. He is advised by Prof Barry Boehm and Prof Gaurav Sukhatme. His research focuses on investigating the nature of acquiring autonomous robotic systems. He earned his MS degrees in Robotics (2001) and Civil Engineering (2002) at Carnegie Mellon University. He is a senior member of the IEEE and ACM and a member of ASCE, and AFCEA and was awarded the CSDP credentials from the Computer Society.