Formula Hybrid+Electric 2024

Change Management Report

Worcester Polytechnic Institute

Goat Fast Racing

#204

Process

Prior to this competition cycle, our team operated without a change management system. This year, instead of continuing to neglect this facet of the competition, we overhauled our change tracking system in order to help our team communicate more effectively. Our new system centers around a change log in our Notion database which can be viewed as snapshots in Appendices B and C, or at this link. The process is triggered when a significant change is necessary or desired by any member of the team. This can be for any reason, but it is typically to fix rules compliance issues, fix reliability issues, or increase performance. We define "significant" here as a change that affects the development of another subsystem of the car, the timeline of the car, or the cost of the car. Admittedly, this criteria leaves a lot open to the person deciding whether the change is significant, so our policy is that if you are not sure if it should go in the change log, add it to be safe.

The process begins by adding an item to the change log with the "Proposed" state, as shown in Appendix A. All of the information about the change is contained in the log entry. This includes a description of the change, a list of benefits, an assessment of risks, a relative cost estimate, predicted schedule impact, and all stakeholders. At the next relevant subteam meeting, the change is moved from "Proposed" to "In Discussion". This means that we have acknowledged the proposal, but have not made any decisions yet. Many change proposals can be resolved in a single meeting, but some require extended conversations with stakeholders. Throughout decision making, information flows through the process entirely via the Notion database, which is viewable by everyone on the team. We also "mention" stakeholders in the body of the log entry, which automatically emails them to make sure they are aware of the proposal. Changes stay marked as "In Discussion" until all of the relevant stakeholders either agree that the proposed change will be effective and positive or that it should not proceed. Ultimately, the final decision is signed off on by our two Project Managers, who update the log status to "Approved" or "Denied." In the final step of the process flow, we discuss changes that have been approved or denied at our weekly all-team advisor meeting, which keeps our advisors and anyone else who was not directly in the loop informed, and gives everyone the opportunity to chime in with suggestions or potential important problems that were missed.

Implementation

Up until a few weeks ago, we were planning on using the same BMW E46 throttle pedal that we used on our 2021-2023 competition car. However, improvements in our pedal box design meant that it was substantially larger than our brake pedal assembly, and therefore the limiting factor in pedal box adjustability. We would still be fully rules compliant with it, but would risk not being able to fit team members who are taller than the 95th percentile male, something that is quite important to our team as we have several tall core members. Will, who was leading pedal box design, wanted to design a custom pedal. He decided that this was a significant change because the new pedal would need to interface with the electrical system and because it would need to be manufactured, affecting cost and timeline. He made an entry in the change log with the Proposed state and filled in all the relevant fields. The full body of the log entry is in Appendix B, but to summarize, the benefits of the change include better packaging, more ergonomic pedal feel, and better mounting geometry, the risks include adding yet another custom system that could create issues, and the major stakeholder was the low voltage electrical team who would have to integrate the new sensor into the car. At the next mechanical team meeting after the log entry was created, the change was discussed, and it was decided that the

mechanical benefits of the change outweighed the risks. In addition to both project managers, a few members of the electrical team happened to be present and said that sensor integration would not be too difficult. The team made the decision to move directly from Proposed to Approved, as no further discussion was necessary. This decision was communicated via the public change log, to all relevant parties at the meeting where it was decided, and to the whole team at our next weekly advisor meeting. Despite this appearing to be a relatively minor mechanical change at first sight, getting the pedal sensors electrically integrated properly is absolutely critical for rules compliance, safety and reliability. Using the change management process streamlined this integration, making sure that electrical team members got involved early and were able to sign off on important design decisions, allowing more of our tall members to drive and improving ergonomics for everyone.

Effectiveness and Improvements

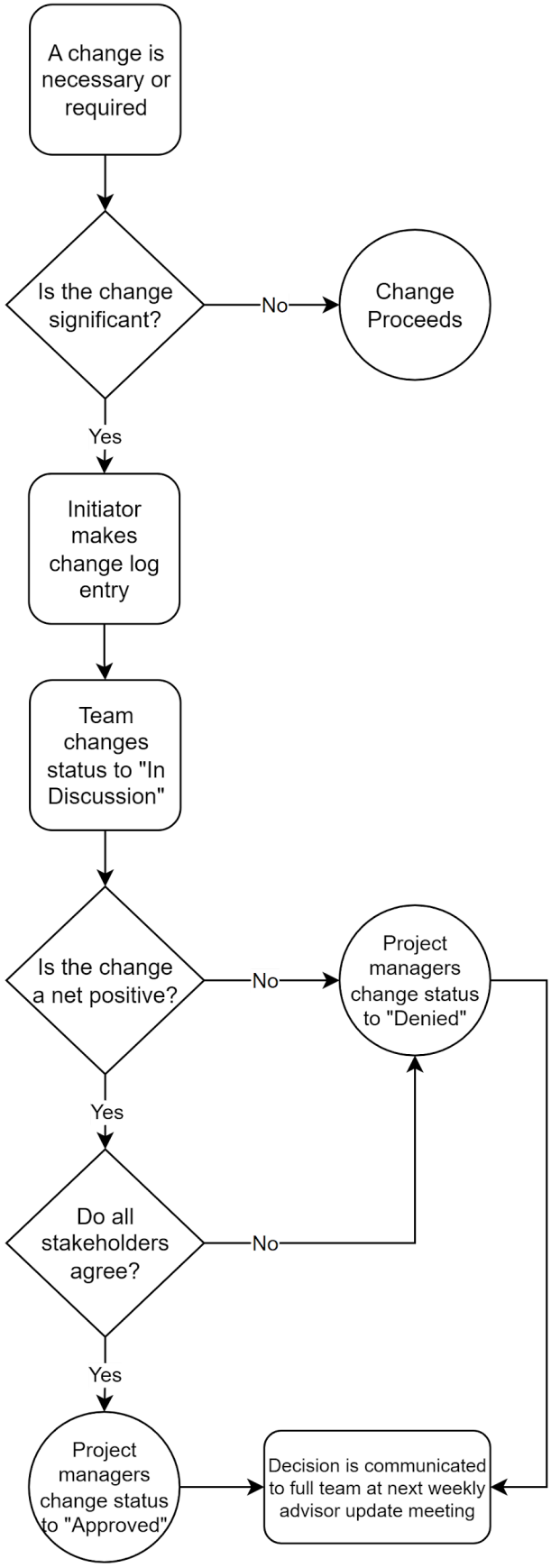
Looking back on the changes we have made this year, it is clear that the formal change proposal system was effective and saved our team substantial time and money. In the accelerator pedal example described, without the change management system, there is a chance that Will might have gone ahead with the design of the pedal without much consideration of the electrical side of things. This may have resulted in a pedal design without redundant sensors, which is unacceptable electrically for both safety and rules reasons - requiring a full redesign. The change management process looped in the relevant electrical team members early and ensured that the design was feasible before progress was made. As a result, the final design included electrical components that the new system needed in order to support a custom pedal.

The first major improvement that we would like to make for next year is having formal gates that require people to actually use the system. A problem that we have seen as we implement our change management process this year is that sometimes people use it after the change has already been made, which turns the entire thing into meaningless paperwork. If we require change approval to progress with fabrication and purchasing, it will definitely make people use the system. We also plan to couple the change log more tightly with our existing version management systems. Both our mechanical and electrical teams track their work in git, so we can use GitHub pull requests to force approval of a change before a branch containing the changed design can be merged in. Unfortunately, most of our mechanical engineers do not have prior git experience, so branching and pull request gates were out of scope for implementation this year, but our plan for next year is to make a system that connects pull requests to their change log entries and does not allow merging without approval.

The second planned improvement to the process is integrating our design review system as a formal step. We had an issue this year where sometimes a design would be reviewed, approved, and then a change would be approved, and the changed design would slip through to production without another review. The idea would be to split the “Approved” state into a “Concept Approved” state, where not every single detail has been fleshed out, and a “Design Approved” state when the change passes full design review. We think that this will make the process more resilient in times when we are stressed and pushing up on deadlines.

Ultimately, we have found that formalizing our change management has made our team much less likely to make costly mistakes due to lack of communication as well as much more able to react when issues arise. While we definitely have room for improvement, there are a number of examples, like the pedal redesign discussed above, where the process has had a positive impact on our team.

Appendix A: Flowchart



Appendix B: Change Log

Change Log

Table

Name	Tags	Date Proposed	Date Approved	Status	Change Owner	Urgency
Change precharge voltage reference from an isolated DC:DC to a LDO	Electrical	March 19, 2024		Proposed	Carson Graham	Medium
Throttle Pedal Redesign	Electrical, Mechanical	March 4, 2024	March 14, 2024	Approved	Harris Brancazio	
Pre-charge and Discharge mounting	Electrical	February 16, 2024	February 20, 2024	Approved	John D	Low
Manual Spot Welding	Electrical	February 14, 2024	February 17, 2024	Approved	evelyn maude	High
Master Cylinder Location	Mechanical	February 5, 2024	February 21, 2024	Approved	Will	Medium
Waterjet Segment Plates	Electrical	January 22, 2024	January 26, 2024	Approved	evelyn maude	High
Accumulator Cooling Firewall Modification	Mechanical	January 11, 2024	January 12, 2024	Approved	Will	High
Accumulator Mount Interference Correction	Mechanical	January 3, 2024	January 3, 2024	Approved	Will	Critical
Structural Floor Firewall Integration	Mechanical	December 4, 2023	December 8, 2023	Approved	Will	Low
Chain Guard Integration w/ Supplementary Structural Member	Mechanical	November 2, 2023	November 6, 2023	Approved	Will	Low
Change Straight Shaft Steering to Gearbox	Mechanical	November 1, 2023	November 12, 2023	Approved	Samuel Kierstead	Medium
Motor Mount Third Arm	Mechanical	October 27, 2023	November 2, 2023	Approved	Will	High

New

Calculate

Waterjetting Segment Plates

Date Proposed	January 22, 2024
Date Approved	January 26, 2024
Status	Approved
Change Owner	E evelyn maude
Tags	Electrical
Urgency	High
Add a property	

E Add a comment…

Description

Changing from milling to waterjetting G10 segment plates

Benefits

- Faster
- More consistent
- Less fiberglass dust potential

Risks

- Fiberglass delamination
  - mitigated by getting waterjet settings dialed in
- We don't have full control over the waterjet and it could break or otherwise be unusable
  - mitigated by schedule padding and also by being able to switch back to milling if necessary
- A short mill operation will still be required (it's genuinely easy though)

Cost

- ~$20 of now useless endmills we already bought
- estimated $300 of garnet abrasive totals

Impact to Schedule

- should improve schedule

Major Stakeholders

- this mainly just affects carson and evelyn as it is just a manufacturing method change

Appendix C: Pedal Change Log Entry

Throttle Pedal Redesign

Date Proposed	March 4, 2024
Date Approved	March 14, 2024
Status	Approved
Change Owner	Harris Brancazio
Tags	Electrical, Mechanical
Urgency	High

Add a property

Add a comment...

Description

Swapped from using an OEM throttle pedal to a bespoke pedal assembly

Benefits

- Easier to package
- Improved ergonomics
- More robust pedal mounting strategy

Risks

- Additional custom system that needs to be designed, manufactured, and validated
- BMW could be better at designing pedals than us

Cost

- Stock = $70
- Sensor boards = $30
- OEM pedal plate = $21
- Added manufacturing and assembly time

Impact to Schedule

- 2 days of machining and component assembly

Major Stakeholders

- Low voltage team, manufacturing leads