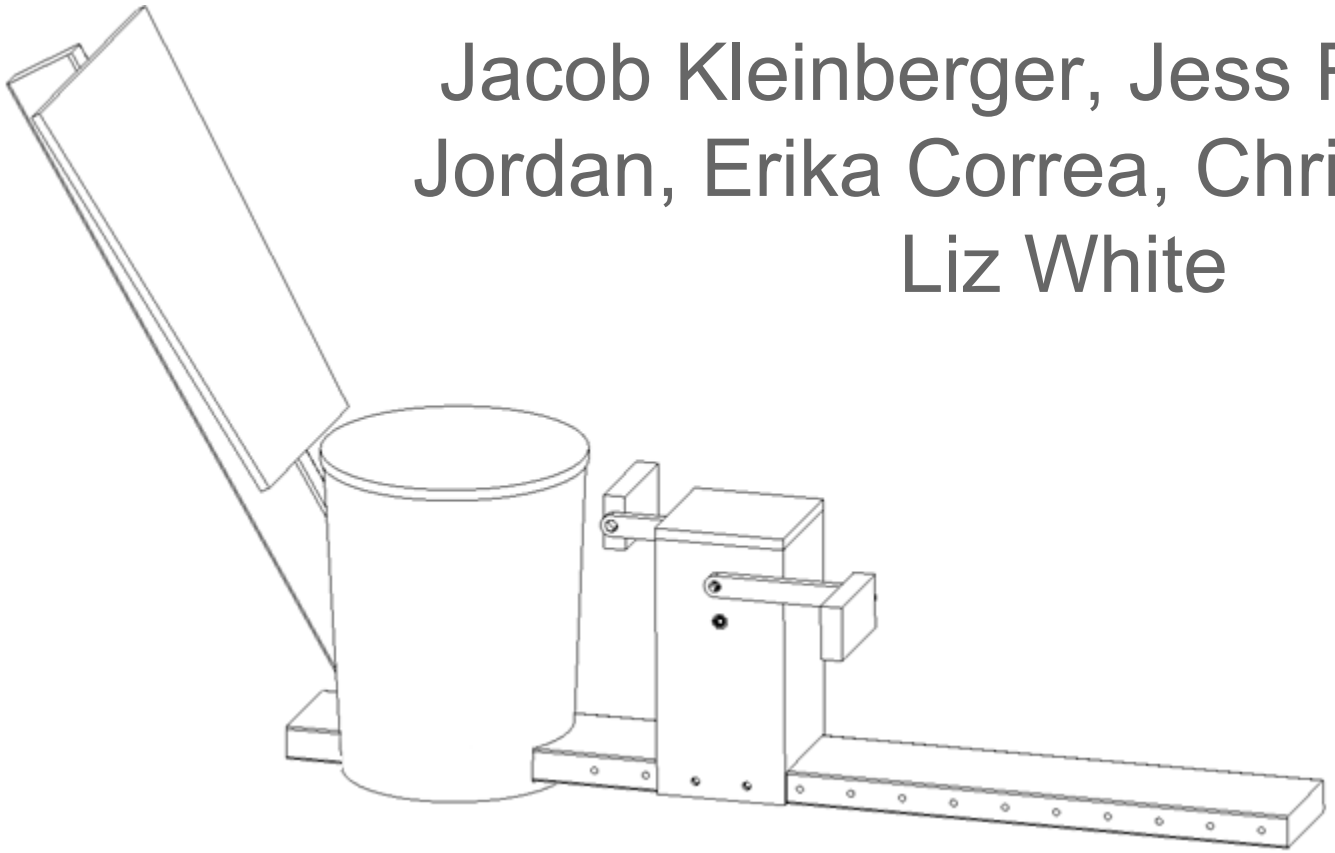
Power Generation for Better Water Maker

Jacob Kleinberger, Jess Fuss, Kyle Jordan, Erika Correa, Chris Falanga, Liz White



Need to do:

Deliverables (70%):o It works! All subsystems tested, some integration; system meets requirements verified with DATA (problems discovered have credible recovery plans in place)

o Complete & up to date documentation package

Process (20%):
o Actions tracked and outstanding items have actionable tasks

o Problem tracking methodology demonstrated (root causes identified, solutions concurred by all team members)

o Risks known, acceptable and being managed

Program(10%):
o Meeting project budget (with contingency)

o Meeting target product cost

o Meeting schedule (plan in place, up-to-date, phase 4 deliverables specific & measurable (late elements have recovery plans in place)

Objective

To create a power generation system for the BWM under the following criteria:

- Produce enough power to run the sanitation system
- Easy to use
- Low in cost
- Easy to assemble and operate
- Designed for women and children

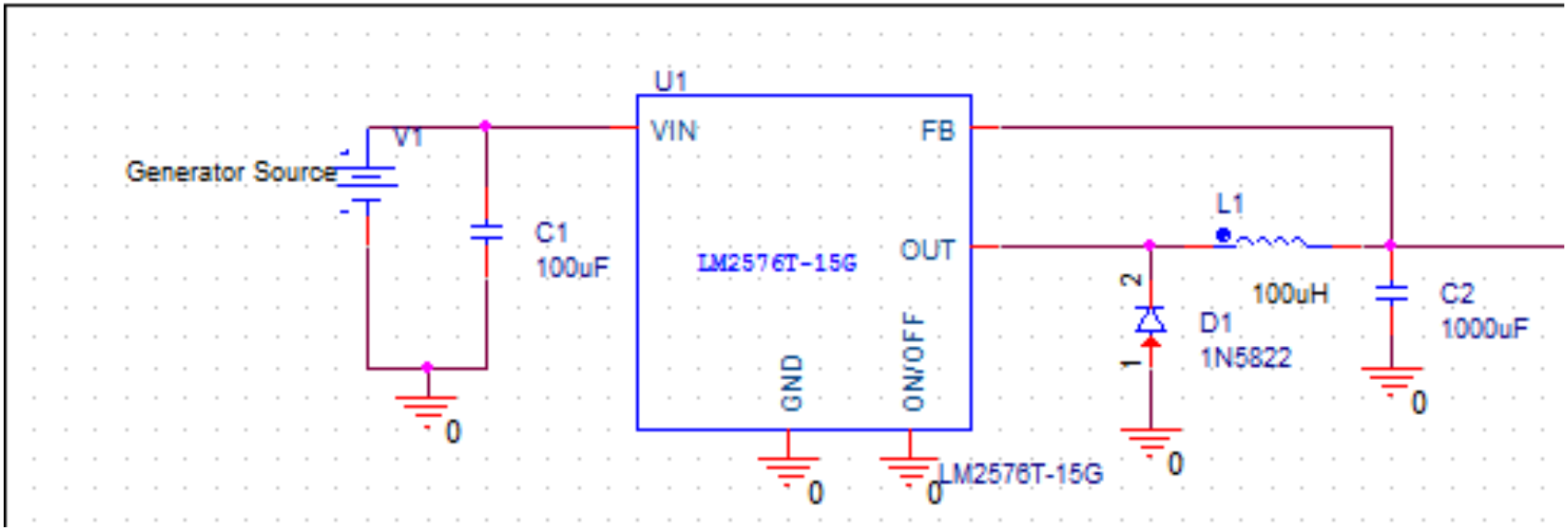
Engineering Requirements

	Function	Importance	Units	Range	Goal Value
ER1	Cost	9	USD	0-200	150
ER2	Generated Power	9	W, V	23-29	27.5, 14.3
ER3	Shipping Size	3	packaging dimensions		
ER4	Training Time	3	minutes	5-30	10
ER5	Ease of Repair	3	minutes	20-60	30
ER6	Effort Required	9	Heart rate	Low to Medium Intensity	Low Intensity
ER7	Weight	3	lb	<50	45
ER8	Number of Installers	3	People	1-3	1
ER9	Number of Tools	3	Tools	1-3	1
ER10	Unit Life	3	Gallons Treated	>180,000	>180,000
ER11	Support User	9	lb	40-200	130
ER12	Can Hook Up to 12V Car adapter	9	Binary	Yes	Yes

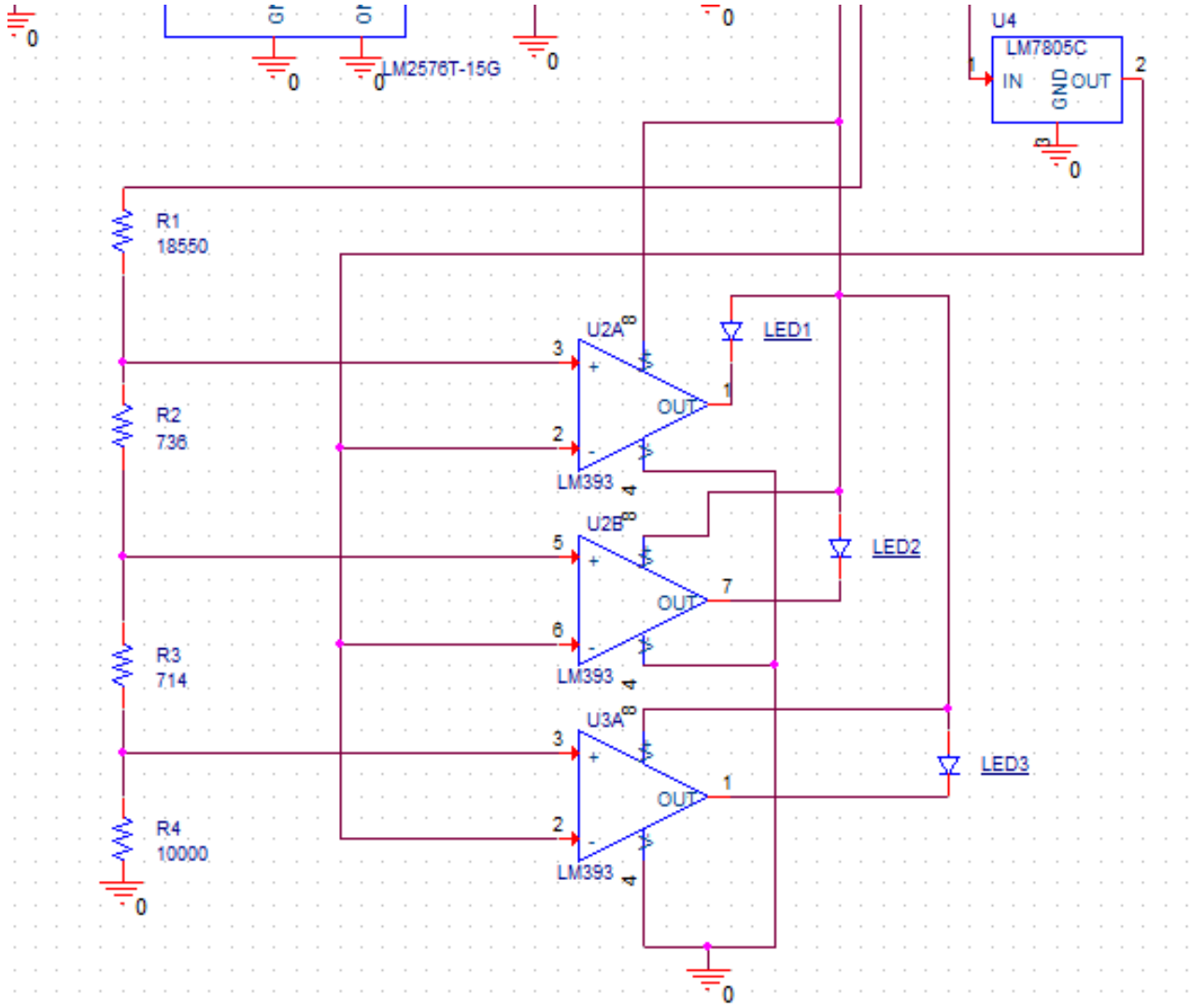
Gearbox (Wally)

- Issues
  - Gear Tolerances
  - Machining requirements
  - Missing tools
  - Design changes mid-manufacture
  - Miscommunication with sub-teams
  - Missing Top/Bottom
    - Bottom still outstanding
  - Gear interference
  - Noisy
- Success
  - Learned perseverance, feeling of accomplishment and machining skills
- Testing will identify improvements and optimization

Final circuit design regulation stage

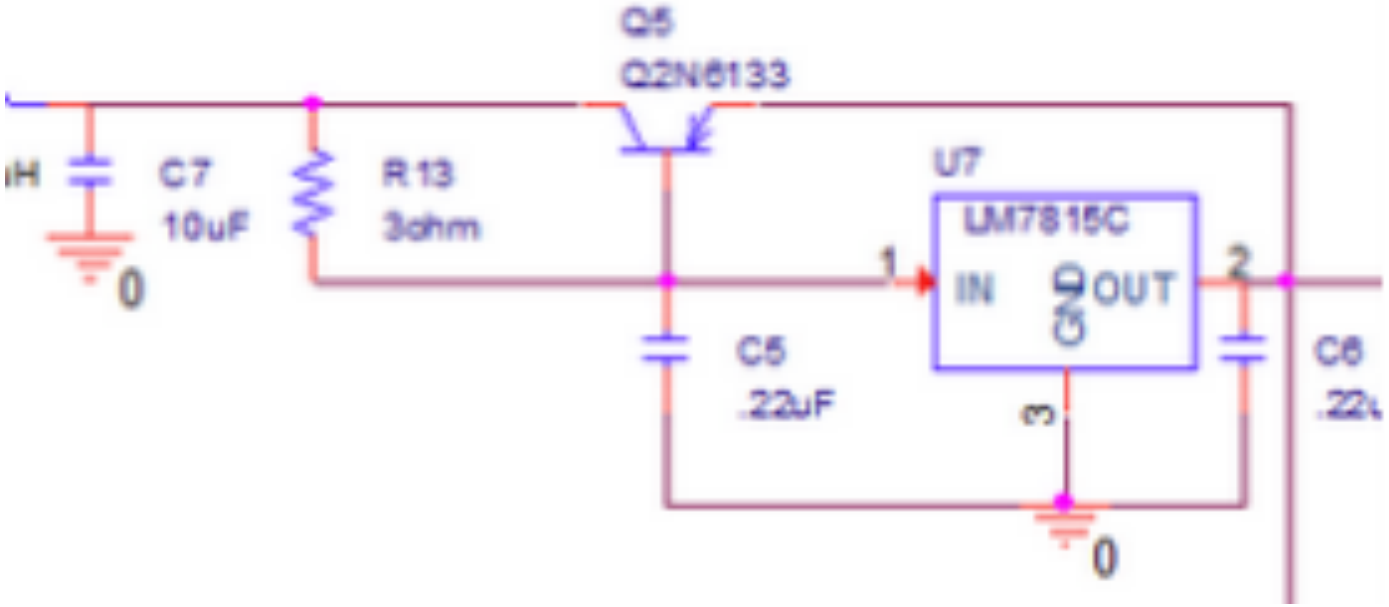


Circuit design LED stage



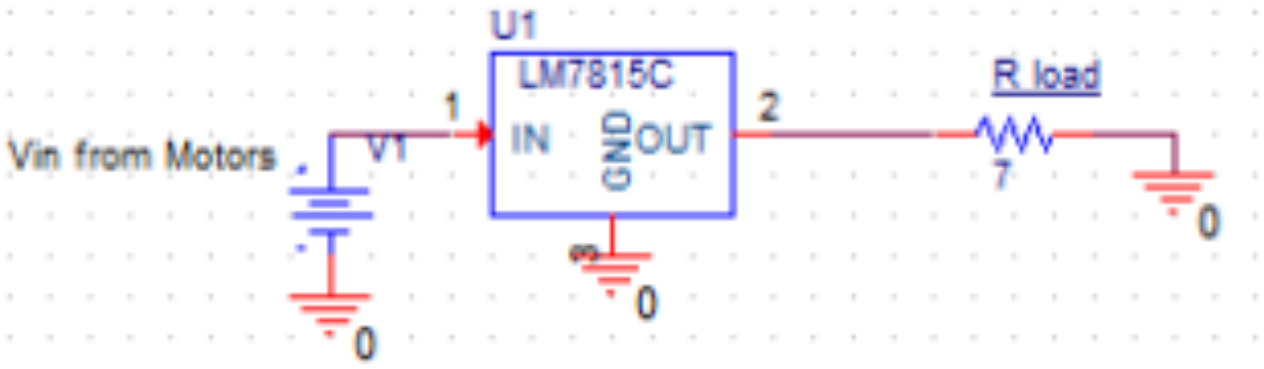
Linear Regulator Testing

- First proposed design called for using the LM7815 linear regulator setup to pass high currents
  - This proved to be too costly and large to even bother testing



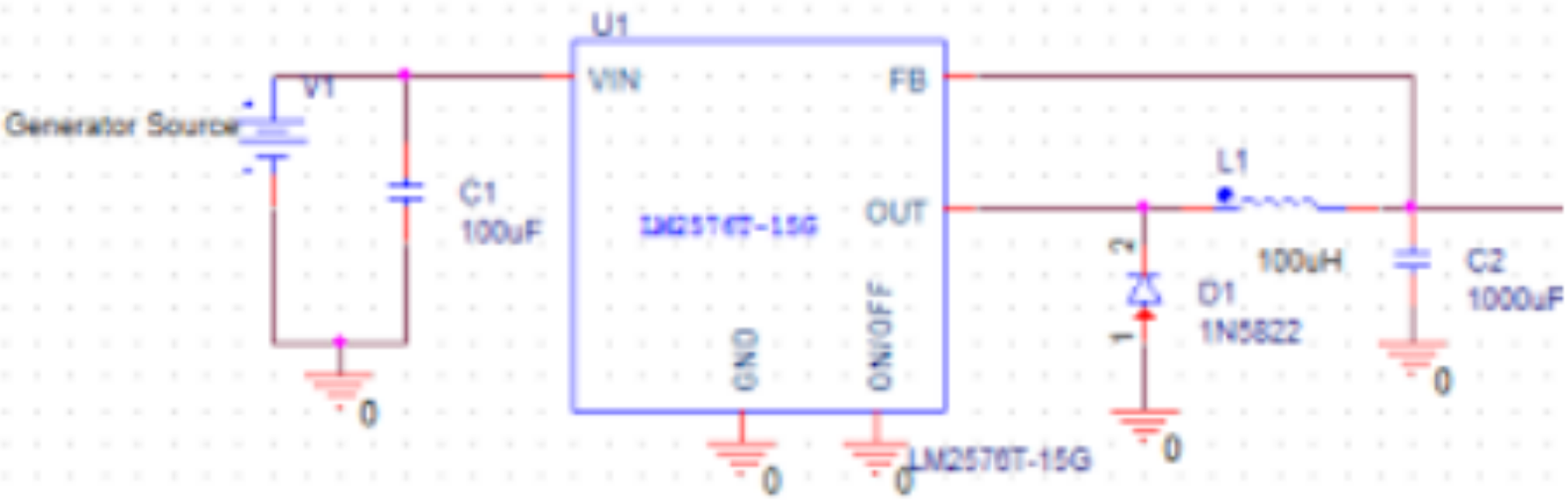
Linear Regulator Test Failure

- So instead we tested this circuit:



- The regulator failed when put under load and was forced to drive 2A to the load

Switching Regulator: LM2576T-15G



- 100uH inductor
- 1000uF capacitor
- 1N5822 Shottky diode
- 100uF capacitor
- LM2576T-15G IC

Switching Regulator vs Linear Regulator

- Not feasible to use a 15V linear regulator
- Linear regulators are inefficient
- At high currents, too much wasted power
- Overheat caused chip to fail

Solution: Switching Regulator

- Still caps the voltage at 15V
- At peak efficiency it is around 90% efficient
- Requires more components than a linear regulator

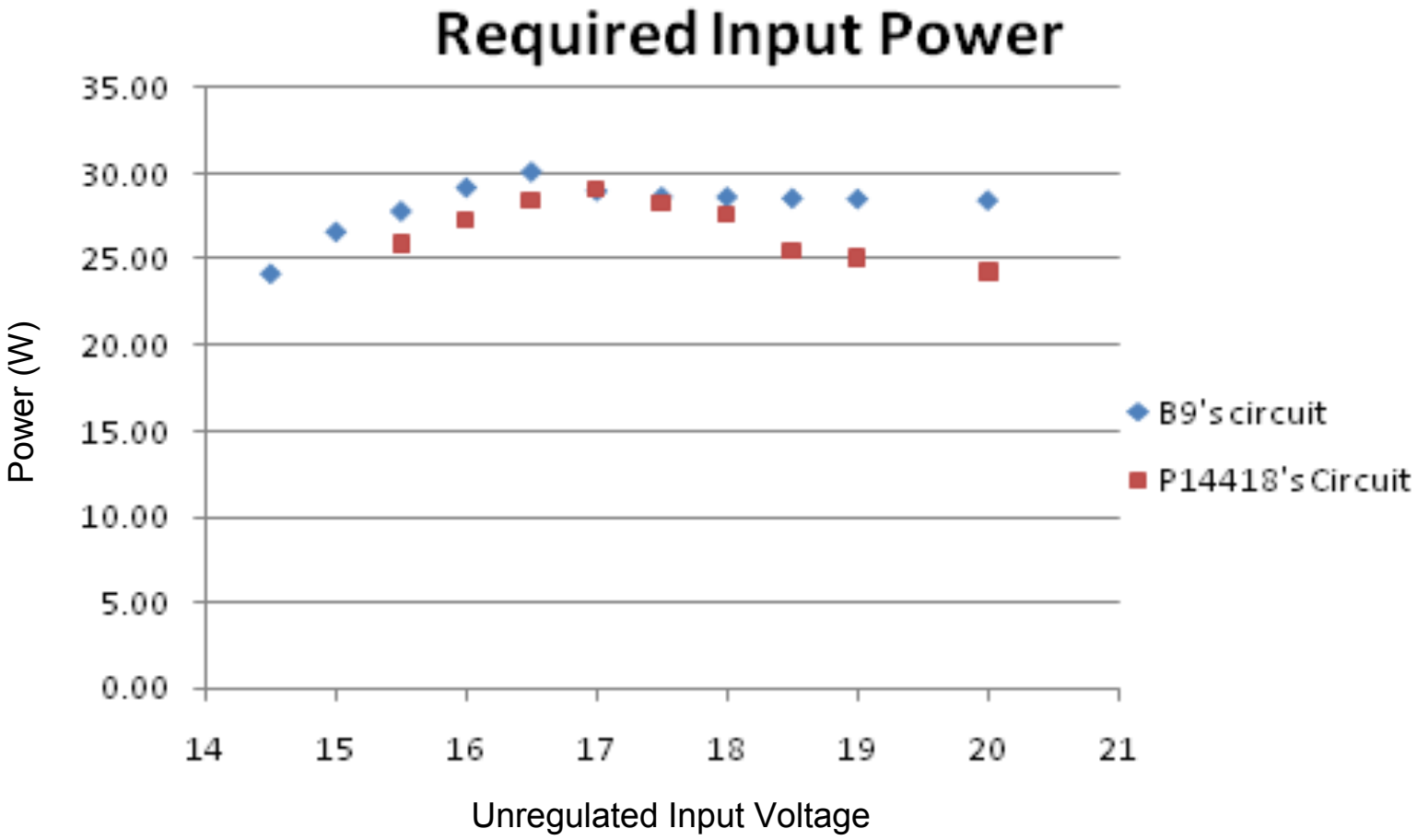
Switching Regulator Test Results

P14418's Switching Regulator Test Data				
Vin(V)	Vout seen at pump (V)	Current Draw (A)	Power in (W)	Pump on?
12	10.4	1.5	15.6	no
13	11.6	1.52	17.632	no
13.5	11.8	1.54	18.172	no
14	12.43	1.55	19.2665	no
14.5	12.94	1.56	20.1864	no
15	13.4	1.56	20.904	no
15.5	13.6	1.9	25.84	yes
16	14.2	1.92	27.264	yes
16.5	14.64	1.94	28.4016	yes
17	15	1.94	29.1	yes
17.5	15	1.88	28.2	yes
18	15	1.84	27.6	yes
18.5	15	1.7	25.5	yes
19	15	1.67	25.05	yes
20	15	1.62	24.3	yes

LED Testing Results

- LED1 turns on when output is 12.9V
- LED2 turns on when output is 13.7V
- LED3 turns on when output is 14.6V
- These values may need to be changed as shown in some of the following slides
  - Circuit is designed so changing the voltage levels is as easy as replacing a few resistors

Comparison of our Regulator circuit to B9's Regulator circuit



Conclusion

- May need to redesign 3 LED design, to make them turn on at higher voltages
  - The regulator is more efficient at higher input voltages
- Maximum inefficiency for our circuit is when V_{in} reaches 17V and the regulator is first starting to regulate
  - Currently this is about where we have the 3rd LED turn on

Track and Seat

The track and seat had to meet several functional requirements:

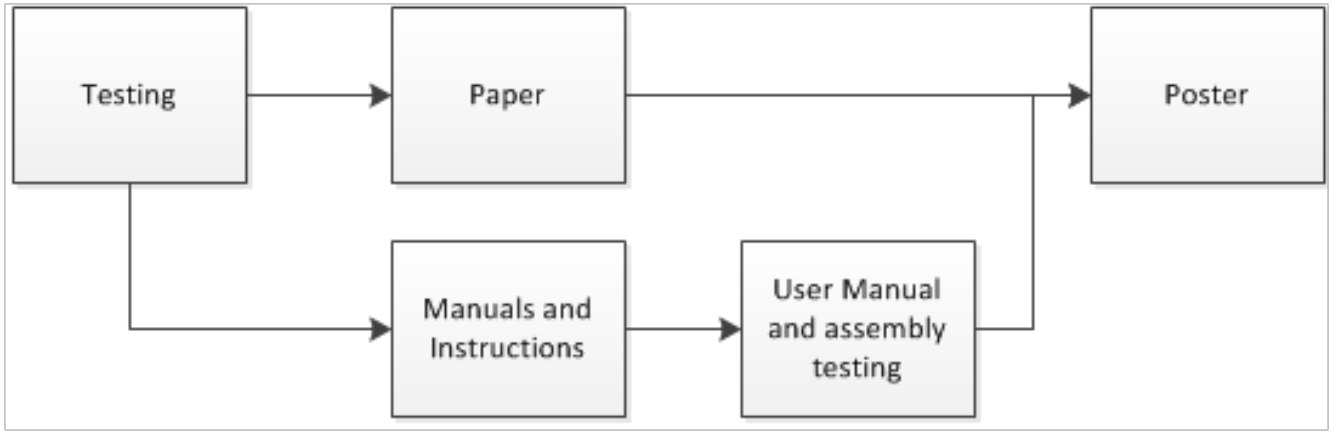
- Adjustable
- Support 130lb person
- User assembly with 1 tool

Issues:

- Theoretical angle too far back for user to see gearbox and caused tipping
  - **Solution:** Adjust angle higher up (research confirmed we were still in recumbent seating angle)
  - **Solution:** Set track to go all the way through bucket to other side at a calculated distance of 4.5 inches (free body diagram confirmed)
- Bucket insert not sturdy enough inside bucket
  - **Solution:** Added brackets to fasten insert to track
    - Issue created: more work during user assembly
- L-Brackets are difficult to screw in with screwdriver
  - **Solution:** In Process
- Bucket lid wouldn’t fully seal
  - **Solution:** Cut slot in bucket lid and cut corner out of insert

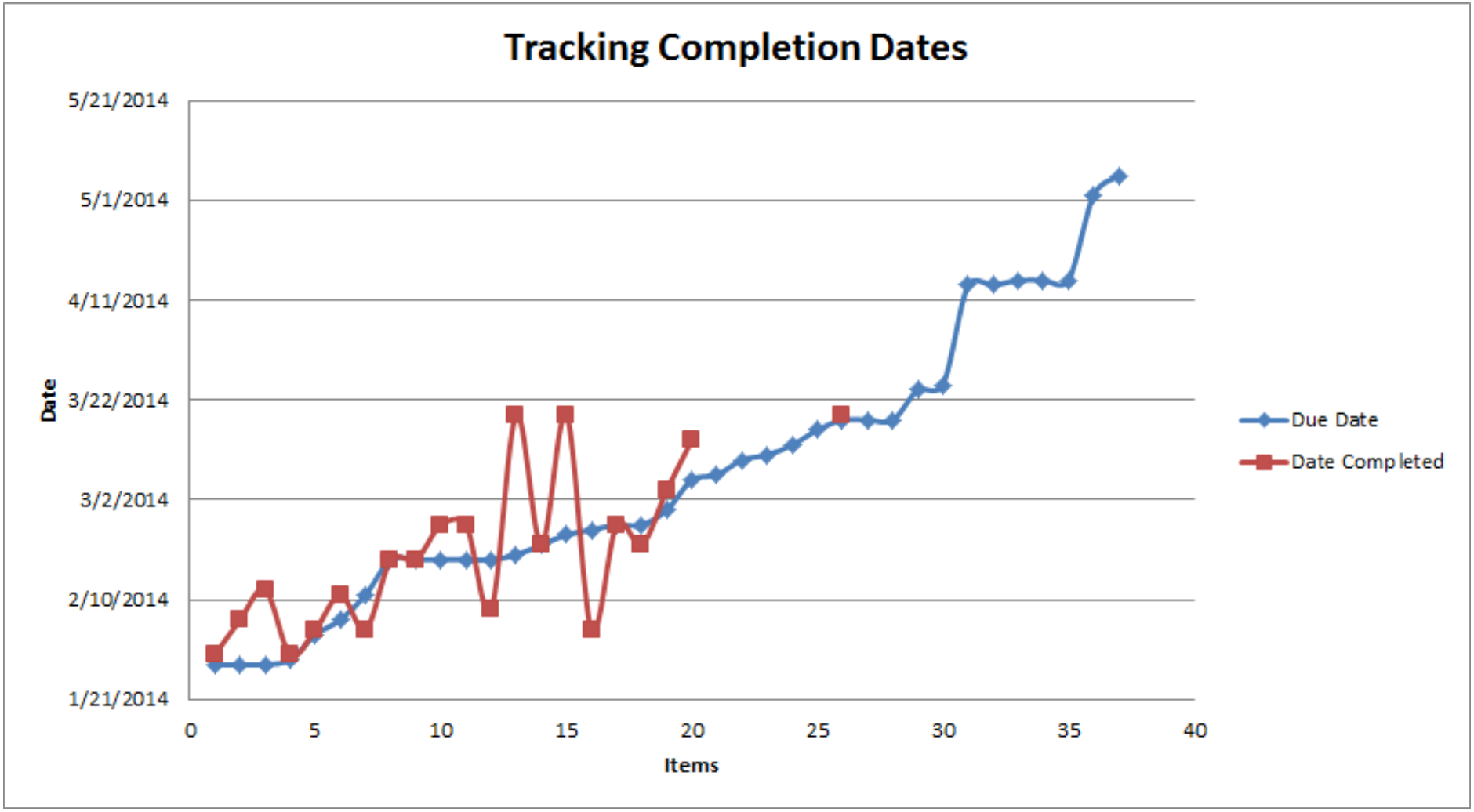
Project Plan

Test PCB	3 days	Thu 2/13/14	Mon 2/17/14
Preliminary Integrated System Demo	0 days	Tue 3/18/14	Tue 3/18/14
Optimize and characterize system (see general results before testing)	2 days	Wed 3/19/14	Thu 3/20/14
Confirm that all testing is showing results that satisfy ER	0.63 days	Fri 3/21/14	Fri 3/21/14
Formalize Testing Plan	4 days	Mon 3/24/14	Thu 3/27/14
Write user/maintenance manual	6 days	Thu 3/6/14	Thu 3/13/14
Formalize any manufacturing instructions (SOP, Standard Work)	3 days	Fri 3/14/14	Tue 3/18/14
Create Poster and Paper	8 days	Mon 2/10/14	Wed 2/19/14
Full Integrated System Demo w/ Customer	0 days	Mon 4/14/14	Mon 4/14/14
Recruit testing subjects	2 days	Fri 3/28/14	Mon 3/31/14
Test full design with Gear Box on test subjects	2 days	Tue 4/1/14	Wed 4/2/14
Test Manual and Set up on kids	2 days	Fri 3/28/14	Mon 3/31/14
System Modifications	15 days	Tue 4/1/14	Tue 4/22/14
Test Full system with modifications	1.38 days	Tue 4/22/14	Thu 4/24/14
Project Complete	0 days	Thu 4/24/14	Thu 4/24/14



Project Plan

- New Meeting process - more efficient and effective
- Full team visibility of project plan, AIDs log to review and deal with all detailed tasks
- Several tasks are behind but the team is aware of these tasks and the risks associated with them
- Tracking available with new PP design


Tracking Completion Dates
5/21/2014
5/1/2014
4/11/2014
3/22/2014
3/2/2014
2/10/2014
1/21/2014
Date
0
5
10
15
20
25
30
35
40
Items
Due Date
Date Completed

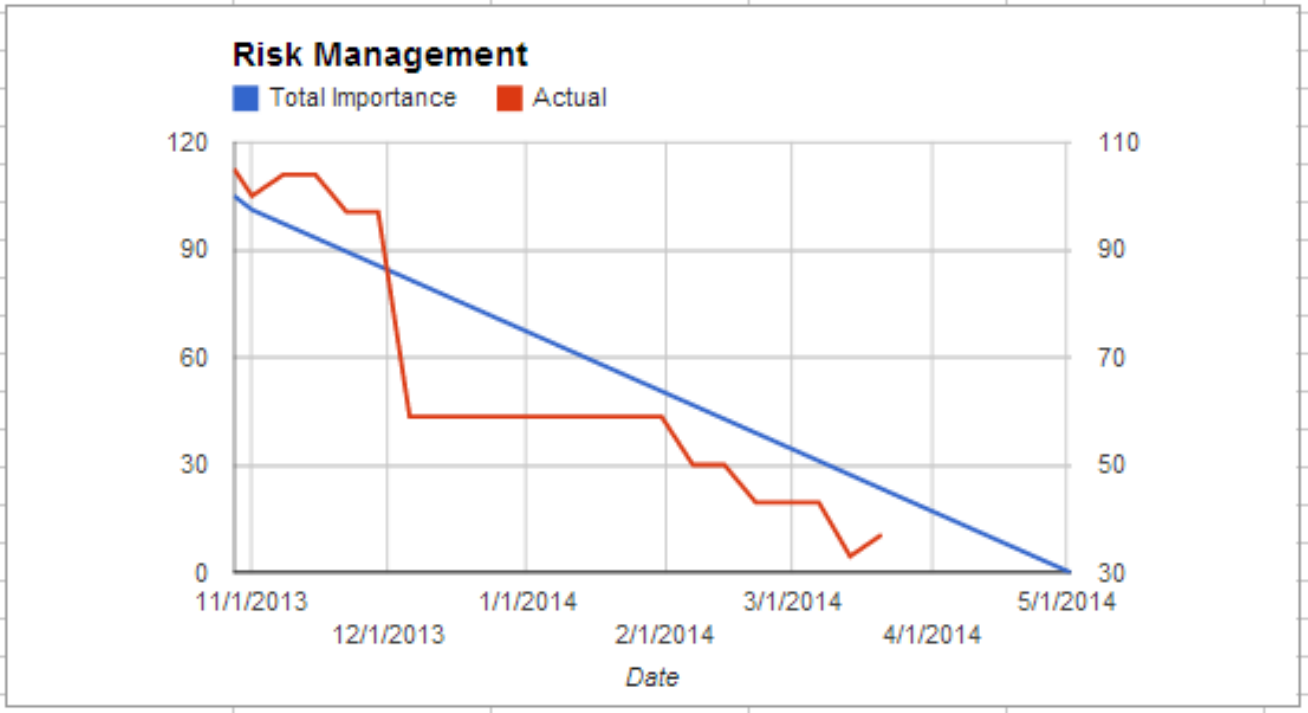
Project Plan

Next Steps:

- Re-drill holes in track
- Re-position bracket locations
- Update some drawings
- Finalize PCB and assemble PCB
- Continue sourcing to reduce cost
- Testing
- Paper
- Poster
- Design competition

Risk Management

- Small increase in risk due to system completion
- Risk Management Drive



Budget

Budget (prototype):

Max: $800

Cost-to-Date: $495

Very few purchases are expected from this point on.

*All POs were tracked and matched to our BOM

Manufacturing Cost

Goal: ~$75

($150 for whole unit and approximation of sanitation system cost was $75)

Actual Cost: ~$132.09

We understand this is above our goal cost but we are looking into ways to reduce the cost through sourcing. We have used quality materials in the gearbox.

BOM Drive

Test Plan

- Test Plans have been created
- Due to prototype delivery time, no significant tests have been completed
- Scheduling volunteers for spring break week.
- Traceability

Test	Components	Subsystem	ER	CR
Gearbox Test Plan	gears	Gearbox	2,6	1,14,17,2,12,13
	shafts			
	motors			
	casing			
Generator Circuit Test	circuit	Electrical	2	1,14,17
	chips			
	wires			
	motors			
	LEDs			
Motor Test	Motors	Gearbox	2	1,14,17
		Electrical		
User Test Plans	All	All	Power Generator	B9

Questions?