HW # 9: TRL, N2 Analysis, Trade Studies
[redacted]
April 4, 2008

Part I: Individual Assignment

19/20

1. *Write no more than 1 page on why you think achieving TRL 6 for technology development prior to Preliminary Design Review (PDR) is a good policy or not a good policy.*

Technology Readiness Levels (TRLs) are a "NASA-established classification scale against which to measure the maturity of a technology". A TRL a measurement that is used to determine the "maturity of evolving technologies prior to incorporating those technologies into systems or subsystems". NASA has created a policy that prevents flight project development to be approved for implementation until the technology has reached a TRL of 6. TRL 6 means that the "system/subsystem model or prototype has been demonstrated in a relevant environment (ground or space)." Basically, if the technology development is not at a TRL of 6 by the time the PDR rolls around, the flight project development will not yet be implemented. ✓

I feel that this is a good policy; in fact, I feel that it is a very crucial and important policy. TRLs measure how far along technologies has come. By the time of PDR, the project is essentially done with the formulation phases of the life cycle and ready to move into implementation part of the life cycle. The next step is final design and fabrication. From this point, most of the concepts and details have been hashed out. The requirements, design, and operations will be reviewed at PDR. ✓ PDR is a critical control gate and is a major milestone in the life cycle of a project; therefore, I agree with the policy that the technology development should be at a TRL of 6. Imagine if NASA has put billions of dollars into a mission and years of effort in Pre-Phase A, Phase A, and Phase B. *more like millions* Then they get to PDR and realize that the project must be cancelled because the new technology just can not be created. A policy that requires the technology to have been demonstrated in a relevant environment shows that the technology is in fact realistic and doable. It is absurd to think that a project could get past PDR and actually begin phases that involve fabrication and system assembly, when the engineers are not even sure if the technology will work. *ah but it has happened!* At the beginning of the life cycle, when systems engineers are writing the requirements, the idea of a technology may seem plausible. It isn't until after engineers and technicians have actually begun developing certain technologies that they may realize they were in over their heads. This policy keeps the engineers from getting too far "over their heads". *[goo]d way to put it*

Also, a TRL of 6 basically implies that it is capable of reaching TRLs 7, 8 and 9. The policy obviously could not require a TRL of 7 (demonstrated in space environment) unless it was through similarity via heritage. Also, a policy that required a TRL of 5 (component validated in relevant environment) would be too lax. TRLs also indicate inherent development risk. A TRL of 6-8 represents low risks. This is another reason to support the policy. If the project is ready to pass PDR, then it is necessary for the technologies to be at low risk. TRLs of 1-5 are typically at high to moderate risks, which is not acceptable when going into the formulation phases of the life cycle.

Overall, I absolutely agree with the policy, and I feel that it should remain in place that prior to PDR, a new technology should have reached a TRL of 6.

good job you hit all the key points:
- life cycle
- role of PDR
- Risk impact

Could also mention
- setting the design baseline @ PDR
- cost / schedule impacts in Phase C

what a great example and personal experience. I am sure the whole concept of TRL means something to you after this.

3. Extra Credit 25/25

While at NASA Ames Research Center this past summer, I worked with the Crew Exploration Vehicle Thermal Protection System Advanced Development Project (CEV TPS ADP). This essentially involved working with the development of the heat shield for the CEV. Prior to my arrival at Ames, my mentor had created an idea for an alternative concept to the baseline for a heat shield design. His idea is to create a "honeycomb heatshield". Basically, the heat shield would be segmented into different parts (the outer gore, inner gore, center cap, and shoulder). Each of these segments would then further be divided into smaller segments. In the end, you would have a heat shield that consists of a heat shield structure resembling a honeycomb, and within that structure, small "inserts" of ablative materials would be placed in the heat shield honeycomb structure. These small "inserts" would have side lengths of less than 2 inches, and throughout the entire heat shield, there would no more than 12 different standard "insert" parts.

When I arrived there at the beginning of last summer, my mentor's idea was just that; an idea. Other than some models he had made in his garage during his spare time and some sketches he had drawn on the whiteboard in his office, this innovative technology concept was just an idea. He had asked the right structures and materials people if this was plausible and he had written a patent that reported his idea, but overall, I would say the technology was at TRL of 1 (basic principles/research observed and reported).

My job was to take his idea and make it more "professional". Essentially, I was to take his concepts and model them in SolidWorks. This would not only allow his concept to become more visual, but it would also allow him to present his work to management. After many weeks of modeling in SolidWorks, talking with companies about what materials to use for the honeycomb (PTFE), researching which ablative material would be best for the "inserts" (PICA versus vendor options), finding ways to determine the feasibility of the concept, and determining how many test coupons were necessary to test in the arc jets, I would say the technology had been advanced to a TRL of 2 (technology concept and/or application formulated). The concept was ~~k~~now ready to take to management in order to ask for funding to actually begin the research necessary to prove its feasibility. My contribution ended here as my internship came to end.

However, within months after leaving, I would estimate that my mentor's idea reached a TRL of 4 (component validated in laboratory environment). Ideas had been brainstormed as to how many test coupons we would need, what kind of tests we would have to do in the arc jets, how to equip the test coupons with the appropriate thermocouples, and what tolerances would be acceptable for creation of this honeycomb heat shield. After necessary funding was reached, the feasibility of this concept would be validated through the use of test coupons in the arc jets at Ames. Because heat shields can not be tested in flight (until of course the first time they are actually needed), a TRL of 4 (validating in a lab environment) is a relatively high level with only moderate risks.

As for maturing this technology/concept and applying it to a mission, the ultimate plan would of course be to use this concept as opposed to the baseline. Realistically, the idea is to make this a standard way of custom creating a heat shield to any re-entry vehicle, not just CEV.