

Evaluating Platforms For Gaming Machines

Addressing the performance, security and product development cycle needs of gaming equipment manufacturers

Executive Summary

Gaming machines employ the latest high-performance computing and graphics technology to deliver captivating games featuring multimedia sounds and images. Under the hood, these machines are running embedded platforms with specific requirements around performance, availability, security and product life times.

Historically, many gaming equipment manufacturers built platforms based on RISC processors with additional integrated features. This provided a large degree of control over the design along with opportunities to optimize the cost of the hardware and create unique competitive advantages.

Today, equipment manufacturers are under pressure to speed up development cycles and launch products throughout the world. In addition to providing a constant stream of increasingly complex gaming products, developers have to contend with greater cost pressures, stricter certification processes, more sophisticated graphics and new technology requirements like networking.

More gaming machine manufacturers, such as Aristocrat Technologies* are turning to Intel®-based modular architecture that can address these challenging requirements while meeting customer expectations for hardware prices that are similar to the PC and consumer electronics industries. Aristocrat, headquartered in Australia, has a well-earned reputation for outstanding performance and strong brand equity in more than 200 jurisdictions around the world. This paper provides an overview of Aristocrat's criteria and process for evaluating computing platforms used in gaming machines.



Table of Contents

- Trends Impacting Gaming Equipment Manufacturers 3
- Aristocrat Platform Challenges 3
- Aristocrat Platform Requirements 4
- Aristocrat Chooses Intel®-based Modular Architecture 5
 - Sidebar: About Aristocrat Technologies Ltd.*..... 5
- Overcoming Intel Platform Issues in Gaming 6
- Intel Platform Benefits 6
 - Product Requirements..... 6
 - Product Development..... 6
 - Project Management Flexibility 7
 - Testing, Quality Assurance and Support..... 7
 - Sidebar: Benefits of Intel Multi-Core Platforms in Gaming Applications* 7
- Future Technologies 8
- Conclusion 8

Trends Impacting Gaming Equipment Manufacturers

Gaming is growing worldwide, and creating new opportunities for gaming equipment manufacturers who can quickly spin products for new markets that satisfy both casino patrons and local regulatory agencies. Launching products faster requires developers to reduce design cycles, despite the need to add features and lower costs. Here are some of the trends that are impacting manufacturers:

- Increasing importance of graphics to meet customer demands – today and tomorrow
- Rising expectations that hardware platforms follow commodity PC pricing
- Growing interest in IP networking

In the future, networked gaming will be commonplace, requiring equipment manufacturers to employ TCP-IP stacks to communicate over the Internet. This technology will ease player tracking and enable new gaming features like “bonusing,” where players can participate in games that span a set of networked machines.

In addition to casino games, there are other gaming devices with specific requirements and priorities. Arcades need very high-performance games, robust player interfaces and receipt tracking. Lottery terminals must be low cost and tamper proof, and they rely on secure networking connections and high system availability.

Aristocrat Platform Challenges

In late 2006, Aristocrat Technologies was evaluating platforms for its next-generation gaming cabinet called Viridian*. Previously, Aristocrat used an embedded design based on RISC processors. They conducted a comprehensive study of platforms using embedded Intel® processors and chipsets. This study focused on the challenges they faced with respect to addressing industry trends and deploying PC technology-based platforms.

- **Regulatory Issues:** For any platform decision, meeting regulatory requirements is the main concern. Any platform issue can impact time-to-market and increase certification costs. A mistake in the design carries a huge penalty, because it can trigger regulatory consequences, and it's difficult to access field equipment due to the security on machines. Even small hardware changes attract regulatory attention, which means the platform must remain stable and employ components with long life cycle support.
- **Networking:** The gaming industry is migrating from RS-232 and RS-422 communication links to IP-based networks. Platforms must now incorporate TCP/IP software stacks to interface to IP networks. It's possible to acquire these software stacks through the open source community and avoid development and licensing costs.
- **Trusted BIOS:** When adopting PC-based technology, the biggest challenge is addressing regulatory concerns regarding potential security holes in BIOS. Some regulators feel the pervasiveness of PCs creates a larger pool of people who can hack into systems. As a result, Aristocrat scoped the effort to modify the BIOS to make it more secure and pass regulatory testing worldwide.
- **Graphics Performance:** Satisfying the hunger for graphics processing performance requires a path to continuous, cost-effective graphics improvements. Not only must the electrical components provide more capability, but technological advances are needed to increase graphical design productivity and shorten product development schedules.

Table 1. Aristocrat Platform Decision Criteria

	Requirement	Expectation
Product Requirements	High Performance and Scalability	The platform supports graphics processing and runs multiple applications simultaneously. The vendor supplies a large selection of CPUs, with various performance, power consumption and pricing levels.
	Graphics Performance and Scalability	The platform provides adequate graphics performance cost-effectively, and supports a dual-screen configuration that meets customers' expectations well into the future. Higher performance graphics configurations can easily connect an external video graphics card using the PCI Express* bus.
	Cost	The platform tracks the declining cost/performance trends of the electronics industry.
	Future Upgrade Path	Vendor product roadmaps encompass future CPUs and chipsets that are competitive and allow a relatively simple COM Express* upgrade. The vendor implements up-to-date modern technologies which are needed at the start of the development cycle due to long gaming product life cycles.
Product Development	Development Time Reduction	The first software development kit is delivered at the start of the project, enabling software developers to get an early start on coding, debugging and testing.
	Availability of Software, Tools and Utilities	The system architecture offers a wide choice of commercial and open source components including a large number of operating systems, software applications and utilities.
	Simpler Software Development	The software emulation environment closely mimics the final target, which minimizes the number of back-and-forth code changes and recompiles.
Project Management Flexibility	Design Flexibility	The platform employs a modular approach that can accommodate feedback from the software developers, such as CPU performance and memory size, relatively close to product launch.
	Availability of Industry-Standard Hardware Building Blocks	Industry-standard processor modules are available in sufficiently large numbers with a range of features and options, long supply life and high reliability design from specialist companies.
	Security	The architecture is flexible and allows the implementation of advanced security features by employing just minor hardware customizations.
	Resource Flexibility	The system architecture is modular, so it is simpler to partition the design and distribute work to in-house and external experts.
Testing and Quality Assurance	Availability of Testing Tools	Hardware design verification and production testing tools are readily commercially available.
Support	Long Product Life	The vendor guarantees component availability for an extended period of time, and matches the long product life cycles of the gaming industry.

Aristocrat Platform Requirements

Aristocrat defined a set of next-generation platform requirements based on:

- Industry trends
- Learnings from their current platform
- Strategies to create competitive advantage

They developed decision criteria that spanned the entire product life cycle of their gaming devices, as shown in Table 1.

Although Aristocrat traditionally used embedded designs based on RISC processors that provided a large degree of control over their design, there were significant drawbacks to the overall development process. These platforms were not supported by a full complement of development tools, requiring hardware and

software developers to create unique tools, which was not an area of expertise. They developed product and manufacturing testing tools and expended considerable effort to ensure the proper amount of test coverage.

Another drawback was that there was no easy way to create an early hardware prototype for software developers. As a result, the hardware team was in the critical path of the project schedule and under pressure to deliver a platform, so software engineers could start coding and testing.

The RISC-based design also forced developers to work at low levels of detail, not at a higher module level. This created more work for the hardware engineers and extended the development cycle. Software developers also had to understand these details, reviewing complex data sheets and specifications, before they could provide early feedback on the hardware design.

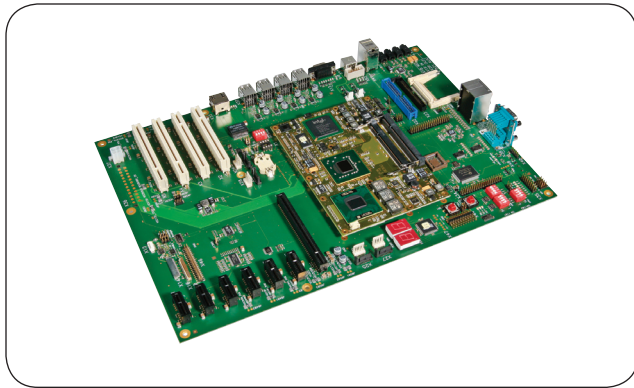


Figure 1. MSC Vertriebs GmbH COM Express* Evaluation Board

Their legacy platform supports two operating systems: Microsoft Windows* CE and Linux*. Aristocrat prefers to have more options, like Windows XP* Embedded, because gaming devices are moving to more multi-tasking, IP networking and broadband, which require a full-features operating system. Future operating systems also need to run the latest networking stacks and security protocols.

Aristocrat Chooses Intel®-based Modular Architecture

After careful consideration and weighing all the different aspects of the design requirements, Aristocrat chose an Intel® technology-based solution for their next-generation Gen7 gaming platform. Switching to a low-power embedded Intel® architecture platform created a number of new possibilities and provided key advantages over a full-custom, embedded design.

“The Gen7 gaming platform has more processing power which means it is able to drive richer game content with its ten times more memory, eight times faster CPU, three times more serial ports, five new USB ports, five times faster bus speed and two extra video outputs.”

Roxanne Costello, Global General Manager Marketing, Aristocrat Technologies

The hardware platform was designed with a modular approach, based on an industry-standard COM Express* processor module that includes the CPU, chipset, integrated graphics and other core functions such as an Ethernet controller. All the gaming-related specialized hardware and interface functions are implemented on a carrier board, as illustrated in Figure 1.

About Aristocrat Technologies Ltd

Aristocrat Leisure Limited (ASX: ALL) is a leading global provider of gaming solutions and is licensed by over two hundred regulators. Operating in over ninety countries around the world, Aristocrat offers a diverse range of products and services including electronic gaming machines, interactive video terminal systems, electronic tables and casino management systems. For further information, visit the company’s website at www.aristocratgaming.com.

Aristocrat’s new Gen7* platform, powered by the latest Intel processor, is described by the company as a “technology pathway.” As well as hosting new native software featuring high-resolution graphics and enhanced sounds, the powerful games engine is able to run a selection of earlier games (emulated), under the new touch-screen UPI. Flexible connectivity, dual-screen functionality, smart card security and compact flash content distribution combine with various hardware enhancements to deliver more processing power, driving richer game content and enhanced player experience. Gen7’s built-in networking capabilities also allow Viridian* to feature Downloadable and Server-Based Gaming.



Figure 2. Aristocrat Viridian* Gaming Machine

The processor module and the carrier board form the core controller of an electronics gaming machine. The versatility of this architecture allows the creation of a range of differently optioned, similar products requiring only minimal customization of the existing hardware design. This is an important advantage as it supports a quick response to new opportunities and accommodates special requirements in certain gaming jurisdictions.

COM Express boards based on embedded Intel platforms are supported by the Intel® Embedded and Communications Alliance, one of the world's most recognized embedded ecosystems. The alliance provides equipment manufacturers with a trusted supply line of Intel®-based products and services, design expertise and total life cycle support from worldwide service organizations. Aristocrat selected MSC Vertriebs GmbH*, who offers industry-standard processor modules that are available with a range of features and options, long supply life and high reliability. MSC modified the BIOS source code for Aristocrat to achieve a unique level of security for meeting regulatory requirements and protecting Aristocrat's intellectual property in their gaming application software.

Overcoming Intel Platform Issues in Gaming

After selecting Intel-based modular architecture, Aristocrat had to make some platform enhancements to meet regulatory requirements for guaranteeing a trusted platform and authenticating application code. "How do you secure a standard PC in a stand-alone environment," asks Jim Morrow, VP Global Games and Platforms at Aristocrat Technologies. He adds, "We're still in a world of stand-alone slot machines, where the only communication is RS-232 and RS-422." Aristocrat addressed many of the regulatory issues by customizing the BIOS and ensuring a more secure boot process.

Since the boot chain of a PC platform is complex, Aristocrat started with an off-the-shelf BIOS and outsourced the required modifications. "It's a lot easier to get someone else to write BIOS," says Steve Byng, software architect at Aristocrat. The BIOS was modified to allow a secure boot chain, which included disabling the BIOS (CMOS) Setup Utility and reading CMOS RAM settings from an external read-only EEPROM. BIOS extensions, like removing unauthorized connections to the Internet, were implemented to make the BIOS more secure. Other routines were added to meet regulatory requirements, such as interrogating a smart card, signature algorithms (e.g., dynamic security agent) and support for two operating systems (Linux, Windows XP Embedded).

Security applications ensure the software code, stored in mass media, is authenticated and signed, a requirement to guarantee the code that runs on the machine is trusted. By signing the code, gaming operators are assured the code came from Aristocrat and was properly tested.

Intel Platform Benefits

Aristocrat mapped their platform decision criteria, which spans the entire product life cycle, to Intel-based modular architecture.

Product Requirements

There is a large selection of Intel processors available with various performance, power consumption and pricing levels. The chipsets supporting these processors integrate many features such as a graphics engine, high definition audio and Ethernet. Aristocrat easily ported its graphics library to the Intel graphics engine and made changes to the driver to improve efficiency. The integrated graphics provides adequate performance, supporting a dual-screen configuration for the majority of Viridian gaming devices, while add-in graphics cards are used in high-end machines.

The gaming industry is moving to wider panels that produce 30 percent greater workload, and Aristocrat plans to take advantage of Intel's processor upgrade path and roadmap. With a COM Express platform, upgrading the processor is relatively easy using off-the-shelf processor modules. "These modules also leverage purchasing volumes to achieve lower component prices than Aristocrat could achieve buying direct," says Sandor Daranyi, lead design engineer at Aristocrat. He continues, "This platform provides access to established and emerging technologies like Serial ATA (SATA) and PCI Express* Intel® chipsets are very flexible and support functionality and interfacing options that would be hard to implement with RISC chips."

Product Development

Intel-based modular architecture shortened the time to give software engineers a prototype emulator that closely reflected the target system. "The software engineers asked whether we could give them some hardware, so we bought a few PCs with the same Intel chipsets we intended to use. They were our early development kits. This was a great timesaver and established an early feedback loop between hardware and software," says Daranyi. It was also easier to reconcile emulator and target performance compared to the legacy RISC-based platform, where changes made on the emulator often had a different performance impact on the target. "There were fewer reconciling issues with the Intel platform, where time lost on the Intel platform was about one game compared to about five games for RISC," say Rick Hayes, software developer at Aristocrat. He adds, "Standard software development is an order of magnitude easier with Intel than RISC processors."

Aristocrat found there's common PC architecture knowledge, so it's easy to get feedback like "this configuration has too little bandwidth" from software and graphics engineers who are already familiar with PC technologies and graphics cards. "If we (hardware engineers) say we are making particular architectural and component choices, the software team will tell us in which areas they expect to have issues," says Daranyi. Software engineers gave feedback on performance, memory size and which CPU to use before the hardware was built. Software engineers can also choose from a wide range of open source software like networking stacks and IPSec. Daranyi adds, "There are obvious software development advantages; a large range of tools and utilities are available for both hardware design verification and production testing."

Project Management Flexibility

By adopting a market leading modular architecture, Aristocrat can choose from a wide assortment of hardware and software vendors, with the advantage of competitive pricing and interoperability. This flexibility allows Aristocrat to free up resources to concentrate on their core expertise: gaming. For example, the Intel-based modular architecture is supported by a large number of BIOS, operating system, application software and hardware companies that are ready to supply off-the-shelf components.

Aristocrat opted for a more modular design that reduced the need to master every new electronics technology, which was stretching expertise very thin. They are purchasing the COM Express processor module from an embedded industry specialist rather than designing it themselves. This board, which contains the CPU, chipset and core functionality, sits in a base board that contains the rest of the gaming machine electronics. The board vendor ensures long life support, which is critically important. This modular approach eases regulatory compliance since the base board doesn't have to change. Aristocrat can also change the CPU and memory late in the development cycle to meet performance needs and meet cost targets.

Testing, Quality Assurance and Support

By choosing an Intel-based solution, Aristocrat can take advantage of testing tools that are readily available for Linux and Windows. They spend less time developing in-house tools and manufacturing tests, and benefit from greater test coverage and higher quality.

The Intel embedded roadmap provides a confident supply line, with at least seven years of life cycle support. Many hardware vendors offer comparable support for boards and subsystems using Intel components.

Benefits of Intel Multi-Core Platforms in Gaming Applications

The latest multi-core processors and chipsets from Intel are delivering more computing and graphics performance, audio and other integrated features. Here are some Intel chipset features that enable cost-effective, high-performance gaming platforms:

• Faster Memory

- Speeds up gaming, graphics and background applications.

• Integrated Graphics

- Enhances the user experience with advanced graphics features and modes for widescreen flat panels.

• High-Definition Audio

- Delivers premium theater sound and special features such as multiple audio streams.

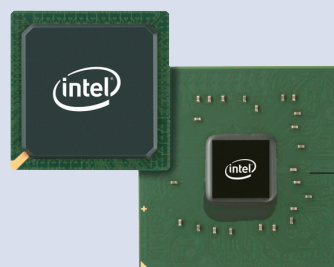
• Serial ATA (SATA) Interface

- Supports faster hard disk drives that increase graphics data transfer rates.

• Embedded Life Cycle Support

- Protects product development and platform certification investments.

In addition to these architecture advantages, equipment makers typically find maintaining software code for general-purpose processors, like Intel processors, is easier than for application specific hardware. This is because Intel processors are supported by a broad ecosystem offering a wide range of mature development tools.



- Dual-Channel DDR2 Memory Support
- Intel® Graphics Media Accelerator 950
- Intel® High Definition Audio
- Serial ATA (SATA) 3 Gb/s
- Intel® Active Management Technology
- USB, PCI Express* and Ethernet Interfuges
- Embedded Life Cycle Support

The Intel® 945GME Express Chipset

Future Technologies

Intel product roadmaps are addressing the performance, security and product development cycle needs of gaming equipment manufacturers, today and into the future. The latest Intel multi-core processors provide the graphics performance needed to drive wider flat-panel displays and run multiple windows. There are other technologies available on Intel platforms that can lower maintenance costs and ease software porting.

- Intel® Active Management Technology¹ allows casino operators to remotely diagnose and repair issues, such as a “hung” gaming machine, over a secure communication link.
- Intel® Virtualization Technology² allows a machine to simultaneously run two operating systems, such as Linux and Windows, which will eliminate the need to port legacy software to a different operating system.
- Intel® Trusted Execution Technology provides a hardware-based security foundation to maintain a chain of trust and protect information from software-based attacks. This will provide a simple yet robust BIOS and application software authentication process without requiring additional components.

Faster Intel processors can also streamline code development. Many graphics engineers develop on high-end PCs with powerful graphics cards and migrate this code to the target platform. In the past, porting graphics typically meant stripping away a significant amount of animation and graphics to avoid reaching the limits of the CPU and memory. Graphics is very CPU-intensive and high-performance processors, like the Intel® Core™2 Duo processor, can process more animation and graphics, even as the industry moves to wider, dual displays. This processing power can save engineers from reworking their code to match the capabilities of the target system.

Conclusion

The gaming industry is employing the latest high-performance computing and graphics technology to attract the next generation of casino patrons. These gaming systems have specific requirements around performance, availability, security and product life times. Intel has a long history of serving gaming manufacturers, and continues to do so with its latest products. Intel-based modular architecture can meet stringent regulatory requirements, ease design effort, increase flexibility and decrease time-to-market. By delivering on these key platform decision criteria, Intel® solutions are enabling developers to improve their systems cost-effectively and enhance the gaming experience.



¹Intel® Active Management Technology (Intel® AMT) requires the computer system to have an Intel® AMT-enabled chipset, network hardware and software, as well as connection with a power source and a corporate network connection. Setup requires configuration by the purchaser and may require scripting with the management console or further integration into existing security frameworks to enable certain functionality. It may also require modifications of implementation of new business processes. For more information, see www.intel.com/technology/platform-technology/intel-amt/.

²Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing.

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