Technologies and processes for establishing products from advanced technologies

Corporate Vice President **Mitsuro Antoku**

1. Introduction

With the spirit “Do what others won’t” in our DNA and as indicated by the vaunted name “Technology of Nissan,” Nissan has created values through technology and delivered them to our customers as products and services.

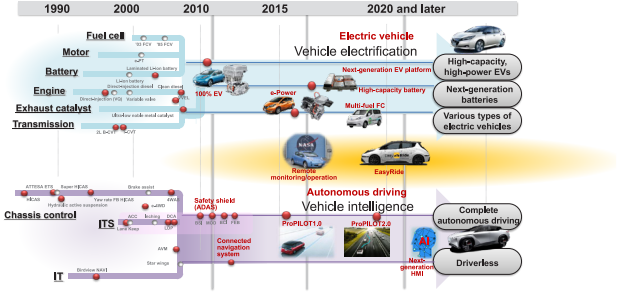
Any advanced technology is meaningless unless its resulting product can be used with pleasure by customers and unless it contributes to solving social issues such as global warming and traffic accidents. This preface describes how advanced technologies necessary for offering such value are born, nurtured, and applied to products.

2. Technology roadmap

At Nissan, the roadmap for developing technology required to realize future visions was created long ago. All research and advanced developments are conducted based on this technology roadmap.

The technology roadmap was created considering the following: “What values offered in our future products and services will our customers find attractive?” To answer this, the requirements and trends of society, as well as the issues that arise from them, are investigated. Technological developments necessary to realize a solution to such issues are incorporated into this roadmap.

In most cases, establishing a new technology requires a long time. Therefore, it is crucial to develop a roadmap, which is a long-term technological strategy. Further, it is important to update this technology roadmap considering changes in social trends, changes in customers’ values and activities, and the evolution and innovation of the technology. The technology roadmap for electrification and intelligence are shown as examples.

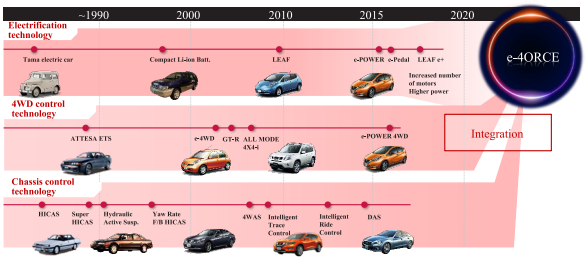


Progress of Nissan’s technological development

3. Research and development to advanced development

A new technology is established in a step-by-step manner from basic research and development (for creating the basis) to advanced development (for practical applications). After completing the research and advanced development of individual technologies, it is possible to combine them to create a new technology. However, sometimes, even after the advanced development process is completed, these technologies may not yet be ready for product application. In such cases, it is crucial to continue the development activities to achieve the original roadmap.

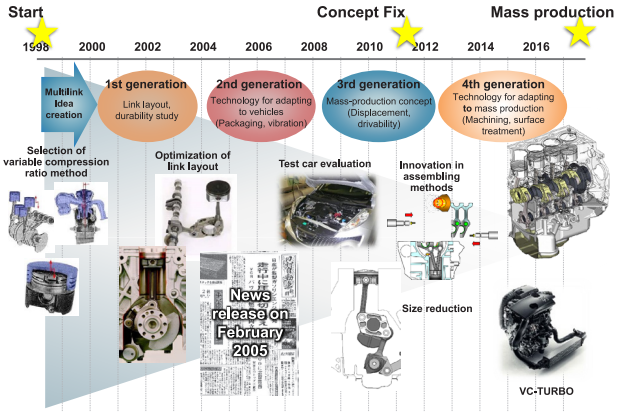
The research and development of motors and batteries, which Nissan had started prior to 1990, did not bear fruit until 20 years later in 2010 as the product Nissan Leaf, the world’s first mass-produced EV, and until 2017, as Nissan’s unique electrification system e-POWER, which offers new value to many of our customers. Another example is e-4ORCE technology, which originated from the 4WD control technology ATTESA ETS and chassis control technology HICAS, which were cutting-edge technologies in the 1990s. They have evolved over the years, integrated with electrification technology, and bore fruit as an integrated control technology e-4ORCE. The e-4ORCE technology performs minute integration control of the front/rear motor drive AWD and chassis system such that the ease of handling, ride comfort, and sense of security can be realized at a high level in any driving scenario.



History of e-4ORCE

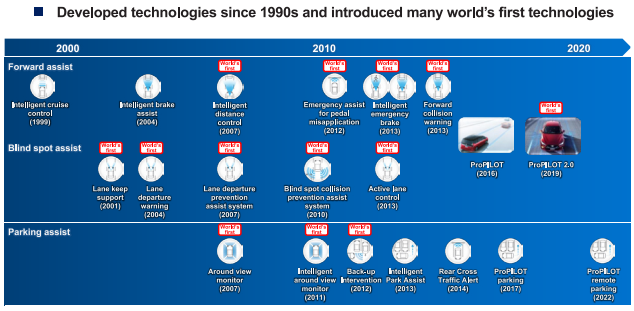
Nissan's VC-TURBO engine, which achieves both high power and low fuel consumption through its variable compression ratio mechanism, took 18 years to develop from its conception to realization. The impressive results achieved were the result of the dedication and hard work

of engineers who made steady progress through research and development, including the advancement of manufacturing technology.



Development history of variable compression ratio

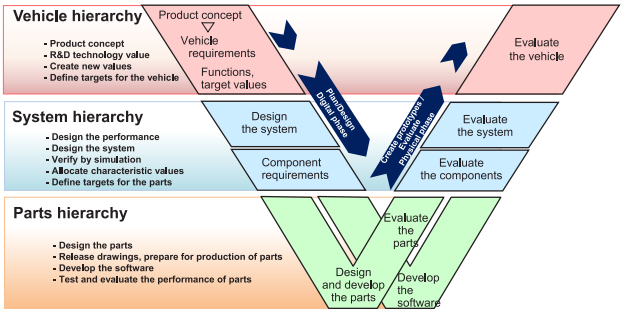
For the drive-assist technology ProPILOT, the development of its basic elemental technology began more than 20 years ago, and individual technologies (many of which were the world's first at the time) have been applied to products since then. These technologies have achieved results and gained market experience, and ProPILOT is a compilation of these technologies.



Evolution of drive-assist technology

4. Development for application to products

The development of a product starts by deciding what characteristics (concepts) to assign to the product. The product concept is determined after performing sufficient market research. Some factors to consider in the research include "Where does the target customers live, and what should the customers' social status be? What kind of value do customers desire?" In the meantime, existing technologies, as well as technologies that have undergone research and advanced development over the years, are combined to study whether it is possible to create new value for the target customers. Such values are coordinated as a whole to convert them to characteristics that are consistent as a product. Thus, value is elevated to an attractive product concept. Teams involved in development, planning, design, and marketing and sales performed these activities, and the characteristics of the products were determined during this process.



Flow of product development

The next step is to define functions and target performances for realizing the product concept and determine the technologies and their combinations that need to be applied. Advanced technologies are part of the technologies intended for application. To develop a technology for product application, its functionality and performance are enhanced to transform it into a new value. Multiple reviews are conducted to ensure that customers can comfortably and easily use the technology at all times and that the final product is easy to comprehend and operate. During this process, it is essential to investigate the required functionality and performance by considering the different ways in which the product will be used.

After the functionality and target performance of a vehicle are defined, the next step involves performing a detailed design of the systems and parts necessary to achieve the functionality and target performance. To achieve the targets of a vehicle in a complex system, it is necessary to allocate performance targets to the systems and parts and then verify the level of achievement of each target. This activity is the so-called performance-design process. This is an important product development process. Technologies for performing system-level and part-level tests and simulations play an important role in this process.

As featured in this technical review, improvements in testing and simulation technologies have enabled the evaluation of elements and systems in the design phase, contributing significantly to improving the level of design assurance. Nissan is also committed to analyses using digital technology, which reproduces actual vehicle-level events in cyberspace in real time.

Using virtual reality (VR) technology, events based on tests and measurements are reproduced and verified in advance during the development and design phases. Models with actual dimensions can be evaluated in cyberspace. For example, a VR experience that reproduces the visibility according to the driver's actions (e.g., driving) can be realized if not only the design information but also the environment outside the vehicle (e.g., the surrounding environment 360° around the vehicle and the surrounding environment for the travelling distance) are reproduced when evaluating drivability, such as

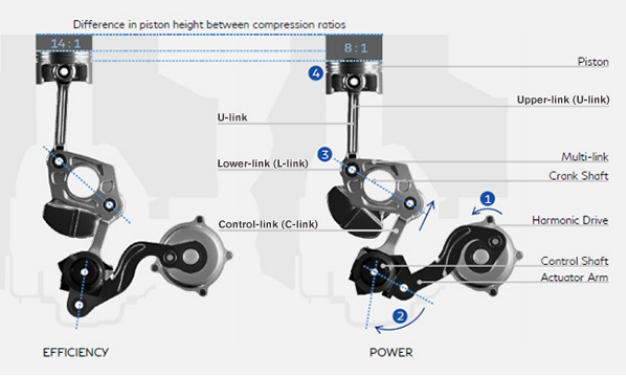
driving operation and visibility. This experience helps evaluate drivability during driving. Owing to this technology, the evaluation accuracy of the visual field of the mirror and ease of using/viewing the switches for driving operations have improved.

After the steps described above and the design of the system and parts were completed, the vehicle prototype is manufactured, and the testing and verification processes are started. This is the process of testing and verifying the assurance of functions and performance at each part, system, and vehicle level.

Owing to the recent improvements in testing and simulation technologies, it is now possible to enhance the efficiency of physical testing and verification. By integrating testing and simulation technologies, it is feasible to carry out accurate product development evaluations within a shorter timeframe. This approach has become indispensable, particularly in complex systems.

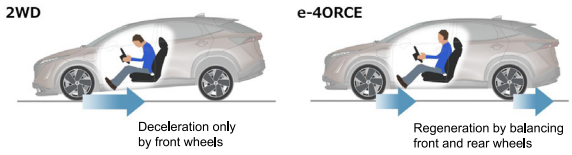
While performing efficient verification in the development phase, data are shared with the production engineering department, production plants, and suppliers. This helps ensure cooperation between the members of mass-production quality, production engineering, plant manufacturing, and suppliers to verify and confirm mass-production quality for ensuring build quality. An example of the application of advanced technology to the new X-TRAIL, which is covered in another feature of this technical review, is provided below.

When Nissan decided to use the VC-TURBO engine for e-POWER, they aimed to achieve not only high power and low fuel consumption but also a high level of quietness and a comfortable acceleration sound. Compared to conventional engines, the VC-TURBO engine could change the compression ratio in a flexible manner, which required the checking of 2.8 times more constants for conformity. The conformity check was based on various factors, including the ambient environment, driving situations, battery charging status, fuel consumption, emissions, heat management, engine sound, and quietness. Since there were many combinations of driving conditions to be checked, a model-based tool was developed, and simulations, bench tests, and actual vehicle tests were used together to efficiently determine the large number of constants that needed to be conformed to.



VC-TURBO engine

The "flat ride" concept, which is one of the values offered by e-4ORCE, was realized by fully utilizing the driving simulator. The targets for "flat ride" could not be set by comparing it with those of conventional vehicles. Therefore, Nissan fully utilized the driving simulator, and the targets were set by analyzing "how occupants feel" when a vehicle accelerates and decelerates as well as when pitching motion occurs. Before manufacturing the actual vehicle, a driving simulator was used to check whether it was possible to provide the intended feeling by the design in line with the targets.



Flat ride provided by e-4ORCE

When launching ProPILOT as a product, it was necessary to consider various requirements, such as the environment of the roads to drive on, traffic situations, and driving conditions. In addition to performing evaluations of individual parts and systems, driving simulators, and actual vehicle tests on the test tracks, Nissan performed public road driving tests for over several tens of thousands of kilometers to ensure functionality and performance. Another important part of technological development before launching the product was the development of a fail-safe design that enables customers to safely use the product, even if a component fails or if the product becomes subject to an external environment exceeding the functional limit.

When Nissan decided to apply ProPILOT to the new X-TRAIL, they undertook developments to improve its display and operability. This was done with the aim of making it more understandable, secure, and safe for customers to use. When optimizing a human-machine interface (HMI), the driving simulator is an essential technology for evaluating the operability of people with different characteristics, such as body build, age group, and driving experience.

Technologies that have undergone research and advanced development undergo a development process for application to a product. After that, the technology is established as a product that will be used with pleasure and a sense of security by customers.

The process flow does not end even after a product is launched in the market. To further enhance customer satisfaction, our technologies undergo further development so that they will evolve further and be ready for the next generation.

5. Summary

Based on the technology roadmap, an advanced technology undergoes research and development, advanced development, and development for applying to a product before it is delivered to our customers as a

product. Simultaneously, established technologies are combined and improved further so that new and higher values can be created and established as products, making them more competitive.

The advanced technologies incorporated in the new X-TRAIL were developed and established as products as described in this preface. Testing technologies, which are the other topics featured in this technical review, play an important role in establishing a product such as the new X-TRAIL. These testing technologies are often used practically after research, development, and advanced developments.

Nissan has implemented a strategy to reduce the time required for applying advanced technologies to their products. We have started to conduct early assessments of potential concerns that may arise during the product development process and are proactively working on solutions during the advanced development stage. By doing so, Nissan can establish solutions for potential issues before they become major problems and accelerate the technology integration process.

Nissan is committed to continuing to develop and integrate their unique "Technology of Nissan" into their products.