RUGGED OPERATOR INTERFACE TERMINALS: BUILD VERSUS BUY
INTRODUCTION

Many of the machines and vehicles in daily use in commercial and industrial settings worldwide feature displays and touch pads for operator input and control. These devices are known as Human-Machine Interfaces or HMIIs, but are also commonly called Operator Interface Terminals and Mobile Data Terminals. As the main means of communication between machines and their human operators, HMIIs must be functional, durable and reliable. In many cases, they must be ruggedized to operate in extreme conditions, impervious to heat, cold, dust, liquids, shaking, jarring or other environmental hazards.

Any manufacturer of complex machines or vehicles that include HMIs must face a crucial decision: should you build your own human-machine interfaces or should you buy these vital components ready-made or customized from an outside source?

The build versus buy decision is both important and complex, involving many tough questions. Is developing the necessary hardware and software in-house the most cost-effective solution? Is such an engineering project consistent with your core competencies? Do your engineers have the time to develop these devices in house? Have you calculated the opportunity costs involved? Will a commercially available product line provide the features and operating reliability you require at a return on investment (ROI) you can afford? How will you ensure required features are present in a third party solution? Can you trust the quality and reliability of the end product? What are the real risk factors involved in developing in house? What are the real costs? Is your company ready to take on the expense and logistics required for testing and for compliance with industrial and regulatory requirements, troubleshooting and repair? How will you handle on-going product development in the face of ever-increasing electronic component obsolescence?

This white paper can help you decide whether building a human machine interface solution in-house or buying third-party operator interface terminal is the right decision for your company’s product line.
ADVANTAGES OF DEVELOPING IN-HOUSE

At first glance, the advantages of developing a solution in-house seem to outweigh the disadvantages—but for every pro, remember there is an equally important con. Briefly, the arguments for in-house development can be summarized as follows:

You Get Exactly What You Want:

PROS: Designing and building your own human-machine interface terminals and programming software to support them will produce exactly what Product Management requests and Engineering specifies. Any third-party solution will be a compromise, unless it is entirely custom-made to your company’s specifications. This last option, however, can be cost-prohibitive. So building what you want may seem to be the best option.

CONS: As in all engineering projects, “feature creep” may be hard to contain. Designing and building from scratch rather than using or modifying an existing product can open the door to long development cycles and delayed availability dates, which may compromise the availability date of your final product. In addition, costs to manufacture, prototype and test can be difficult to estimate accurately if your engineers do not have specific experience designing HMIs for harsh environments.

You Save Money:

PROS: Original Equipment Manufacturers (OEMs) of machinery have a strong incentive to reduce the cost of their purchased components on each machine in order to increase profitability and market competitiveness. It is often cheaper to build an operator interface in house than to buy from third-party manufacturers who sell at increased prices to make a profit.

CONS: Today, electronic components must be purchased in such volumes that cost savings are only realized if you are building human-machine interfaces in large quantities, say 10,000 or more units per year. Most third-party manufacturers benefit from large quantity purchases of component parts, which keeps product costs down. In addition, the hidden costs of prototyping, testing and obtaining certifications are often overlooked when estimating product development costs. Even harder to estimate are the costs associated with redesign caused by specification changes or component obsolescence. The opportunity costs associated with bringing an engineering project of this scale in house are also very difficult to determine but must be factored in.

You Run Less Risk:

PROS: It is often risky to deal with third-party manufacturers. You are at the mercy of their supply and demand fluctuations and have no control over their ability to produce and provide the quantity of products you need when you need them.
CONS: Unless building human machine interfaces is a core competency of your company, designing and manufacturing them is a very risky venture. Much specialized knowledge is needed to design and build terminals that will function consistently and reliably, particularly in adverse environmental conditions. The risks of starting an HMI project from scratch far outweigh the risks of sourcing proven, tested and certified products from a reliable third-party manufacturer.

A CLOSER LOOK

To help you solve the build versus buy dilemma, let us take a closer look at what is involved in designing, building, testing and maintaining a human machine interface system by outlining a typical product development cycle.

**Planning**

Begin by making an honest assessment of your engineering capabilities. Given your company’s core competencies and priorities as well as the opportunity costs involved, is the design of a human-machine interface terminal the best use of precious engineering resources? In particular, does your engineering capability include the following key areas of expertise:

- Design for environmental ruggedness?
- Design for long life with operator use/abuse?
- Design of graphical interface software?
- Design for required ergonomics?

Next, assess whether your overall product development schedule allows for the full gamut of good engineering practices for developing rugged terminals.

- Electrical, mechanical and software design.
- Product prototyping and testing.
- Iterations on designs and prototyping.
- Final testing and certifications.
- Release to manufacturing with full documentation and support.

Finally, in the planning stage be sure to secure answers to the following critical questions.

- Have all required and optional features been identified and prioritized?
- Have all operating requirements and testing standards been fully researched?
- Have cost targets been clearly defined and judged attainable?
- Does your company own or have access to environmental test facilities and equipment?

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**PRODUCT DEVELOPMENT CYCLE**

For each stage in the cycle, you should assess your company’s ability to address the issues raised. This will provide a useful guideline for determining whether you should build or buy the HMI solution you need.

**CORE COMPETENCY**

The bottom line: know your company’s core competencies. If you can properly allocate the resources – time, effort and money – needed to develop, test and maintain the hardware and software, you might want to consider building an human-machine interface system in-house. Otherwise, industry-acclaimed third-party solutions provide the most reliable, time-sensitive and cost-effective solution.

**WHAT ARE CORE COMPETENCIES?**

Core competencies are strategic business capabilities that provide a company with a marketplace advantage. Core competencies are the skills, abilities, knowledge and characteristics that help distinguish superior performance and are the root essentials of a company's or an individual's expertise.
Design Phase

The first consideration in the engineering design phase is whether your engineers have the experience to design and build for environmental ruggedness. To understand how complex a task this can be, read the section called Environmental Tests on pages 8 and 9 of this white paper. There we have compiled an exhaustive list of qualification and certification testing for human-machine interfaces that will be used in machinery and vehicles of all types in the USA, Canada and Europe.

Next, consider that many aspects of electrical and mechanical design are highly specific, if not unique, to the requirements and constraints of environmental ruggedness. In particular, the ability to specify components that will operate at extreme temperatures, to mount components so they can withstand vibration and shock, and to seal displays and keypads from liquids, dust and other environmental hazards is highly specialized knowledge that most engineering design teams struggle to master. Developing those skills from scratch is a costly and time-consuming effort.

Finally, do not discount the complexity of software development for even a simple human-machine interface. Today, most displays provide graphical feedback to the human operator. The demands of programming in a graphical environment are many times more complex than programming for character-only displays. Unless you build your terminals to use a general purpose software platform such as Microsoft Windows® or Windows CE®, you must plan for a significant software development task in addition to the hardware development of your human-machine interface. In addition, using an OS such as Windows involves a very challenging and costly “port” to the specific hardware platform. Decisions such as these can greatly affect time-to-market for your final product.

Prototyping

It is important to prototype early and often in the design phase of a new product. Assess your company’s ability to develop mechanical prototypes quickly and cost effectively. Do your engineers have access to a 3D printer, for example, or will they have to send CAD files to an outside service? Have they identified prototype sources for custom components of your human machine interface such as keypads, touch screens and housings? Prototyping is costly and time-consuming if you do not have the necessary tools in-house or strategic partner relationships in place.

Testing

How will your engineering team address the issues of testing both the hardware and software components? Does your team have the capability
to design and build test fixtures and write the testing software? Also, fixtures and software must be created prior to the final assembly of a product. It is important to note that manufacturers of rugged human-machine interface terminals typically “burn-in” production terminals in an environmental chamber for 24 hours at temperatures ranging from -20 °C to +70 °C to ensure the units’ production quality. Does your company have the equipment to perform environmental tests such as these?

**Iteration**

How many iterations of a design will your product development schedule allow? There are many potential failure points in the design and manufacture of an human-machine interface that must function in harsh conditions. Multiple re-designs and prototypes can use up critical weeks of development time. Yet most complex engineering projects require from three to six prototype stages to fully optimize the final product.

**Final Testing and Certification**

The final testing and certification of rugged HMIIs is a demanding discipline. Depending on the environment in which the machine will be used, HMIIs may have to be tested for operation over extreme temperature ranges, as well as for thermal shock as devices are taken instantaneously from one temperature extreme to another. They may have to meet humidity requirements or be tested for sealing against immersion or high volume liquid spray. They may need to meet vibration and shock tests, and they must withstand electrostatic discharge and electromagnetic interference. In addition, they will have to pass regulatory certifications such as FCC Part 15, UL, CSA, or CE.

These tests are expensive and time consuming. Many of the environmental tests cannot be performed without specialized equipment and must be performed in a special laboratory. Regulatory certifications can take weeks or even months to schedule and pass. Some certifications require that you quarantine parts that are used to produce a product, and require quarterly visits from the qualifying agency to certify the parts and processes used to produce the product. Both are time consuming and expensive.

An exhaustive test suite is listed on page 9. Are your engineers ready to take on this challenge? Has the necessary time been built into the schedule and have accurate costs been included in the budget to cover all testing requirements?

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**PROTOTYPE EARLY & OFTEN**

“Prototype early and often. Prototyping is not only a practice that helps identify problems early in the development process, it is also important in conveying the concept that ‘It is OK to fail, but try to fail when it costs the least.’... The use of prototypes to identify mistakes is the best practice for achieving a realistic view of the new product (which could be a physical item or a service). The use of prototypes in developing new products is critical. CAD drawings and other renditions are OK, but there is something magic in holding the new part in your hands.”

*Dr. Brent Strong, Lorin Farr Professor of Entrepreneurial Technology, BYU*
Release to Manufacturing

The final release to manufacturing involves the generation of many types of documentation, including manufacturing documents, assembly drawings and flow diagrams. Repair manuals are required for service technicians and operator manuals for end users. The documentation task alone for an HMI involves many man hours of coordinated work, as well as a documentation tracking and updating system. Is your company ready to take on this task?

Manufacturing also requires its own specially designed testing software and fixtures. Have you included these costs in your product development budget?

Sustaining Engineering

Once a human machine interface is incorporated into your product, the issues of maintenance, repair or replacement are major cost factors that must be planned for up front. If you source a terminal from a third party, product maintenance and repair will be covered by warranty, so no internal engineering effort is required on your part. In addition, when an HMI that you design requires an upgrade or becomes obsolete, your engineers will be responsible for the redesign. A strategic partnership with an experienced third-party manufacturer, however, will provide an upgrade path or replacement products in a timely, efficient and cost-effective manner.

ENVIRONMENTAL TESTS

Third-party manufacturers of rugged human-machine interfaces typically subject their products to the qualification tests listed in Part A. Products destined for vehicles (forklifts through heavy trucks, plus boats and planes) should go through qualification testing in Parts A and B. Certain products may be required to pass qualification tests in Part C, based on additional customer requirements or end customer specifications (such as military specifications). Part D lists various certifications that are usually performed by independent test labs. Items in parentheses indicate the equipment required to do the testing. Where “powered” is indicated, the device must be connected to proper monitoring and power cycling apparatus during some or all of the tests.

STRATEGIC TECHNOLOGY PARTNERS

As enterprises continually re-evaluate and prioritize core competencies, they are looking for strategic technology partners that can deliver true business value — that is, value aligned to the specific business objectives of the enterprise.

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Part A – All Products
- Storage temperature (environmental chamber)
- Operating temperature (environmental chamber, powered)
- Thermal shock (two environmental chambers)
- Humidity (environmental chamber with humidity capability, powered)
- Sealing
  - Spray (NEMA-12 or NEMA-4 spray equipment)
  - Emersion (emersion tank)
- Storage vibration (shake table)
- Operating vibration (shake table, powered)
- Transportation shock (transportation shaker)
- Operating shock (shake table, powered)
- Electrostatic Discharge, ESD (ESD test gun and station, powered)
- Electromagnetic interference (radiated & conducted, powered)
  - Emissions (EMI detection equipment & facility)
  - Susceptibility (EMI generation equipment & facility)
- Key life (pneumatic key tester, powered)

Part B – Vehicle Products
- J1455 sealing (J1455 spray chamber)
- J1455 power-line transient (transient generation equipment, powered)
- Ambient light (light & contrast measurement equipment, powered)

Part C – Additional Testing
- Dust (dust chamber)
- Wind-blown rain or dust (wind tunnel)

Part D – Certifications
- FCC Part 15 (for equipment in the USA, powered)
- CE Mark, Immunity (for equipment destined for the EU, powered)
- CE Mark, Safety (for equipment destined for the EU)
- UL, FM or CSA certification (variety of certifications, frequently required by customer or end customer, some are powered)

NEMA 4/12
NEMA Standard 250-1997 lists ten different enclosure requirements, of which 4 and 12 are two of them. Roughly, NEMA-4 is for hose-down environments, while NEMA-12 does not have to handle hose-down, but does have to handle oil seepage. The standard includes test methodologies.

J1455
Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle applications. Covers environmental factors and test methods for factors such as: temperature; humidity; sealing; altitude; mechanical vibration; mechanical shock; electrical environment; transient, noise and electrostatic characteristics; electromagnetic compatibility/electromagnetic interference.

FCC Part 15
A specification regarding electromagnetic radiation and susceptibility that all electronic equipment sold in the USA must meet. It has two classes: A and B. A is the less stringent class and applies to industrial or commercial equipment. B is the more stringent and applies to consumer equipment.
A key issue for the product manager to weigh in determining whether to build or buy an HMI is time to market. While your engineering team may have the skills and resources to design, build, test, certify and manufacture the human-machine interface you need, does the product manager have the time to wait for a non-core competency piece of technology to be developed and deployed for the first time? The alternative is to turn to a specialist in HMIs for a customized product. For example, a hand-held human-machine interface that may take a year to design and manufacture in house can likely be customized to your requirements within a matter of weeks or months.

Another issue for the product manager to consider is cost. There are many hidden costs to developing a rugged human machine interface that your engineering team may not consider or may not be able to estimate accurately. These include the costs to adequately prototype, test and certify the hardware as well as the cost to develop the software interface. Once the product is in production, there are the additional costs of ongoing maintenance and support. All of these costs can be contained by purchasing a finished terminal from a known source.

One of the hardest costs to calculate is opportunity cost. If you commit engineering resources to the development of a non-core competency human-machine interface, what other more important or more lucrative projects may be affected by this decision?

Risk factors must be honestly assessed by the product managers. These run the gamut from the risk of losing key members of an in-house design team to the need to change a crucial specification, such as screen size, in the middle of product development. Risks are also involved in the availability of component parts, particularly if you need them in low quantities that are sourced from off-shore manufacturers. Headaches such as these are eliminated when you have a relationship with a reputable terminal manufacturer. Changes in specifications can be more easily accommodated by a company that already builds a variety of HMs in many different sizes and configurations. The volume purchasing power of such a partner usually assures faster access to components vital to your design specifications.

A final consideration for the product manager is the product upgrade path for an in-house human-machine interface terminal. Continual innovation in the consumer electronics industry is creating a significant corporate challenge today: component obsolescence. When components become obsolete, an HMI specialist will always anticipate, redesign and replace those components faster than an in-house engineering team.
**Purchasing**

There are many hidden costs to manufacturing your own rugged human-machine interface terminal, costs that are not always apparent to an engineering design team.

For example, minimum component order sizes can be a purchaser’s nightmare. The trend among offshore manufacturers of electronic components is increasingly towards requiring large component order sizes. Resistors, capacitors and other components that could be purchased in low quantities before the explosion of products for the consumer electronics market now must be purchased in minimum order quantities of three to five thousand units. In addition, many suppliers now require a buyer to place non-cancelable/non-returnable (NCNR) purchase orders. This greatly increases the risk of cost over-runs on first-time product designs.

Minimum lot sizes, long lead times and inventory carrying costs are realities that purchasing officers must face as they seek to source electronic components from off-shore suppliers who now favor high volume consumers with short product life cycles. All of these headaches can be eliminated by purchasing complete human machine interface systems from a reputable manufacturer.

**Decision Chart**

Use a chart like the one on the right to help you decide whether building or buying is the right decision for your company.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>BUILD</th>
<th>BUY</th>
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</thead>
<tbody>
<tr>
<td>Quick deployment time</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Exact feature set required</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Testing and compliance</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Need life cycle control</td>
<td></td>
<td>X</td>
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<tr>
<td>Company core competency</td>
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<td>X</td>
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<tr>
<td>Consistent product upgrades</td>
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<td>Complete product support</td>
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<td>X</td>
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<tr>
<td>Low annual quantities</td>
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<td>X</td>
</tr>
</tbody>
</table>
the Bottom Line

Industry experts agree that the build versus buy question in any manufacturing industry finally comes down to a handful of key questions. This white paper has outlined those issues with respect to the highly specialized area of rugged human machine interfaces. Three questions are crucial to consider: time to market, risk assessment and cost analysis. All three are subject to the overriding question of core competency and opportunity costs.

If designing and building reliable terminals for your company’s line of products is not a core competency of your business, then the fastest, safest and most cost-effective course is to partner with a reputable manufacturer of rugged human machine interfaces.

TIME TO MARKET CASE STUDY

A manufacturer of hydraulic equipment began a feasibility study for replacing an older, expensive human-machine interface system that had limited capabilities with a lower cost, more feature rich system. The initial projection for developing a LCD panel with touch pad, graphical interface and wireless connection was two years. This was unacceptable to product management, so a third-party provider of rugged HMIs was invited to bid.

The HMI provider quickly determined that an existing operator interface with a 5.7” display panel and touch pad would meet the customer’s needs with modifications in three areas: power supply, wireless communications and housing. Within a matter of weeks, the manufacturer supplied detailed drawings of the customized product and a demo application written in the graphics programming language provided with the system.

On review, the manufacturer changed the specification, preferring a handheld display with harness and keyboard. Since the HMI provider had a line of handhelds in stock, it took just a few weeks more to submit a proposal that met the manufacturer’s needs. This was quickly followed by a prototype unit running a demo application that included simulated fork lift operation, weighing, data logging, a simulated wireless connection, and so on.

Several weeks of discussions between the two companies’ design teams resulted in a detailed specification that met the manufacturer’s exact needs. The HMI provider submitted a proposal that included timing of six weeks to make initial pilot units, four weeks for phase two pilot units, and six weeks to production.

The total elapsed time from first contact through production was about six months.
ABOUT QSI CORPORATION

Established in 1983, QSI Corporation is a manufacturer of rugged handheld, panel-mount and pedestal-mount terminals for industrial OEMs and commercial vehicle systems integrators. QSI’s human machine interface (HMI) and mobile data terminal (MDT) products include character and graphic terminals that are programmable, customizable, CE certified and NEMA 4/12/13 rated. Numerous interfaces are available, including EIA-232, EIA-422, EIA-485, J1708, Ethernet and Power-over-Ethernet. QSI excels at designing and building custom and semi-custom terminals able to withstand high levels of shock, vibration, humidity and other environmental parameters. All QSI Corporation products are manufactured in the USA at the company’s headquarters in Salt Lake City, Utah.

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