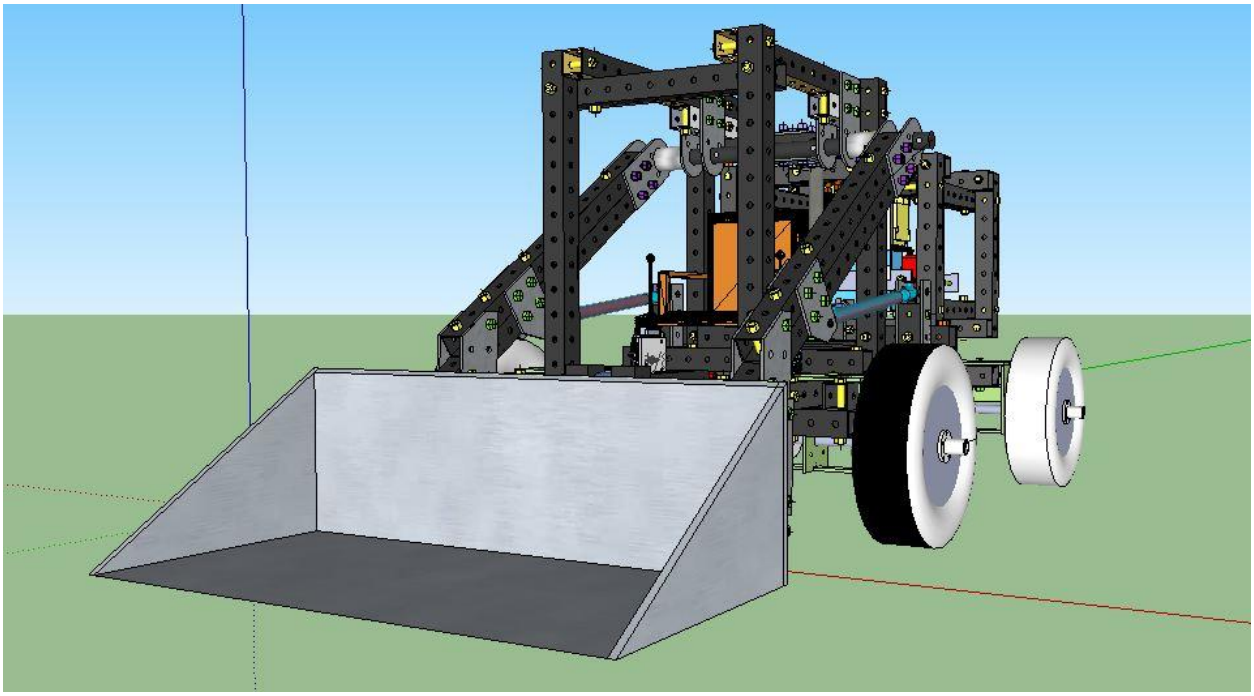
OSE – ISIS Joint Internship

Jonathan Miller



Timeline of Events Summary

– For more details and visuals of design work, see Jonathan's DPV Log

Week 0 (Pre-Arrival @ OSE)

Read through CyPhy Starter Guide, MSD Tutorial and CyPhy Reference Guide. Downloaded "Required Programs" from CyPhy Beginner's Kit. Printed out & compiled other PDF doc's into a 3 ring binder for later reference (Curating CyPhy Components, Curating CAD Models, How to Build a Modelica Model, How to Build a Modelica Component, RC Car Guide etc.)

Week 1 (Arrival @ OSE on Aug 5)

Assigned to a design group of 3 other "DPV's" (Dedicated Project Visitors) with Scott Eisele and two others. Our task was to re-design the LifeTrac front loader tractor modules & systems to improve function over version 5. Gary DeMercurio is OSE's Chief Technical Officer & Product Lead who supervised our progress and questions.

OSE expectations were set – dedicate 8 hours / day to OSE priority tasks:

- Tractor design
- Inventory
- Materials familiarization
- Help with CEB Press assembly
- Documentation

In my spare time at night I worked on & finished the MSD Tutorial and started the RC Car in GME. I got to the point where I had all the components "mechanically" connected in the right places.

Week 2

Provided consulting information pertaining to:

- New DPV & remote collaborator orientation and direction needs.
- Information management & distribution
    - Created a central repository of info & current work for modules to be used on LifeTrac 6.
- Establishing design requirements for tractor modules.

Worked with Dave (fellow DPV) on designing the following portions of the tractor:

- Power Cube mating interface with the articulated steering pivot module.
- Power Cube dimensions to fit new engine components
- Loader Arm geometry
- Cab interface with the Loader Arms

Worked with Scott in:

- Understanding Dymola and Open Modelica model & simulations of the OSE Welder
- Developing a presentation strategy for Meta Tools to OSE
- Creating a PowerPoint slide show for the presentation.
- Filming the presentation for later use.

All 3 other DPV's on my team left for school or home this week, leaving me the sole DPV working on the tractor design. Meanwhile, supervision was somewhat limited because OSE management dedicated most of their time to internal process & business plan development.

Week 3

During my day-time and often in free time hours, I worked tirelessly on the tractor design to get it ready for the prototype build that would happen only 2 weeks later. This week, I worked on and had OSE approve the design for the following:

- Loader Arms & lift cylinder geometry
    - Sourced 2 cylinders from surpluscenter.com
    - Lift Cylinder interface for frame and arm connection
- Bucket & tilt cylinder
    - Sourced 1 cylinder from surpluscenter.com
    - Tilt cylinder interface for arm and auxiliary mount connection
- Cab & Wheelbase

As a side project for future models, I noticed that the gearbox housing the motor, driveshaft and axle bearings currently used was too long to have a wheelbase that could be safely loaded on a trailer. In order to minimize the length of the gearbox and retain the concept modularity, I designed a new gearbox that utilizes a chain. OSE management loved the idea and wants to pursue the idea for use in a future model.

Week 4 (Departure from OSE on Sept 1)

I finished the design of the LifeTrac 6 modules early in the week and approved the bolt pattern. The final design includes the following modules:

- Cab
- Front & Rear Wheelbase
- PowerCube Frame
- Articulated Steering
- Loader Arms
- Bobcat Quick Attach
- Ground-Hugger Pivot

I also re-designed the hydraulics schematic and sourced the hydraulics controller joysticks from supluscenter.com

During this time, I was also helping with assembly of CEB press 3 which will be used to compress earth bricks used in the upcoming MicroHouse build. Edited and published the presentation video filmed

during week 2. DPV Lucas arrived and helped with hands on projects and "received the baton" from me on my projects before I left for Utah.

Scott and I talked several times during the week in attempt to present his work on curating parts from OSE's parts library "Warehouse." Unfortunately time ran short and changes were made in paradigms on his end. I also had trouble getting the right versions of GME, CyPhy and Creo to interface with each other to help curate CAD models.

Week 5 (Post-Departure)

Internship Documentation & remote collaboration questions with OSE.

Findings on Original Tasks:

1. **Introduce Meta Tools to OSE management. (Video of presentation can be seen Here)**

   During week 2, Scott and I developed, executed and filmed a presentation about the potential of Meta Tools to help OSE reach their goals of scalability and quality design. In the presentation, we proposed a working relationship with OSE to continue collaboration with Scott and Jonathan after their Dedicated Project Visits ended.

   Our proposal included the following:

   - Scott & Jonathan continue collaborating with OSE to optimize important modules
   - Short Term Goals
     - Explore the design space in "auto-packing" the Power Cube
     - Verify the system on the Modelica model of the Welder
   - Long Term Goals
     - Establish OSE as a project partner with ISIS
     - Establish strong ties with Vanderbilt and Brigham Young University communities.
     - Build component, module and system libraries to be utilized in future OSE GVCS machine projects.

   The presentation was very well received and all OSE management members showed high interest in pursuing a collaborative environment with ISIS and Meta Tools. However, before dedicating a lot of OSE management time to learning the Meta Tools language & software, they felt like they needed to focus on other high priority tasks first (such as business plan & process development). Once these high priority tasks are completed, they felt like they should have someone permanent @ OSE well versed in Meta. In the meantime, they were very happy and excited to see Scott's work on the Power Cube "auto-packing."

2. Identify current problems and inefficiencies in OSE design methods that can be solved or improved by using Meta Tools

a. Problems

i. OSE simply does not have ways to run **systems analyses** on nearly any aspect of their prototypes before or after they are built. (See presentation video about OSE's lack of "system validation and verification" 0:50 – 3:33)

1. Example: The hydraulics system on LifeTrac 6 has a flow schematic, but **no way to model and analyze system behavior** under different scenarios in the field. Essentially – there's no way to know if you've picked the optimal circuit schematic for the plumbing, engine/powercube size, hydraulic pump size/ displacement capacity, hose diameter, etc. The current configuration on LifeTrac 4 is underpowered and the drive system is unbearably slow. This has to be improved in order to have a more functional product.

ii. Remote collaborators & dedicated project visitors are often **new recruits that have no understanding or easy way to access previous design insights** from previous collaborators. This causes inefficiency and redundancy in the design process.

1. I had to dig through countless other collaborators' logs to find useful information from previous versions of the LifeTrac. Luckily James Slade, a project enthusiast who helped build LifeTrac 3, 4, and 5 was onsite and provided invaluable insights that would make fabrication simpler. Without his insights, I would have struggled a lot more.

iii. Often the **design requirements are unclear** at the assembly, subsystem/module, and system levels. This causes inefficiency & rework (and frustration) when collaborators' work does not meet expectations.

1. We worked on the loader arms quite a bit the first weekend without the design requirements defined and were disappointed that our assumptions were wrong and our work had to be scrapped.

iv. **Lack of professional CAD software** with constraints makes visual modelling cumbersome.

1. Most work is done in Google Sketchup to allow free collaboration. Although the software is easy to learn, it has many limitations and doesn't offer ways to model physics.

b. Solutions by using Meta Tools

i. **Open Modelica** offers a way to **model circuit schematics,** run simulations on them, change their configurations based on findings, and optimize the system. This is what OSE desperately needs to improve the function of their machines.

ii. OSE needs an **intuitive centralized repository** for their components and modules. **The Artifactory** repository could be a perfect fit for these parts. When newcomers join a project, they need to be able to see the current status of the modules being used and add their work to the Artifactory to be seen by other collaborators.

iii. Using Meta Tools would necessitate **the design requirements be outlined before the tools are used.** If the design requirements were changed, the corresponding changes necessary in the models to meet those requirements would be relatively simple. For example: the power cube module components change periodically. The size & shape of the engine, hydraulic pump, fuel and hydraulic fluid tanks change depending on the power requirements of the machine. In order to make the power cube frame fit the size of the components, only a few parameters for the inner dimensions would need to be changed & "auto-assemble" the frame around the inner components.
iv. In order to **curate new CAD parts**, a more powerful program such as Inventor, SolidWorks or Creo would need to be used.

3. **Develop trust and a long term relationship between ISIS and OSE by working productively on OSE high priority tasks.**

Attached are Recommendation Letters from Gary DeMercurio (Chief Technical Officer) and James Slade (OSE Co-Collaborator)

Gary DeMercurio
Open Source Ecology

909 SW Willow Road
Maysville Mo, 64469

September 6, 2013

To whom it may concern:

I am writing on the behalf of Jonathan Miller regarding the excellent contributions he made while volunteering his time at Open Source Ecology.

While Jonathan was onsite he accomplished many things other interns were unable or did not have the skill set to do. Working what seemed like nonstop for his entire stay, I can speak very highly of his work ethic and his commitment to a project.

Jonathan had an overwhelming passion in his daily tasks that would often flow into separate projects completed on his own time. One of these projects culminated in a complete redesign of a gearbox complete with a quick attach, gearing, mounting 3D rendering, modeling, and soon to be completed, stress testing. This entire project that Open Source Ecology will be incorporating into LifeTrac 7 was finished completely on Jonathan's own time.

Among many other accomplishments Mr. Miller's last contribution was modeling an entire hydraulic system for an articulated tractor driven purely by hydraulics. In essence, Jonathan designed the nervous system of our tractor that you will be able to see for yourselves on our website by October 1st. This tractor will contribute to the build of a micro-house developed in conjunction with Ball State University. The tractor is our sole deliverable for our funding foundation this month. Needless to say it was a very important project for us to complete.

Open Source Ecology has given Mr. Miller an open invitation to return any time he likes. We sincerely hopes he accepts our offer in the future to continue to work with us as his contributions were invaluable.

If Jonathan only utilized half of his talents, passion and hard work into his professional life he will be wildly successful and an amazing addition to anyone's team. As the acting Chief Technical Officer at Open Source Ecology, I cannot say enough good things about Mr. Miller.

Regards,

Gary DeMercurio

It gives me great pleasure to write this letter of recommendation for Jonathan Miller. I have worked with Jonathan for the past few weeks here at OSE's Factor E Farm. During that time I assisted him with his tractor design and he would also assist me building Compressed Earth Block machines. He is absolutely an awesome person to work with.

Assisting him on his tractor design generally consisted of me sharing my experiences with tractors and him using that info to help in his design. He is very open to others thoughts and opinions, which really builds up a good working relationship. His tractor design really addresses a lot of the issues we've faced with previous versions and his knowledge with the tools is invaluable. The effort he has put into the modeling will really help the project overall. Such great work on his part.

Jonathan also was able to share his skills in the shop and also took time to learn and improve other skills he didn't already have. Having more hands on the shop projects really helped get a lot more done than was previously possible. He put in many hours across the board that went above and beyond what most others would have done. His faith in this project is exactly what is needed for things to succeed.

I was very sad to see him leave but look forward to working with him again in the future both on this project and others. If you need any further information from me, please don't hesitate to contact me.

Sincerely,

James Slade
OSE Co-Collaborator
512-695-9254

4. Propose a plan of implementation of META Tools for future OSE design initiatives.

Meta Tools and OSE seem to be a perfect fit for each other. OSE needs a more efficient way to design, simulate and test their prototypes. ISIS needs Meta Tools to be used on real life applications that can be tested and produce validating data proving that the simulations work. The Global Village Construction set of 50 machines have design requirements that fall under each of the design domains that Meta Tools is being developed to map. Potentially, utilizing Meta Tools in the design, simulation and testing of these machines would be a perfect way to beta test most of Meta Tools' capabilities in the real world.

In order to implement Meta Tools in future design initiatives, 3 things are required:

- Understanding of OSE process and practice
- A high level of collaboration & relationship with OSE management and their development teams
- Understanding and skills in Meta Tools use.

I have a proposal that I think would benefit both ISIS and OSE right now. The hydraulics system that will run LifeTrac 6 will not be simulated before building the system nor tested (numerically) afterward if current OSE processes are used. Just like the open source welder we presented about, there's a schematic that has been or will be drawn up for the hydraulics system, but beyond prototyping it and actually building it, there won't be much analysis & calculation. As far as functionality on the tractor goes, the plumbing of the hydraulics is paramount.

What I'd like to work on is a Modelica Model that describes & simulates the behavior of the hydraulics system to be installed on LifeTrac 6. I would need some collaboration with the onsite OSE management and Vanderbilt-ISIS research team, but I could do it remotely here from BYU. This would be really valuable because we could simulate field scenarios, circuit variations and reactions from the tractor without actually spending the time and resources to redo it physically.

I think if the model is well done and somewhat close to accurate, we could find the best working configuration given all the different components we have on hand there. Potentially, we could test the performance with a combination of small 27 hp power cubes & compare to the larger VW engine they intend to install. Also, potentially we could test performance with different sized hydraulic pumps, motors, & double acting cylinders. Even if the results from simulation aren't totally accurate, I think we could find holes and problems in the system and at least improve them.

How can OSE and Vanderbilt Collaborate in the Future?

OSE has an interesting organizational structure. They have 4 managers who are employed full-time. Other than them, they get their labor and work done from Dedicated Project Visitors (DPVs) and remote collaborators.

DPVs visit the Factor E Farm for a minimum of 1 month, and work on high priority projects that OSE needs completed, and/or projects which the DPV has a high level of experience. To learn more about a DPV experience, visit the Dedicated Project Visit page and DPV Orientation Page.

Remote Collaborators can contribute by replicating their published work and improving on design and process ideas. These new ideas are then documented and shared back with OSE to incorporate into the existing machine documentation. DPVs and Remote Collaborators can participate in weekly online design sprints. Design sprints are web conferences where people from all over the world collaborate and share expertise and skills in machine design. Sprints usually occur on Saturdays and run most of the day. Before going to Missouri, I participated in a few design sprints and offered my skills in CAD. To learn more about Design Sprints, visit the Design Sprint Page.

Vanderbilt research students and faculty can collaborate with OSE remotely during school, or if they want to be more immersed in the experience and involvement, they can make a Dedicated Project Visit to OSE in Maysville, Missouri. The most applicable projects that would help OSE and test Meta Tools would be optimizing component, module and system libraries for assembling structural frames. Of equal importance is optimizing their power transfer systems. Currently their vision is to use hydraulics to power their mechanical machines. Current machine projects under development and improvement include the Compressed Earth Brick Press (CEB), Front Loader Tractor (LifeTrac), Backhoe attachment, Soil Pulverizer Attachment, Bulldozer, Micro Tractor, & Power Cube.

In either case, a high level of communication with those onsite @ OSE is absolutely necessary. It is also very helpful to have contact with supporters, collaborators, and enthusiasts outside of management who have participated in build projects. I have worked directly with all members of OSE management, several DPVs and long-time enthusiasts and have gained their trust.

Pick Up Where I Left Off:

Read Jonathan's DPV Log, and Scott's DPV Log. If you need more information than what is included in this document, it would be best to contact Jonathan Miller and/or Scott Eisele.

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