

CHAPTER 3

Technology and innovation



Leadership in travel technology



The travel industry relies heavily on technology. This trend is accelerating, with multiple channels and methods to interact with travelers. The extraordinary circumstances in 2020 have accelerated technology advances with a major impact on travelers such as touchless passenger handling and electronic IDs.

Most travel providers use sophisticated methods for merchandizing their products, evolving toward fully personalized offers covering all parts of a trip. This customization requires an understanding of traveler behavior that is achieved through the analysis of large amounts of data. Artificial intelligence and advanced cloud-based data analytics are starting to play a critical role for providers and distributors to stay ahead in this very competitive industry.

The wave of technology innovation in the travel industry isn't drying up – on the contrary, we're observing a trend of consolidation together with a continuous flow of new entrants. This includes both start-up companies that can quickly build niche functionalities, and major technology companies expanding their existing portfolio of solutions into travel.

In this dynamic context, Amadeus enjoys a privileged position. We offer a large portfolio of travel-dedicated applications to customers across the travel industry: travel providers, travel distributors and retailers as well as their traveler customers – and in almost all countries. This means that our platforms handle a rich set of functionalities, huge amounts of information and historical data reflecting all kinds of travel situations. And by operating applications for both travel providers and distributors/retailers, we have an up-to-date view on the evolution trends in the industry, covering the elements of the entire travel journey.

We maintain and develop our technical leadership through a unique combination of capabilities:

- _ Our engineering organization has deep knowledge and field expertise of all aspects of travel. This knowledge is the basis for our solutions and services covering almost all areas of travel,

- including airlines, airports, car rental companies, ground transportation, hospitality, leisure travel and tours, rail, travel payments, travel retailers both online and offline, travelers themselves.
- _ Extremely high-performance transaction processing under stringent system availability, security and performance requirements. All our applications evolve while ensuring a continuous service to our customers. In 2020 we processed over 100,000 user transactions per second at peak time in our main data center.
- _ Rapid response time for all functionalities from any point of access in the world, serving hundreds of thousands of simultaneous users, and a greater number of travelers connecting to the websites of our customers. This network of travel professionals and consumers forms one of the largest web ecosystems worldwide in terms of traffic.
- _ The management of very large databases with full transactional integrity, an essential factor in travel reservations. In 2020 we continued the implementation of new database techniques to enable the deployment of our applications over multiple data centers and public cloud. In 2020 we implemented our first major distribution of databases.
- _ A true omnichannel approach, servicing all functionalities from a wide range of devices and interaction methods, such as agent desktops, websites, kiosks, cell phones, tablets and chatbots, as well as system-to-system integration via various application programming interfaces (APIs). Whatever the channel, our customers are all accessing common data records and processing them from a single set of community applications, delivering a seamless traveler experience.
- _ We use a combination of intellectual property rights (notably copyright, know-how, patents, trademarks and domain names) and appropriate intellectual property provisions in transactional agreements to protect our innovations. We also contribute to the development of open source communities in the context of our partnerships with major IT vendors.

These capabilities and assets combined with a very close collaboration between our engineering and commercial organizations when working with our customers is at the core of Amadeus' position at the forefront of the travel technology industry.

A current example of our leadership role in travel technology is how we're driving forward across the industry the International Air Transport Association (IATA)'s New Distribution Capability (NDC), an XML-based data transmission standard that is critical for enhanced travel retailing and implementing sophisticated merchandising techniques. Collaboration across the travel supply chain – as an IT provider and aggregator – is key for NDC to really take off.

Amadeus' philosophy is that NDC must focus on end customers' needs first and foremost. Travelers today want simplicity, transparency and personalization. NDC facilitates this by allowing improved access to personalized offers and services, in real time. A new world of inspiration and possibilities is being opened by NDC, based on an increased recognition and understanding of each traveler when the offer is being made.

NDC isn't a revolution. It's an evolution that's already happening. It's a transformation involving all industry stakeholders. It's one of the biggest changes the industry has seen in a long time, and Amadeus is taking an active role here. NDC bookings have been processed via Amadeus technology since 2018. Amadeus is delivering a fully end-to-end integration of content via NDC connectivity, with a focus on providing omnichannel servicing through highly scalable and performing solutions in line with the strategic objectives of both airline and travel seller.

And this is just the start: NDC is the foundation for a broader industry vision toward other initiatives such as ONE Order, Dynamic Offers or One Identity. We're committed to developing these standards and initiatives by working hand-in-hand with industry partners such as IATA and our airline and travel seller customers to drive this change.

Amadeus research and thought leadership papers

Blueprint for recovery



Destination X: Where to Next



Insights for the new world of travel
From human touch to human tech



Insights for the new world of travel
Omnichannel



COVID-19 RELATED

The Future of Airports



Making a Positive Impact on travel



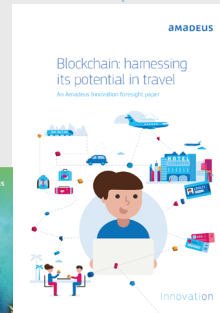
Digital Footprints: Spain



Frictionless Travel Payments



Blockchain: harnessing its potential in travel



Defining the future of travel through intelligence



DIGITALIZATION AND NEW TECHNOLOGIES

A business-oriented technology organization



2020 was a year of major change for the Amadeus technology organization. As well as the challenges of the COVID-19 situation, Amadeus reorganized its engineering functions, creating the new role of Chief Technology Officer (CTO), with the vision of “capturing and creating opportunities for all travel industry actors with first-class technology.” The CTO directly leads a new transversal organization including all our cross-platform technology and operational resources, which is called Technology Platforms & Shared Capabilities (TEC). The CTO’s mission is to guide the global technology strategy across businesses and ensure the entire Amadeus engineering community is as effective as possible in its role of governing and delivering our technology efforts.

The Amadeus engineering community is responsible for the development cycle, from design to delivery, as well as the operational coverage of our applications in production. Engineers’ roles encompass product specification, software development, quality assurance, operational deployment and management as well as project management.

The Amadeus engineering community consists of teams embedded into all the business units, as well as the TEC organization.

The engineering and development teams organized within the different business units focus on the functional evolution of our products and solutions to help our customers succeed. Amadeus makes sure its technology teams work closely with commercial business units and customers, right through the customer life cycle.

The TEC organization combines all technological capabilities and provides secure and stable platforms upon which customer solutions are built. These platforms include the core airline reservation, pricing and shopping applications that are common across Amadeus’ main business solutions (our global distribution system and our airline IT products). TEC also provides executive governance, quality

management, development tools, and agile or traditional project methodologies across all businesses and customer segments.

This set of shared capabilities have the objective of enabling the engineering units to adapt to new realities, foster excellence and stay ahead of competition. They also help promote alignment, sharing, fast decision making and execution, based on pragmatic technology choices. To reach these goals, we’re implementing an open platform model, accelerating our move to the cloud and actively developing an effective engineering unit with strong technical leadership.

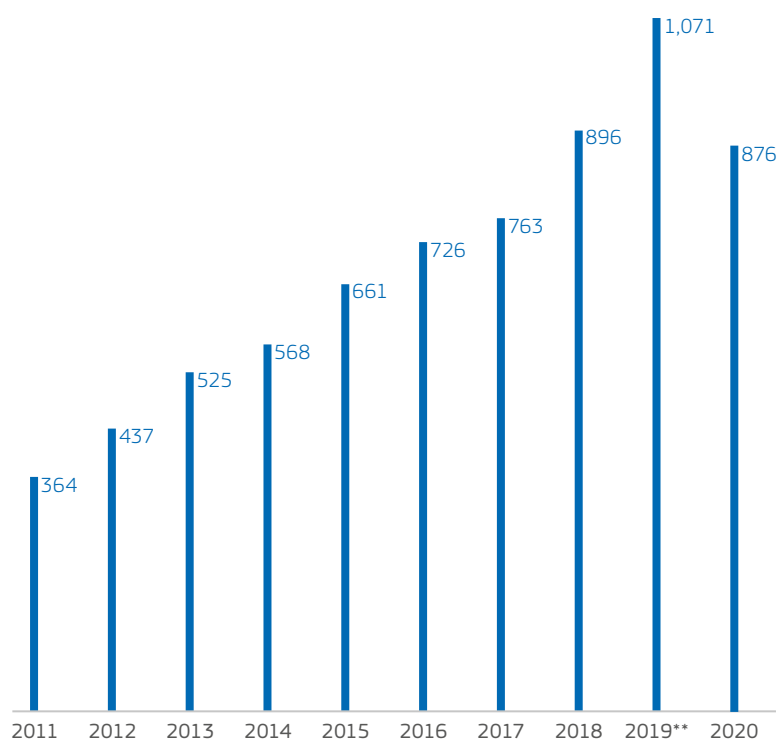
The TEC organization leads Amadeus’ technical research, whose goal is to understand the travelers’ behaviors and create a smarter, seamless and more sustainable travel experience, leveraging digital data, computation power and Artificial Intelligence (AI). To that aim, we have an active academic collaboration program with several PhDs (e.g. price prediction, understanding customers’ online behavior for searching and booking), as well as internal exploration (e.g. hardware acceleration,¹ or APIs imbedding AI for flight delay and travel recommendations).

¹ Using specific computation capabilities to execute a dedicated task faster than a regular computer could do.

In 2020 Amadeus led the European travel industry's R&D Investment Scoreboard for the ninth year running. Amadeus also ranked third largest R&D investor in the European software industry.

Recruitment for Amadeus' engineering teams is oriented toward incorporating a wide range of expertise and international cultures. Staff mobility, short- or long-term, is encouraged between both

Amadeus R&D investment*



● R&D investment (figures in € million)

* Gross expenditure on R&D.

** Due to recent changes applied to our accounting systems, which allow for a better tracking of our R&D activity, from January 1, 2020, the scope of R&D investment has increased vs. previous years. For comparability purposes, the 2019 R&D investment figure has been restated according to this change in scope.

business expertise domains and geographical locations. Amadeus also offers numerous internships to top international schools, with formal recognition of their contribution in the form of an annual intern contest. Since 2015, Amadeus has promoted the expert career path to recognize the value of deep business or technical knowledge. So far, more than 180 people have been appointed as experts and specialists in all our critical functional and technical domains.

Technology centers worldwide

The Amadeus engineering community is organized as a network of technology centers across the world. These technology centers create a pool of globally distributed resources that share responsibility for larger globally used products as well as providing local specialization. The localization is based on either technically specialized teams or deep local market knowledge relevant to our customers.

In 2020 we've responded to the COVID-19 business impact to Amadeus and our customers by reviewing our technology organization resource levels and locations. As a result, we've consolidated some of our technology centers and reduced resources as appropriate and required. In spite of the challenges, we've continued to operate dedicated technology teams in the same locations as key customers, for example in our Dallas, Dubai, Tokyo, Seoul and Sydney sites.

All technology sites work closely together, and our projects and product development processes are increasingly distributed over several regions. Nice (France) and Bengaluru (India) are the largest technology centers, with single-site and global teams developing solutions for all our business units, as well as the TEC organization developing the core platforms and technology.

Amadeus' global operations groups within the TEC organization develop the operational tools and deploy the infrastructure in our data centers. Our growing public cloud deployments are also governed by the TEC organization. In addition, it has full responsibility for operational support based on a follow-the-sun model, with dedicated specialist support groups in Australia, Germany, India, the United Kingdom and the United States. This distribution over strategic locations in different time zones ensures that round-the-clock service is guaranteed with the fastest response to any customer incident.

Amadeus provides its staff with a stimulating environment that fosters creativity and helps spark innovative thinking, promoting teamwork and staff interaction. Our office buildings have a collaborative space design to facilitate the dynamic deployment of teams, both on site and across sites. This is an essential component of our development methodology within a geographically distributed organization.

In 2020 Amadeus has managed the challenge of the pandemic closing access to our offices across our entire technology team. This involved ensuring that all employees could work effectively from home-office for as long as necessary. Amadeus successfully achieved this goal and the engineering teams in all locations have demonstrated great commitment in continuing to deliver for our customers.

State-of-the-art development methodology

Early in 2014 we started introducing Agile methodology into our software development activities.

Agile is a set of practices and collaboration tools mapping all phases of software development in frequent iterations (sprints) managed by small teams, instead of sequencing the specifications, coding, testing and delivery with a large organization. This methodology is now widely used in modern IT companies.

Cutting product development into smaller chunks gives better control over the progress of a project, and, very importantly, ensures the convergence between functional specifications and customer requirements. It's also instrumental in leveraging the high modularity of our systems, allowing the applications delivered to our customers to share and reuse functionalities and technical components.

Considering the functional span and complexity of our products, typically involving large development efforts, we've adopted the Agile methodology to encompass the activities of multiple teams, frequently spread over various sites.

In many cases, we've also involved customer representatives in the Agile cycle. This is why, as of 2018, we've been embracing the industry standard SAFe® methodology (Scaled Agile Framework). SAFe promotes collaboration and alignment for a very large number of Agile teams along the whole production cycle, from the product requirements stage to delivery. As it's a standard, it makes it easier to collaborate with customers and technology partners. SAFe has been adopted as the global methodology for the whole Amadeus organization, including our commercial activities.

Despite the exceptional context of 2020, we developed a strong internal pool of SAFe experts who have been able to continue our business agility journey. We've deployed SAFe through Agile Release Trains in various business units supported by a strong and robust training plan. Indeed, SAFe comes with an implementation roadmap including training courses for every team member and their management, upskilling employees with quality learning and official

certifications recognized in the industry. In 2020 we've been able to train more than 1,000 people on the SAFe model in accordance with their roles. Following and expanding the SAFe Agile Release Trains, we've explored and implemented Lean Portfolio Management at various levels of the organization, promoting more transparency and alignment in our business strategy and investment funding.

The objective is to accelerate the value development cycle, connecting more efficiently commercial functions to the whole software development cycle, align strategy to execution and maintain extremely high levels of quality. For Amadeus, this is a very beneficial investment, as we manage a large volume of features and functional evolutions for a wide range of customers.

In 2020 we continued our SAFe implementations, strengthening our full implementation of Continuous Integration/Continuous Delivery (CI/CD). CI/CD is a set of best practices and tools used to automate and monitor the software production cycle, from programming to delivery. And we went above and beyond with the adoption of Lean Portfolio Management practices. These practices align strategy and execution by applying Lean and systems thinking approaches, improving arbitration of priorities and budget allocation.

In 2019/2020 a large proportion of our applications went under CI/CD, from development to pre-production. This has led to noticeable improvements in the overall time to deliver many projects. It also allowed us to launch tools decommissioning initiatives to rationalize our ecosystem.

The last element of the software development cycle, which is actual deployment to production and operational management, has been addressed since 2018 by promoting a DevOps approach. DevOps is both a type of organization mixing development and operational skills, and a set of practices, procedures and tools covering application management in a production environment.

Following successful DevOps pilots in 2019, in 2020 we've successfully implemented the first major DevOps team for our travel reservation platform. This is one of our largest and most critical applications, and so is a major step on our road toward a fully DevOps-based delivery model that will continue in future years.

An effective cloud-based architecture

Cloud-based architectures encompass a set of design practices and concrete technical implementations all aiming to provide the highest levels of flexibility, reliability, resilience, scalability and performance for very large systems. They promote an explicit separation and abstraction of the application, platform and infrastructure layers.²

The core concepts are based on redundancy, isolation and operational monitoring of components in a distributed architecture, providing built-in scalability and intrinsic tolerance to system failure. Applications are containerized and can easily be deployed over any compliant infrastructure.

One unique benefit of cloud-based architecture is the ability to seamlessly distribute an application over several infrastructures. This provides a full solution to resilience and capacity management. Applications will always be up and running on one of the infrastructures, and there's no limitation to adding (or reducing) the number of machines in each infrastructure where applications are executed. For business applications, this translates into the ability to handle extremely large volumes of data and processing with quasi-continuous system availability.

In 2020 Amadeus clarified its cloud strategy and advanced toward a cloud native model. This means all new applications will be developed to optimally take advantage of the benefits of deployment in a cloud environment. We've already started preparing our existing applications. Amadeus Cloud Services is central to this model and has been further defined and developed in 2020.

Amadeus' cloud model is flexible enough to support different types of applications. Applications that weren't initially designed for cloud deployment can be migrated with some adaptations but may only benefit from a subset of the advantages in this set-up. Designing applications specifically for the cloud allows us to maximize their value, whether it's the optimization of infrastructure costs, scalability, agility to deploy evolutions quickly, or the optimization of operational costs through powerful automation. The cloud native world, which is fostering small computing units called microservices, is also maximizing the reuse of components across applications.

² These layers are often referred to as SaaS (software-as-a-service), PaaS (platform-as-a-service) and IaaS (infrastructure-as-a-service).

We may not necessarily re-engineer all our applications to be cloud native. However, our technical strategy is to ensure that any new project – or any new feature developed for an existing application – can be done in a cloud native way.

This year we took some giant steps toward a cloud native architecture. The technology vision has been matured and a new infrastructure platform to host cloud native applications and services has been introduced to production. This new platform provides a parallel hosting environment to our traditional platform and hosts our new cloud native applications. This enables seamless integration of new cloud native applications with the existing applications hosted on our traditional platform. The cloud native platform also simplifies the evolution of our traditional applications into a hybrid model to allow them to migrate smoothly to modern designs. Several Amadeus applications are now running on our cloud native platform, and the platform is also hosting numerous cloud native extensions for our traditional applications.

As part of creating Amadeus' cloud native application design, we made a lot of progress in the use of an event-based communication model between application components, called Realtime Stream Processing. This means that on top of an application component being able to explicitly call another to execute a use case, the application is also equipped with a nervous system of events, and any application component can react to any event in the whole platform. This enables powerful plug-and-play capabilities and offers great flexibility to implement service evolutions.

Following our successful exploration work with Google in 2018 and 2019 for Amadeus' search and shopping solution, we focused our 2020 efforts on Amazon Web Services and Microsoft Azure. We selected more complex applications from our portfolio for pilot migrations to ensure maximum coverage of scenarios required for our journey to cloud.

A dedicated team of experts formed a cloud exploration team with application architects and explored the key features of the cloud providers. They then developed prototypes and piloted the use of these features with Amadeus applications. This helped us to establish the foundation for a large-scale migration. To mention a few specific achievements this year:

- _ We incorporated the latest standards, technology and recommendations into the security design for our applications and data in the public cloud

- _ We reached new levels of automation with infrastructure as code and application blueprints, which are key for faster on-demand deployment and removal
- _ We successfully deployed Oracle instances managed by us into the public cloud in a way that meets our security, reliability and performance needs
- _ We designed different models to deploy applications to the cloud in a highly resilient way, allowing critical services to continue even if they're affected by catastrophic events

We now consider the use of public cloud in all our architecture designs. We have solutions for the rapid migration of applications to our cloud platform in our catalogue. This reduces the re-engineering effort for applications and enables them to move to our cloud platform clusters in our own data centers or the public cloud. This has particular benefits in reducing the time it takes to deploy hybrid solutions. Once applications are part of our cloud environment, they can continue to develop into cloud native services in a smooth manner. These activities have extended the proportion of our application portfolio that we can migrate directly to the cloud.

During our exploration of cloud providers, we took the opportunity to thoroughly assess their technology offerings. This identified new technical opportunities not possible in our own data centers, such as leveraging the performance of RISC microprocessors³ and the new capabilities of managed services. These managed services will help us accelerate our data platform roadmap and opening our application platform to airlines and partners.

Beyond the technical and operational benefits of distributed architectures, we believe that the evolution of our systems is fully in line with the business trends of the travel industry. The New Distribution Capability (NDC) standard of the International Air Transport Association (IATA) specifically promotes the concept of distributed travel shopping and reservation as opposed to a centralized reservation system, in which performance will become a critical factor of viability and adoption.

With our investment in cloud-based architectures, Amadeus will be in the best position to propose advanced solutions to the entire travel industry and even wider from a common core of services and data platforms.

³ A reduced instruction set computer, or RISC (/risk/), is a computer with a small, highly optimized set of instructions, rather than the more specialized set often found in other types of architecture.

Distributed operations and data centers

Medium-low impact



Data center operations are a critical element of Amadeus' strategy to deliver competitive products and services to customers. Beyond cutting-edge functionality and features, our customers also expect robust, versatile and fast systems as their businesses increasingly rely on our platforms. Capabilities such as continuous availability, sub-second response times and flexibility of deployment are becoming mission-critical business features. Response time is seen as a critical factor to adoption and conversion. Our customers need advanced security to develop trust with their users and partners, so they can safeguard their personal and financial data.

Amadeus delivers its services to customers from many locations – a combination of our private Amadeus Data Center, private clouds in remote locations, and public clouds such as Amazon Web Services, Google Compute Engine, Microsoft Azure and Salesforce.

As a key element of Amadeus' strategy, we always maintain full oversight of all operations, irrespective of the nature and location of the physical server infrastructure. This is crucial for Amadeus because of our end-to-end responsibility vis-à-vis our customers. It also ensures we can execute required changes to our technical or operational frameworks without external dependencies or constraints.

The increasing customer demand for travel information and reservations has led to a rapid and ongoing increase in our IT systems capacity needs. We've moved from a few tens of shopping requests to thousands of "hits" per booking. This inflation in demand has resulted in exponential growth in data processing and data storage requirements. Industry standards like IATA's NDC will likely increase these requirements.

In 2020 we benefited from our use of flexible on-demand public cloud computing resources. In the early part of 2020, we used additional on-demand resources to cope with peak business volumes. Then from Q2 onward we reacted to the COVID-19 business impact on our customers by quickly scaling down our resources and consolidating our computing locations to reduce our costs.

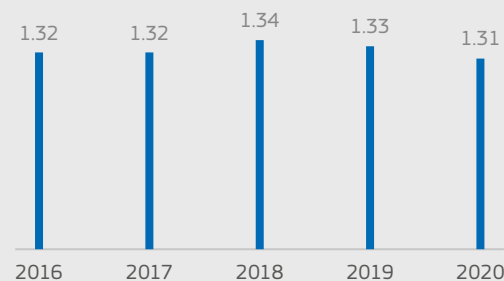
More generally, Amadeus' operations strategy is based on distributing our applications and services across multiple data centers. In 2020 we've continued to migrate our applications to the Amadeus Cloud Services framework, making them agnostic to the physical infrastructure they're hosted on. This enables us to distribute our applications away from the Amadeus Data Center and into remote public cloud data centers more easily.

The distributed operations approach delivers native redundancy of systems and dynamic capacity with on-demand models, supporting our commitment to high performance and, when applicable, regulatory constraints by moving our systems close to the customer location or in a designated country.

The Amadeus Data Center remains a key asset of this strategy. It's one of the largest data processing centers dedicated to the travel industry. It's designed with embedded redundancy, using a concept of independent fire cells,⁴ and has the capacity to host a significant number of servers, supporting one of the highest rates of transactions in the industry.

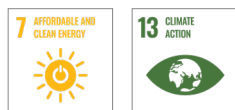
In 2020 Amadeus continued to invest in making the Amadeus Data Center a modern private cloud facility by standardizing and virtualizing the infrastructure for transaction processing, storage and networking. This enables us to use the resources more flexibly and efficiently.

Data Center Power Usage Effectiveness



⁴ Fire cells are sections of the Data Center building that are fully isolated for electrical power, cooling, networking and cabling. This is like having multiple data centers in one big data center.

Green IT and energy efficiency



Amadeus has always been focused on the energy efficiency of all its operations. →

In 2020 Amadeus also looked beyond this into innovative approaches to computing in order to reduce the power needed to deliver our services. These investigations included using artificial intelligence techniques to reduce the processing required and therefore energy used to search for suitable flights for a customer. We've also worked with technical universities to investigate the savings possible from using specialized computer processors called field-programmable gate arrays (FPGAs).⁵ These processors are highly effective and potentially deliver significant efficiency gains in large applications that can help reduce our power demand even further.

For the Amadeus Data Center, we received Energy-Efficient Enterprise certification from TÜV SÜD in March 2010 (the certification was renewed in 2012, 2015 and 2018 and lasts until December 2021) for its power supply, IT equipment and cooling and climate control processes, as well as its procurement, installation and de-installation procedures.

We've also extended our Amadeus Data Center certification to EN 50600, the new EU standard for data centers that is even broader in scope and more difficult to achieve.

In 2019 we reached our target to achieve carbon neutrality at the Amadeus Data Center. In 2020 we continued to use Guarantees of Origin to meet our zero emissions Data Center policy. This initiative continues to have a large positive impact in overall company emissions, which were reduced almost by 70%⁶ since we started using Guarantees of Origin, marking a significant

step toward Amadeus' ambition of zero company emissions by 2050, in alignment with the objectives of the Paris Agreement on climate change.

Our ongoing investments in the Amadeus Data Center have also resulted in the continued reduction of the annual Power Usage Effectiveness (PUE)⁷ ratio from 1.49 in 2009 (when this value first began to be closely monitored) to 1.33 in 2020. According to the latest annual Uptime Institute⁸ survey, the average PUE ratio for a data center in 2020 was 1.58.

Security



Security is at the heart of Amadeus' systems in terms of application design and operations. Under the supervision of our Chief Information Security Officer organization, Amadeus follows the best practices of the IT industry, securing our data, our products and our people, responding to security incidents and achieving full security compliance (e.g. ISO 27001 certification or SSAE 16 compliance).

In 2020 we continued our efforts toward compliance and maintenance, as they evolve, of advanced security standards.

In December 2020 Amadeus renewed its certification for the Payment Card Industry Data Security Standard (PCI DSS) Level 1, the highest level for card processors. This standard pertains to the management of credit card payments with the highest measures of data protection.

We've been a member of the Aviation Information Sharing and Analysis Center (A-ISAC) since 2017, testament to our continued efforts to increase our customers' trust and to implement best practices.

→ See "Environmental sustainability," p. 109.

⁵ A field-programmable gate array (FPGA) is an integrated circuit designed to be configured by a customer or a designer after manufacturing.

⁶ The 70% reduction refers to scope 1 and 2 emissions combined. Scope 1, as per the Greenhouse Gas Protocol standards are direct emissions from burning of fossil fuels, Scope 2 are emissions related to the use of electricity.

⁷ A common metric used to measure the energy efficiency of data centers. The closer to 1 the PUE, the more efficient the data center is.

⁸ The *Uptime Institute Journal* was founded in 2013 to promote the thought leadership, innovation and proven methodologies of various disciplines and professions within the global data center industry.

Amadeus has taken the necessary steps to comply with the General Data Protection Regulation (GDPR) introduced in May 2018 by the European Union regarding data privacy. We conduct a continuous assessment of compliance for all our systems and processes pertaining to personal private information with the support of specialized consulting firms.

From a global operations and technology perspective, Amadeus relies on an independent Security Operations Center (SOC) to monitor the security status of the services we provide to customers 24/7. This service also helps us understand emerging technical threats and invest in the most appropriate technology to mitigate new risks. The SOC covers the application development process, the Data Center infrastructure, employees' office activities and cloud services.

All Amadeus staff, regardless of function and location, receive continuous training on security and data confidentiality best practices. For technology divisions, this is complemented by dedicated sessions on application security, based on state-of-the-art practices known as secure development lifecycle (SDL) and on defense-in-depth for the protection of IT infrastructure.

With the adoption of new and disruptive technologies such as social networks, mobile, big data, cloud deployment and connected objects, Amadeus must protect its systems and customers from new types of vulnerabilities, cyberattacks and fraud. In 2020 we continued to deploy new tools and services to enhance our proactive capabilities for the detection of potential incidents and our ability to respond to new fraud practices as they emerge.

From open API to a platform-enabled strategy

Amadeus was the first global distribution system to introduce a structured API back in 2000 that later evolved to XML and web services. Today we expose more than 1,000 services out of our central applications, not counting the APIs exposed for the web front-ends and mobile applications. Our APIs power a large ecosystem of travel actors and are becoming a value-adding business in itself, enhancing Amadeus' position as the reference source for travel services.

Amadeus' open API concept is primarily about being more systematic in the exposure of Amadeus' systems functionality and in aligning with industry best practices (i.e. being API-minded). Beyond the modernization of underlying technical frameworks, the objective is to promote the business dimension of our APIs. This facilitates the creation of new generations of solutions, by opening Amadeus functionality for collaboration with third-party services. We can enhance our own services, leveraging our past investments, and customers can complement our services with their own custom development.

Amadeus for Developers⁹ is our open API program dedicated to start-ups and third-party developers to experiment with the Amadeus functionality within their own products and services. There's a large flow of demand for this coming from both travel and non-travel sectors. In 2020 we further enriched our offer by exposing openly and for the first time, booking, hotel and destination API capabilities. With this, we provide travel sellers with additional services which are reducing their development efforts, especially when the functionality deals with multiple travel providers.

Amadeus goes beyond the Open API model with its platform strategy. The concept of platforms is general to the industry and practiced by major players such as Adobe and Salesforce.

In previous years, we made substantial progress on the development and initial deployment of the Amadeus Airline Platform. Airlines have been extremely receptive to our platform strategy, which they value for its potential to give them greater flexibility for innovation

⁹ More information on Amadeus for Developers can be found at <https://developers.amadeus.com/>.

and differentiation. Several hackathons conducted with airlines have demonstrated that this approach speeds up the delivery of differentiating features and that airlines benefit from a shorter time to market.

In 2020 we set out our vision and our plan to extend this platform with a catalog of data, machine learning capabilities, microservices and more. The vision is to make it a unique technology hub where all travel players (travel providers and travel sellers), as well as third-party partners can autonomously access Amadeus' functionality to build their own independent new services or complement Amadeus services.

Advanced data analytics and business intelligence



Our customers' expectations of offer and sales systems are very high. They don't want raw data, but insightful information on behaviors and patterns that can help them create the right offer to the right customers and boost sales conversion. They want to turn data into knowledge, and then use it to trigger actions in real time. This is what we call data-enriched transactions.

Amadeus has long been building data management applications offering our customers a comprehensive view of their travelers and the travel business environment. This entails capturing and analyzing a large amount of information about the traveler and the context in which they interact with the system – before, during and after a trip. Such massive amounts of information, often referred to as “big data,” must be stored, mined and transformed into meaningful parameters that can later be injected into real-time transactions.

To support the growing demand for data and keep up with the exponential growth of data volumes, we leverage techniques such as NoSQL databases and grid-based distributed data clusters (Hadoop).¹⁰ We're also moving to

¹⁰ NoSQL and grid databases are frameworks specifically designed to manage extremely large volumes of data and documents for transactional flows, interactive search and analytics. Data can be distributed over several data centers in a synchronized manner. These techniques are cloud-compliant and used by all major IT players.

cloud-based architecture for deployment that will support rapid growth of data volumes in the future. Our framework is used for all functional domains and customer types. For airlines our digital platform relies on the framework to store data and manage events. It also supports our distribution, airport and hospitality business lines. Internally we use the data framework to capture and monitor the large volumes of technical data coming from the operation of our systems.

Our global data platform is capable of handling exceptionally large volumes of data that enables predictive analytics, even on unstructured data. We also integrate the results of these analyses with our transactional applications to make the resulting services data-driven.

Our framework includes powerful data analytics techniques, some in real time that are based on supervised and unsupervised machine learning, including deep learning algorithms coming from the artificial intelligence domain. Examples of current use cases that are already creating value include machine learning algorithms that are used in areas such as:

- _ Flight management to improve fuel load and optimize cargo
- _ Schedule recovery to rebook passengers affected by delayed or canceled flights
- _ Shopping and low-fare search products to minimize central processing unit (CPU) utilization

Beyond the improvement of operational efficiency or improved revenue generation, these applications of machine learning help Amadeus and our customers become more energy efficient and environmentally friendly. →

We believe that our global approach to data and analytics is the basis for a positive feedback loop: the more data, the more relevant the pattern analysis, in turn feeding back transactions with contextual information and generating more data.