LAND VEHICLE FOR EDUCATION LESSONS LEARNED & RECOMMENDATIONS FOR FUTURE ITERATIONS

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SYSTEM:

LESSONS LEARNED:

- The first day can be extremely overwhelming: provide students with more adequate background material beforehand.
- The guides are there to help you. Don't hesitate to ask questions. If you don't ask, it makes it a lot harder for them to help you and can be frustrating for everyone involved.
- Communicate frequently with the customer and be sure to get their opinion before any major changes are made.
    - Understanding the customer needs will be the difference between a successful design and an unsuccessful design.
- The systems team is responsible for ensuring the customer satisfaction (functionality, quality, cost, etc.) and this should be the ultimate goal.
- When faced with a design that is over budget, push back on the sub-systems to reduce cost.
    - Make sure the other teams can provide backup and justifications for their part selections.
    - Don't let the subsystems drive the cost.
- Shipping costs can take up a large portion of the budget, especially when the budget is small to begin with.
- Nail down the prototype budget as well as mass production budget as soon as possible.
    - Materials should not be purchased prior to a finalized budget since design changes may be required in order to meet budget specifications.
- Interfacing and standardized documents play a significant role in multi-team projects.
    - Make sure that the engineering specifications match up across the board in order to avoid confusion in the future.
    - Make sure that the teams communicate frequently and that everyone is made aware when a design or specification change is made.
- The QFD and Mission Profile should be completed earlier on and should be used to influence the designs of the sub-systems.
    - The QFD can quickly become bulky and difficult to navigate – keeping it simple will make it more useful in the end.

RECOMMENDATIONS FOR FUTURE ITERATIONS:

- Try to get more definitive answers from the customer in the beginning.
    - It makes the design process a lot more frustrating when you discover critical needs once the design has been completed.

- Listen to customer suggestions. They know what they want more than you do.
    - Just because you have a completed design doesn't mean that it's the best design. (This is especially true when your customer is the Mechanical Engineering Department Head).
- Research existing vehicles with similar purposes and strive to competitive with those.
- Keep shipping costs in mind when formulating the bill of materials.
- Don't just create documents to meet grading requirements.
    - Make them clear and concise so the sub-systems can use them to drive the design.

CHASSIS:

LESSONS LEARNED:

- Don't limit self to only in house processes, if the design will better meet customer budget requirements.
- Pin down your customer and make sure that you understand his/her priorities; vague hand waving won't cut it and will hurt you in the end.
- Budget is king, aesthetics are expendable, despite what faculty guides may say.
- Interface control is very important, make sure that it is well established and kept up to date/the various groups are held to it!
- Document/drawing control goes hand in hand with interface control, make sure that all groups have access to the various documents and drawings, and that they have a common reference system, such as drawing numbers.
- Review previous iterations final papers, if you can't find them ask someone.
- Review documents from previous iterations, so you don't make the same mistakes.
- Do not design in unnecessary extras, i.e. battery indicators, obstacle climbing, etc. unless explicitly asked for from the **<u>CUSTOMER</u>**. This is a primary cost control measure.
- Keep your budget up to date, and ensure the other groups are aware of it.
- Keep your engineering specs up to date and ensure that they reflect the system specifications.
- Ensure that your system managers actually follow the project progress and that their documents reflect the actual design.
- Prototype and mass production budgets are critical to the success of the design, ensure that they are under control.
- Make sure specifications map to customer requirement, don't make things up if not required.
- Team Functions/Structure
    - Make sure that the various groups are aware of what is going on, and are ok with designs that affect them.
    - Work across team lines to ensure that the final project is successful, not against each other since it only leads to animosity.
    - Make sure that ee's, me's, ce's, etc. understand what the different disciplines are doing and what is needed from each other to successfully communicate.
- Technical Considerations
    - Make sure you have adequate safety margins on your design (factor of safety), but don't over design it at the same time (i.e. don't build a safe when all you need is a cardboard box).
- Integration across subsystems

    - Study sharing components between teams if it will reduce costs or increase efficiencies (i.e. one main control board instead of a bunch of separate boards).
    - Keep interface control documents up to date, and ensure that they are followed.

RECOMMENDATIONS FOR FUTURE ITERATIONS:

- The Box (don't let aesthetics hold you back, cost is the main driver), for example Item number: 75065K16 from McMaster-Carr – a 12"x8"x4" steal box ($23).
- Investigate Unibody Structures for Path Forward
- Investigate weight reduction, which can lead to smaller motor sizes (which are cheaper i.e. plastic gearmotors instead of metal, a savings of ~$10/motor see item 1119 vs 1109 at pololu.com).
- See robotshop.com for additional concepts
    - Entire robot kit similar to P11211,12, and 13's creation for $3587.50 (at quantity)
        - RB-Rbo-12 robot body for $230
        - RB-Ard-05 (wireless card) for $80
        - RB-Lyn-76 (gripper) for $15
        - RB-Lyn-118 (gripper attachment) for $6
        - RB-Hit-27 (servor motor for gripper) for $11.50

CONTROLS:

LESSONS LEARNED:

- Helpful Info at start
  - Exact budget for control system Maximizes RF solution, no “overkill”
  - Amount of room in the chassis option to combine PCB boards Minimize cost
  - Type of motors on chassis Caused a delay on determining motor control
  - Autonomous or Real time Need for sensors and feedback?
- Team structure/functions
  - Room for one more computer engineer
  - Team meetings after interface meetings, sometimes fell behind interface changes.

RECOMMENDATIONS FOR FUTURE ITERATIONS:

- Major things to adjust in the design are the overall cost of the RF solution as well as the cost of the microprocessor dev boards.
- For reduction of the micro processors it may be possible to use a single Arduino or similar dev board for both the chassis control as well as control of the MSA.
- Decrease overall PCB space by incorporating both control systems on a single board with a single micro-controller.
- Issues that may arise by moving forward with this option is a limited number ofI/O ports are available on each development board.
- In particular the current Arduino Nano that is being utilized on the control board only has a small number of PWM ports.
- RF solutions can be found off the shelf rather than using WOCCS and have similar if not better performance.
  - An example of one would be http://www.sparkfun.com/products/9034 which costs 35$ and supports an equal number of channels. This would half the current cost of RF while the board itself is a much smaller component which would allow more flexibility from a chassis design standpoint.

MSA MECHANICAL:

LESSONS LEARNED:

- The importance of communication between member, particularly with multiple groups. A number of times information was unclear between groups on metrics for needs, specs, and requirements of the system to operate.

- Importance of cost driving design. Everyone in our project clearly had an issue with meeting the bottom line, and as a result of making purchases too early, have produced a product that is still out of budget. I'd attribute this to getting entrenched in a design, where everyone started down a path and refused to turn back.

- Keeping customers involved. We lacked a bit in narrowing down the scope of the project, and everyone seemed to have a different vision of how it would perform. A late meeting drastically changed how the MSA would look, and nearly, possibly even should have, changed the chassis design as well.

- Helpful Info at Start:

    - It would have really been helpful to have a much narrower scope of the project before the start of the project. A better idea of what the MSA should look like was known going into the project, but didn't seem like it was portrayed.

    - A more defined budget earlier would have helped, as it was certainly flexible to start. Also, the number of units should have been better defined. Together, we could have picked a direction early rather than guessing at a breakdown of budget and number of systems that might end up not meeting customer needs.

    - Defined rolls for student members would have been better. Particularly where multiple people of the same major were on a team, personal responsibilities didn't really manifest rather than things getting assigned to groups. Sometimes it lead to finger pointing for shortfalls, or certain members picking up slack for others.

    - A better definition of impressiveness would have really helped with the design. It wasted a lot of time early with design features that pushed hard on our budget, when others felt impressiveness meant something else.

    - The level of adaptation between other projects should be better defined. For the first several weeks we thought we were looking to make every MSA project, and have multiple projects for the MSA. If this was better defined, the first day would have been much less overwhelming. It was awfully intimidating to pick one solution that met all the criteria.

    - It would be nice to meet a better compromise on the pulling requirements of manufacturing and different solutions. Having student made parts that are all different such that everyone has unique solutions, but very similar that the shop can make them all, seemed impossible. A more refined definition of what was meant by this might help.

RECOMMENDATIONS FOR FUTURE ITERATIONS:

- In the MSA, a significant cost could likely be saved by producing the gripper in house. This can be done with a fairly simple assembly of parts in the 3D printer, similar to that of the gripper purchased. It would further tax an asset of the ME department that's very busy, but could have a significant cost savings without having any decrease in performance. An obstacle to this was purchasing items before completing a budget, and designing a gripper that could adapt to a servo since specs for dimensions on servos are not commonly available. (Note: it's the most expensive part on the MSA at bulk 30x, $26 each, where a servo could be bought for less than $10, plus material for the gripper and shop time costs). It could also decrease weight and decrease power required by the servo.

- If the plate were attached to the LVE by screws rather than a non-threaded attachment, it could save some on costs. Though cotter pins would still be required for clevis joints, and it would take more time to attach and remove, it would decrease costs to simple screw in. The risk there is ripping out threads.
- Link material could be reduced in size, either by limiting the scope or envelope of potential solutions or getting thinner material. The thinner material could be cheaper, but much more flimsy and bend. This could reduce power required for the drive servo.
- An overall decrease in size of the LVE platform size could reduce the cost of plate material (currently about $15). This could save a few dollars per MSA.

MSA CONTROLS:

LESSONS LEARNED:

Unfortunately we were handed a very obscure problem on our first day of MSD 1. Needless to say, our group had NO IDEA how to approach the problem and find ways to solve it. Now that we know what we know here are some suggestions for the controls portions of future projects.

RECOMMENDATIONS FOR FUTURE ITERATIONS:

The MSA controls were designed for future expansion in mind. Due to the plated mounting hole issue and some other minor layout issues, the schematic and layout files were modified slightly. All files are available on the P11213 documentation page.

Also, due to the compatibility issues with the WOCCS all microcontrollers in the LVE should be used at 3.3V. The reasons for this suggestion as follows:

- Running at 3.3V requires less power than running at 5V.
- All microcontroller and transceiver SOCs are compatible without external hardware (level shifters)
- The only issue that can arise out of this is that a buffer will be required at the output of the MSA microcontroller in order to drive the servo control signal properly
    - Note: the buffer can provide 5V instead of the 3.3V from the microcontroller. It also protects the microcontroller from possible damaging transients from the motor

Team Arrangement: It is also suggestion to arrange all electrical/computer engineers in one group in order to collaboratively work together on all controls aspects of the design.

WOCCS

Unfortunately lower cost microcontrollers do not have a USB interface. USB is generally more complex and difficult to debug during development.

The UART interface is very suitable for the WOCCS because the WOCCS can only operate up to ~250 kbps. (While most UART interfaces operate up to 115.2kbps)

Suggestions about future WOCCS designs:

- Mounting holes to enable use of #4-40 stand offs.
- Decrease the board footprint (size) (<= 2 x 3 inches)
- For the LVE we don't necessarily need a 900 MHz solution. A 2.4 GHz wireless module could be more suitable instead
    - Note: the difference of range 6miles and ~400m respectively
    - Note: the speeds are drastically different. Up to 250 kbps for 900 MHz and up to 2Mbps for 2.5GHz
- Bring out all associated serial communication protocols: UART, SPI, and I2C to be used with future projects.

- For cost savings this device can also perform as a general-purpose microcontroller so it may be prudent to bring out all other available GPIO pins (general purpose I/O)
- Dip switches to determine whether the unit is a remote or base station unit (i.e. if the unit requires USB or if it requires UART)
    - Note: This could be accomplished with one switch.
        - On=remote
        - Off=base station
- One requirement that shouldn't change is the minimal transmission rate.
    - Should be **115.2kbps**. (But more is always better if possible)

- **WOCCs alternative:** Here's a link to a board already in production: http://www.sparkfun.com/products/9034 - This board is based off of a 2.4GHz transmitter. (The TI equivalent would be CC2511 and CC2510)
    - I would like to see the WOCCS team emulate something like this. This board currently costs $36 at mass production levels.
    - By keeping all the same interface connections (USB connector, 2.54mm pitch header connections, etc) these two devices could be swapped out interchangeably.
    - Note: depending on what band being used different antennas may also need to be used as well.