ESG WHITE PAPER

The Best Gets Better: Oracle Again 'Ups the Ante' for Autonomous Database Agility

Exadata Cloud@Customer X9M Brings a New Exadata to Run Autonomous Database with Enhanced Performance, Capacity, and Cost-effectiveness

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Executive Summary

Exadata is Oracle's platform for optimally running Oracle Database. Regularly updated for more than a decade, its latest iteration, the Exadata Database Machine X9M, does not disappoint one iota in terms of awe-inspiring "oomph." It continues what we've grown accustomed to: *increasing* performance, scale, and automation while *decreasing* costs and *eliminating* operational and functional differences based upon location or consumption choices. It's all too easy to be swept away by the sheer brute force of this thing, but its simple yet intricate capabilities are just as compelling and important.

This report highlights how the Oracle Exadata Cloud@Customer X9M service enhances the ability of customers to optimize their automated Oracle Database and fully managed Autonomous Database experiences,[1] not only in terms of improved performance, scale, availability, and lower costs, but also in terms of new functionality and advanced security. Customers have access to identical capabilities whether they are running Oracle Database or Autonomous Database on Exadata infrastructure in OCI (Oracle Cloud Infrastructure) or on Exadata Cloud@Customer X9M in their data center, making it possible for users to (re)focus their IT spending on helping their organizations' true mission (whether that is a line of business improving revenue generation or enhancing its users' experience).

Of course, different enterprises will have varying challenges and opportunities with their businesses and therefore require a different mix of transactional databases, data warehouses, and advanced analytics depending on their industry and the state of their IT. For example:

- eCommerce companies might be focused on low latency and high IOPS to handle both online purchases and concurrently manage inventory in real time.

- Electric utilities could need to monitor distributed equipment and energy usage, while using machine learning to identify potential reliability issues or supply and demand imbalances before either become actual problems that compromise or bring down the grid.

- Financial services firms are likely to need to provide personalized advice to a broad range of customer inquiries by combining in-database analytics with transactional applications while ensuring that fraud is eliminated.

Whatever an organization's focus, three "Cs" are simultaneously crucial considerations for users *and* prime benefits of the Oracle Exadata Cloud@Customer X9M: Consolidation, Consumption, and Competencies.

Consolidation: Retiring multiple older platforms in favor of fewer, newer, and higher performance platforms not only means customers have fewer systems to manage but also allows them to deliver both increased database performance and lower costs. Oracle maximizes the potential value of Exadata-based consolidation with its converged database approach—that is, a single database for OLTP, analytics, document, graph, spatial, time series, and other types of databases and data types. Converged Oracle Database capabilities are optimized on Exadata, allowing customers to move and run all their database workloads simultaneously on a single, high-performance Exadata Cloud@Customer X9M deployment. By definition, customers running a number of specialized databases offered by other vendors will find it extremely difficult to consolidate. The result is siloed data that requires considerable time and effort for any sort of analytics and an inherently riskier approach. Having one application potentially communicate with a myriad of different databases doesn't really sound like a strategy anyone would plan on, but using alternative approaches to Oracle, they can just accidentally get there over time.

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[1] This report focuses on Oracle Database and Autonomous Database on Exadata Cloud@Customer X9M, because it's the key current deployment model. The foundational Exadata X9M platform remains as flexible as ever and available for multiple database workloads.

Consumption: Oracle's vision for Exadata embraces the growing move to consume data center resources via a "pay-as-you-go" approach. Exadata Cloud@Customer X9M running either standard Oracle Database or Autonomous Database uses a subscription-based model for infrastructure together with software-inclusive or bring-your-own-license (BYOL) pricing for resource consumption. Autonomous Database adds automatic, workload-driven, and non-disruptive scaling of database resources combined with consumption-based expenses, which permits Oracle to provide a more flexible and inherently cost-optimized database solution. This compares favorably to (for instance) Amazon RDS on AWS Outposts, which requires downtime when moving databases from one of its relatively fixed compute "shapes" to another.

Competencies: The prior generation Exadata X8M introduced key technical competencies such as Intel Optane Persistent Memory (PMem) and RDMA over Converged Ethernet (RoCE) to deliver eye-watering improvements in read latency (<19 microseconds), log writes, and IOPS. The X9M generation adds even higher IOPS to accelerate OLTP and mixed workload environments, as well as mind-numbing system throughput for all forms of analytics and machine learning algorithms. Exadata Cloud@Customer X9M eliminates the cost of managing Oracle database infrastructure and allows customers to take advantage of Cloud automation and economics while maintaining data sovereignty in their data centers. Running Oracle Autonomous Database on Exadata Cloud@Customer X9M eliminates most management activities related to database software and wraps the whole package with valuable security, self-scaling, and self-tuning capabilities that further reduce the overall system TCO. On top of that, Exadata X9M delivers additional cost benefits simply because it is up to 50x faster than other local cloud database as-a-service offerings.[2] How? Because cloud services consumption time directly drives costs. Exadata X9M's higher performance means existing workloads run faster and cost less as a result.

Introduction to Exadata X9M

As digital initiatives continue to evolve, expand, and mature, highly responsive and capable systems that are also highly available *and* perform at a high level are prerequisites for business success. That's the motivation behind the Oracle Exadata Cloud@Customer X9M database service. The specifications and capabilities of the X9M are built to deliver the highest levels of availability, performance, and security, but it is the combination of these capabilities that allows the X9M to address today's most pressing business and IT challenges by providing industry-leading elasticity, flexibility, and low data center costs. Crucially, this tight co-engineering of systems, storage, networking, software, and Oracle Database allows Exadata Cloud@Customer X9M to provide capabilities that are simply unavailable elsewhere.

IT professionals are always considering new approaches that improve performance but must always balance these with these solutions' total cost of ownership (TCO) and a need to simplify their data center. Many do-it-yourself and local cloud as-a-service approaches that organizations attempt to use for mission-critical databases often prove unsatisfactory in real-world deployments because they lack scale, performance, availability, and flexibility. In contrast, Oracle Exadata Cloud@Customer X9M provides a proven pathway to converged and consolidated databases that simplifies the integration of multiple data types and access models while providing scaling for multiple forms of analytics and machine learning. Exadata Cloud@Customer X9M provides organizations with the ability to flexibly configure their local cloud database platform to meet any mix of workloads with over 1,000 total CPUs for Database and SQL processing[3] and over 600TB of Oracle databases that can support 6PB of data warehouses.

Exadata Cloud@Customer X9M advances are focused on performance, which in turn underpins other extended values in database consolidation and other use cases. For instance, single-rack IOPS can now reach 22.4M (nearly double the preceding X8M and almost 5x that of the original X8), with critical SQL read latencies of <19μS to accelerate databases for

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[2] This comparison is sourced from Oracle but is in turn based on comparing publicly available numbers for (a) the SQL Read Latency on Exadata X9M of less than 19 microseconds and (b) the AWS RDS latency for io2 volumes of <u>"single-digit milliseconds."</u>
[3] Specifically, it's up to 496 for Database and 576 for SQL processing in Exadata storage servers.

OLTP4. In addition, Exadata Cloud@Customer X9M offers an 80% increase in SQL throughput over the prior X8M version to support a rich suite of business, graph, spatial, and machine learning algorithms. This all means invariably better results (and fewer headaches) than using a system like AWS RDS on AWS Outposts with its higher latency, lower IOPS, and lower throughput (even if it supported Oracle Database or Autonomous Database).

Before looking at Exadata and the X9M version in more detail, let's briefly examine the state of database data needs.

The Data Challenges of Contemporary Database Environments

Databases and the applications that they serve often slow down as data size and processing demands increase because their underlying hardware can't access data fast enough, deliver sufficient IOPS for OLTP, or provide the level of uptime that business-critical applications require. This can lead to lengthy transaction times or service unavailability and thus reduced productivity and customer satisfaction. Similarly, systems supporting the analysis of business data for inventory control, planning, and analysis of customer purchasing patterns are often not sufficiently responsive due to low storage throughput and the requirement for database servers to process every byte of the data. Organizations will often try to address both of these lack-of-performance issues by just adding more databases and servers, but this is simply "throwing money at the problem" and usually increases solution complexity and management headaches with sprawling numbers of databases (and data silos), which can actually exacerbate the underlying problem rather than address its root cause.

An analog to the performance challenges that organizations face is the lack of data scaling that they may encounter. Lack of scaling is driven by the inherent limits of some databases and infrastructure, which restricts the size of databases being analyzed on compute nodes and requires complex work-around architectures that, again, lead to increased database management and infrastructure sprawl, whether the organization is trying to implement them on-premises or in the cloud.

Meanwhile (and this is an overall point, not just for databases), most organizations are evaluating ways to better address data center resource consumption and consolidation. The "as-you-go" pricing and consumption models driven by the cloud are typically the most desired approach. In fact, according to ESG research (see Figure 1), 48% of respondents report that they would prefer to purchase on-premises infrastructure through a consumption-based model. And IaaS users are even more likely (53%) to prefer a consumption-based model for their data center infrastructure than the 38% of non-IaaS users that said they prefer a subscription model.[5]

Consequently, IT professionals are aware that lack of cloud automation, combined with poor infrastructure utilization efficiency, is increasing the amount of management required and thus the overall costs of their database environments (and data center operations as a whole). Data, free flowing, accurate, and fast, is the lifeblood of a high-functioning database environment. Oracle recognizes this and provides identical capabilities across its Exadata Cloud Service, Exadata Cloud@Customer, and Exadata Database Machine platforms, enabling its customers to seamlessly move Oracle Database workloads to the location and infrastructure that best suits them at any point in time. Furthermore, the capabilities of Oracle's enhanced Autonomous Database on Exadata Cloud@Customer X9M make it easier than ever for customers to extract maximum value from their database workloads by eliminating manual processes and focusing more on strategic priorities.
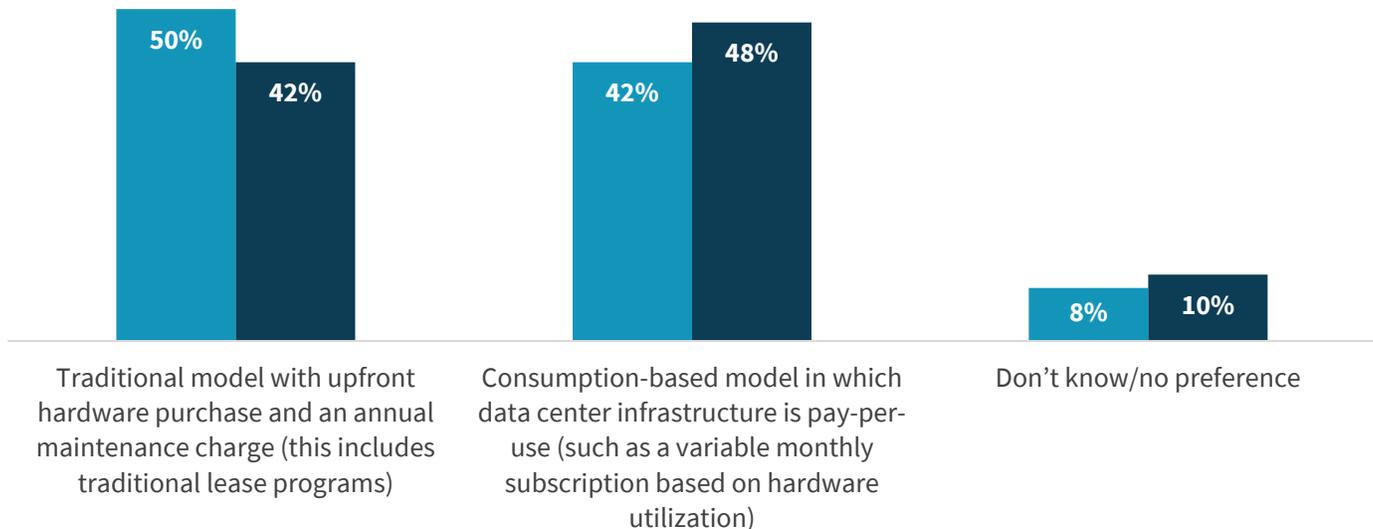
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[4] Exadata X9M leverages PMem data and commit accelerators to bypass the network and I/O stack, which eliminates expensive CPU interrupts and context switching, reducing latency from 250μS to less than 19μS.
[5] Source: ESG Research Report, *2021 Technology Spending Intentions Survey*, January 2021.

Figure 1. Growing Preference to Shift Data Center Infrastructure to OpEx Model

Assuming the net-cost was the same, which of the following do you believe would be your organization's preferred payment model for on-premises data center infrastructure? (Percent of respondents)

■ 2020 (N=658)   ■ 2021 (N=664)

	2020	2021
Traditional model with upfront hardware purchase and an annual maintenance charge (this includes traditional lease programs)	50%	42%
Consumption-based model in which data center infrastructure is pay-per-use (such as a variable monthly subscription based on hardware utilization)	42%	48%
Don't know/no preference	8%	10%

Source: Enterprise Strategy Group

A Better Way to Run Databases: The Oracle Exadata Vision

Oracle's next-generation Exadata Cloud@Customer X9M provides extreme performance and availability at an attractive and surprisingly low cost. The "better way" that Oracle delivers encompasses a host of notable hardware and software features that are co-engineered with Oracle Database. While a more comprehensive list can be found in Oracle's marketing materials,[6] there are several highlights to call out in this analysis.

Exadata Cloud@Customer X9M – Highlights

Oracle promotes its latest generation Exadata by stating, "We've made the best place to run Oracle Database, faster and more cost-effective." And that's hard to argue with when you consider even this small selection of details:

- **Solving OLTP challenges** by implementing 32-core Intel Ice Lake CPUs to increase query concurrency and maintain the extremely impressive <19 microsecond read latency offered by the X8M while increasing IOPS to as high as 22.4M (that's 87% more than the X8M) to support more OLTP transactions and more complex queries.

- **Solving analytics challenges** by offloading SQL queries to intelligent storage servers (a hallmark of Exadata's unique capabilities), Exadata Cloud@Customer X9M delivers 540 GB/second of throughput, 80% higher throughput than the

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[6] Oracle.com, *Oracle Hardware*

equivalent X8M, supporting all types of in-memory, business, graph, and spatial analytics workloads as well as scalable, in-database machine learning algorithms with incredible performance.

- **Increasing consolidation** across multiple database use cases with higher OLTP and analytics performance to get more work done per CPU core. 24% more CPU cores and 28% more storage capacity are provided at the same price as prior models to enable additional consolidation.

- **Improving business agility** across mixed Oracle Database workloads by allowing users to dynamically scale workloads or introduce new ones without the time and expense associated with acquiring new equipment. Sharing larger pools of compute and storage resources enables organizations to consolidate more database workloads onto less infrastructure at a lower cost—a win-win-win proposition.

- **Increasing security** is always a concern for IT, and Exadata Cloud@Customer takes a uniquely integrated approach. Not only does it provide mandatory encryption and include extensive Oracle Database security features, it also includes new Operator Access Control capabilities that meet stringent user requirements to manage remote access to systems holding sensitive data. These capabilities, far more extensive than those typically found on other local cloud database as-a-service offerings, allow organizations to control how Oracle Cloud operators can remotely access Exadata Cloud@Customer infrastructure by requiring authorization for all access, limiting what remote operators can do and for how long, monitoring what they do, and providing the ability to completely terminate access at any time.

- **Increasing deployment flexibility and lowering costs** with elastic storage expansion, which enables enterprises running the Oracle Database with data-intensive workloads to incrementally add storage capacity, throughput, and SQL processing power without increasing the number of database servers or Oracle Database licenses. When combined with Exadata Cloud@Customer's intelligent storage tiering across PMem, flash, and disk drives, Oracle states that Exadata X9M's flexible design provides up to 87% improvements in performance over previous Exadata Cloud@Customer offerings without increasing prices and lowers the cost of running equivalent current workloads by as much as 47%.

In simple terms, Oracle is responding to the growing requirements for cloud simplicity, cost-effectiveness, flexibility, performance, availability, and the need for organizations to comply with legal or business requirements by keeping data in their data centers with its Exadata Cloud@Customer X9M. The online scaling of database consumption without downtime and the automation of this scaling with Autonomous Database precludes or eliminates the headaches associated with monitoring the performance of cloud databases and the downtime associated with scaling them up or down on other platforms. The complete suite of Oracle Database software is available at an extremely affordable consumption-based price and, as a nod to existing Oracle Database customers, there is a BYOL-based resource consumption scheme as well.

One of the most impressive public customer stories is that of Deutsche Bank.[7] It selected Exadata Cloud@Customer to deploy thousands of Oracle Databases—more than 95% of all its systems, supporting mission-critical payments processing, risk and capital planning, trading and regulatory reporting —as well as Autonomous Database, a combination that is expected to deliver triple-digit-millions of cost savings for the financial services leader.

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[7] Source; ZDNet.com, *Deutsche Bank expects 3-digit millions in cost savings from move to Oracle Cloud@Customer,* July 2021, and Oracle Press Release*, Deutsche Bank Partners with Oracle to Accelerate Technology Modernization*, June 2021.

Database lifecycle management is included via the Oracle Cloud console. It's a one-click database provisioning tool. But provisioning databases is only part of the story; data protection and malware protection are also automated with one-click integration with Oracle's Zero Data Loss Recovery Appliance X9M and the ability to archive databases to Oracle's cloud.

The Recovery Appliance offers seamless integration with Oracle Database to eliminate data loss and accelerate recovery in the event of data corruption or a data center outage. It helps protect against cyber and ransomware attacks by storing up-to-the-second copies of all database blocks and changes on a separate, highly secure system. Recovery Appliance also offers several noteworthy enhancements in its X9M manifestation with a 30% increase in backup capacity and a 50% lower entry cost, which can equate to as much as a 62% lower cost per Terabyte of protected storage. Enhanced Recovery Appliance archive-to-cloud and backup/recover anywhere capabilities (along with a cyber vault architecture that provides a network-isolated group of technology components inside the data center itself) help organizations protect themselves against a wide range of outages or cyber-attacks.

Market Relevance and Competitive Overview

When you take an airplane, the in-flight announcement almost always says that "we know you have a choice of airlines," but frankly that's simultaneously a truism and a frivolity because the product (a flight from A to B) doesn't really vary much between carriers. While superficially the same might appear true for database platforms, even a cursory investigation will show the unique advantages and impressive value of using Exadata Cloud@Customer X9M for Oracle Database and Autonomous Database.

A few years ago, it was clear that some IT organizations wanted to take advantage of cloud automation and economics when running databases, but that some databases just couldn't move to the cloud, either due to data sovereignty, security, or application integration issues. Oracle recognized this need, and in 2016, it pioneered the idea of bringing cloud database infrastructure into customer data centers with its Exadata Cloud@Customer. Fast forward five years, and other vendors have also embraced the concept. These alternative local cloud database as-a-service offerings vary in maturity, infrastructure implementation, and capabilities, but Oracle's lead in experience (half a decade of production deployments and a real-world-hardened architecture) translates to superior capabilities and performance, plus sophistication and low risk compared to competitive offerings.

So, what does it mean to "fly Oracle" with Exadata Cloud@Customer X9M in the local cloud database as-a-service airspace, and why should you consider it? Here are some comparative stats for the X9M and its market alternatives that should make this a moot question:

- **50x better latency:** Exadata Cloud@Customer X9M delivers <19 microsecond read latency versus 1,000 microseconds on other cloud vendors.

- **23x better aggregate read IOPS and 280x better than a single database node**: Exadata Cloud@Customer X9M delivers up to 22.4 million 8K SQL read IOPS with a full rack of 8 database and 12 storage servers compared to another cloud vendor's full rack offering where systems provide just 80,000 IOPS per server or 960,000 in total.

- **18x better aggregate throughput, and 225x better than a single database node**: Exadata Cloud@Customer X9M provides up to 540 GB/second throughput with a full rack of 8 compute and 12 storage servers compared to a full rack configuration in another cloud vendor's offering whose system's throughput is just 2.375 GB/s per server or 28.5 GB/s total.

- **9x larger databases and 24x larger data warehouses:** Exadata Cloud@Customer X9M supports uncompressed databases of up to 615 TB in size and over 6 PB with typical Hybrid Columnar Compression benefits. This compares to

the databases running on other cloud offerings, which are limited to 64 TB in size or 256 TB with typical 4:1 compression.

But these raw stats, while impressive, are only a part of the story. In a similar vein to when we discussed the value of X9M in itself, it's the details that matter and that make it virtually impossible for anyone else to truly replicate what Oracle can deliver. For instance:

- While other vendors use generic hardware for their local cloud database as-a-service offerings, Exadata Cloud@Customer X9M is a complete hardware/software stack that integrates servers, intelligent storage, networking, virtualization software, operating system software, and most importantly, Oracle Database and Autonomous Database. Oracle owns both ends of the proverbial wire and the wire itself, allowing it to make software changes to support new hardware capabilities and hardware changes to support new software, all without requiring customers to make changes to their databases or applications. This extreme level of co-engineering at the source code level improves performance, scale, and availability while also reducing management costs.

- The X9M's intelligent storage servers provide up to 576 cores for SQL, analytics, and machine learning algorithms, offloading compute, and I/O-intensive tasks from database servers, resulting in faster performance without requiring additional database licenses. This contrasts with other local cloud database as-a-service vendors whose offerings provide no intelligent storage capabilities and require licensed database processing cores for all processing, potentially reducing performance *and* increasing costs.

- Exadata Cloud@Customer X9M offers online scaling without application downtime and running Autonomous Database on it automates this scaling. Other local cloud database offerings invariably require services to be paused and the database to thus be unavailable while infrastructure is re-sized and maybe even moved to another physical system.

- Exadata Cloud@Customer X9M's redundant, scale-out architecture allows for continuous database operations while service is performed on individual database and storage servers or while patches and upgrades are implemented on a rolling basis across a cluster. This means that unplanned outages are minimized and there is no downtime for planned maintenance.

- Oracle Database and Autonomous Database on Exadata Cloud@Customer X9M achieve extremely low latencies with PMem and RoCE enhancements that bypass the operating system and network software stack. Organizations can take advantage of in-memory performance levels without facing memory size constraints or requiring application changes.

- Exadata Cloud@Customer X9M runs the *same* Oracle Database and Autonomous Database as customers use on Oracle Cloud Infrastructure so its users can develop in one location, deploy in all locations, and move database workloads seamlessly. Analogous identicality between local cloud database as-a-service offerings and cloud offerings is not available on other vendors' platforms.

- Oracle offers advanced database capabilities with both Oracle Database and Autonomous Database on Exadata Cloud@Customer X9M, including graph, spatial, time-series, JSON, machine learning, blockchain tables, and built-in, low-code development using Oracle Application Express (APEX). Providing these capabilities on other platforms requires running multiple databases and added-cost services.

- Exadata Cloud@Customer has been in production inside customer data centers for half a decade, allowing Oracle to learn and then address advanced operational needs such as Operator Access Control.

The overall value of the Oracle Exadata Cloud@Customer X9M is that it provides a clear and proven path for organizations to increase the performance of diverse, converged database environments and consolidate their execution. It's co-engineered with Oracle Database using a scale-out architecture that combines "mind-blowing" foundational hardware specs, together with unique and highly advanced software capabilities. Adding the sophistication and cost-effectiveness of the Autonomous Database capabilities to Exadata Cloud@Customer X9M only serves to distance Oracle from the pack when it comes to local cloud database as-a-service offerings.

The Bigger Truth

Oracle has done it again with the Exadata X9M generation. Building on its heritage and customer-proven value, Oracle Exadata Cloud@Customer X9M delivers performance and enhanced functionality that not only addresses current business challenges but also provides the cloud foundation to support new generations of applications. Driven by its breakneck performance, Exadata Cloud@Customer X9M is perfect for any organization that is looking to gain higher database and application performance at a lower cost while also striving to reduce data center overheads in general and gain peace of mind in terms of data sovereignty and database security.

No one seriously questions the business value that Oracle Database can deliver; indeed, it is so ubiquitous, it's hard to think of a transaction in our day-to-day lives that does not somehow, some way interact with an Oracle Database. Such a powerful tool deserves the best possible platform on which to run. For Oracle Database and Autonomous Database, that platform is Exadata, now in its Cloud@Customer X9M manifestation.

There's a famous quote usually, but very dubiously, attributed to Henry Ford that's useful here: "If I had asked people what they wanted, they would have said faster horses." With Exadata Cloud@Customer X9M, Oracle is not simply delivering a faster horse. Instead, its properties (both oomph and sophistication) are akin, in transportation terms, to delivering some hybrid of a Formula 1 car, a 787 jet, and an 18-wheeler truck. These properties (in IT equivalence, of course) apply to databases and other enterprise applications in general. Yet, if an organization is, or will be, running Oracle Database (of any type and in any location), then the necessity of a long comparative debate with alternative local cloud database as-a-service offerings can be done away with, as nothing else comes close.

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