Control System Choices for OEM's

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Foreword - Often in the business of electronic control system design, while the tools of the trade change and shift to meet an ever-accelerating technological landscape, the methodology behind the designs tend to permeate well into the future. Such is the case with semi-custom control system design, which in fact is more effective now than ever before, with the growing prevalence of community-based support and higher focus on powerful development tools by hardware developers. Because the concepts detailed in this paper are as relevant now as they were when this paper was written 20 years ago, it is being republished with only aesthetic revisions as of January 2021.

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Introduction - OEM's that use control systems in their equipment have four choices of control solutions: PC's; PLC's; full custom; and semi-custom. The PC and PLC categories seem well defined. They are off the shelf, relatively easy to implement, and are targeted at industrial applications. Full custom seems well defined also - write a specification for the requirement, and design a custom control to meet the spec. With this choice you get exactly what you need, no more, no less. The semi-custom category, however, is less well defined, and is challenging not only to describe, but also to understand.

In just about every issue of the professional trade journals I read, there are advertisements for off-the-shelf controls that can be tailored to any set of customer control requirements (i.e. semi-custom). Here is a partial list of some of the offerings:

- "SoC" (system on chip)
- "SBC" (single board computer)
- "Modular Single Board Computer"
- "Embedded PC", "PC/104"; "PC based Open Control"
- "PC on a Chip"
- "Embedded Controller"
- "C programmable Controller"
- "Stand Alone Controller" (used mostly with motion controllers)
- "Industrial Computer"
- "Embedded Development Kit"
- "Platform Based Design".

The software offerings for semi-custom are equally daunting, but are, for the most part, the same as those used for full custom... for example:

- "Windows" (of all varieties)
- "DOS"
- "Linux"
- "Real Time Operating Systems"
- "C"
- "C++"

- "Java"
- "Assembly Languages (of all varieties)"
- "Object Oriented Programming"

and so on.

An engineer that needs a control for an application should be asking: "What are the tradeoffs between PC's, PLC's, full custom, and semi-custom, and under what circumstances does one make more sense than the other?" To answer, not only do you need a good understanding of the hardware/software issues, but here is also a partial list of some other important issues to consider:

1. Production Volume - The lower your production volume, the less likely you will be able to justify the custom or semi-custom approach. The NRE of a custom (semi-custom) control wants to be paid back through the recurring cost savings. If you are only making 50 units per year, a $200 recurring savings returns only $10K in the first year.

2. "Look and Feel" - If you care less about "look & feel" and more that you can just buy the hardware off the shelf, the PC and PLC options are appealing. If you are more interested in "look & feel" and want to customize the control to suite your application, making your own using semi-custom or full custom control allows more flexibility.

3. Internal Development Staff vs. Technical Outsourcing - The PC's & PLC's are easier, and the custom more difficult, whether internally done or outsourced. The more "off-the-shelf" the solution, the easier it is to outsource. PC's & PLC's are commodities and there are many companies proficient in their use. The custom & semi-custom are more difficult, and there are fewer capable sources.

4. Recurring Cost - Feature for feature, the more "custom" the control is, the less the recurring cost should be. That is because with a custom control you get exactly what you need, no more.

5. Non-recurring Cost - The more "custom" the control is, the more the non-recurring costs will be.

6. Features / Benefits - The more "custom" the control is, the more you can tailor the control to the application. This usually results in a control with features better suited to the application, which increases usability and "look & feel". One area where custom controls are at a disadvantage to their PC counterparts has to do with Graphical User Interfaces. If you need a "Windows" type user interface, PC's of any type are the control systems to use.

7. Technical Risk and Technical Difficulty – These, in fact, are two different concepts. Technical risk refers to the probability that your plan is fatally flawed in a manner that is yet unknown. Technical difficulty can be judged independently of technical risk. For example, using an 8051 based microcontroller to implement a PID temperature control is a low technical risk project, but for a beginner, it is likely to be technically difficult. The more "custom" the control, the more these two concepts can become issues.

8. Part Obsolescence Risk - This is a tough characteristic to categorize because all controls carry this risk to some extent. With PC's & PLC's it is more a function of the product life cycle of the specific control you are purchasing. With custom and semi-custom, it is more a function of the schematic, if there are single-sourced parts, and how popular those parts are. My feeling is that the more you are in control of the schematic, the better you can control this risk.

9. Business Cycle Assessment i.e. Where in the Business Cycle is the Product?
(Each of these could dictate a different control implementation)

1. **Market Study** (trying to determine if there is a market for your product)
   This product cycle wants to have the lowest up-front cost. It does not make sense to spend a lot of money developing a product if you do not know what the potential market is.

2. **Market Penetration** (trying to capture market share before your competitors)
   This product cycle wants to have the quickest time to market. If you have identified a market that is yearning for a solution, you need to react quickly to make a lasting impression. If you react slowly, someone else may notice your idea and may outspend you to buy market share.

3. **Market Maturation** (trying to maximize efficiencies in your on-going production)

This product cycle wants to have the lowest recurring cost, and the fewest on-going production issues. If you have good production volume, your up-front costs to get to this point are less of an issue.

Conclusion - Make an uninformed choice among these difficult technical/business issues, and the ramifications can be disastrous. Stories about failures abound, and the scars are long remembered. I suspect this is the biggest reason the full custom solution is viewed with such trepidation... it is probably the most difficult, has the highest development cost, and carries the highest technical risk. The semi-custom solutions want to claim the same benefits of the full custom solutions, only at a lower development cost and with lower technical risk, and I suspect that many of them do... but which ones? Will a semi-custom solution that worked well for one project, work well for a significantly different project? How are you going to implement a still technically challenging development... with internal staff or sub-contractors? (Semi-custom is still no piece of cake) This remains a dicey proposition, and again, is probably why the PC/PLC, which is the least complicated lowest up front cost solution, is frequently chosen, even in applications where it's probably not the best choice.

What would be ideal is a semi-custom solution that provides low implementation complexity, low up-front cost, low recurring cost, high performance and a high level of flexibility. This is exactly what WRD's "ProductMaker" was designed to do. By mitigating many of the disadvantages of custom controls, and retaining most of the advantages, this solution has been providing low cost, low risk, high quality "custom controls" to WRD's customers for many years.