# Marketing of the "ShieldPRO" Rugged Notebook with User-Centered Design

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## Abstract

If information can be input, output and processed by using information-processing terminals even in dusty factory workshops or in outdoor environments that are exposed to harsh winds and rain, it becomes possible to implement an efficient system capable of more real-time utilization of information.

To meet these needs, NEC has developed and is marketing advanced rugged notebook computers that feature enhanced environmental resistance.

This paper introduces the process whereby we reflect customer opinion in order to enhance our products. It also refers to the markets that we have been able to develop thanks to the enhancement of products and the activities that we conduct with the aim of generating new customer values.

## 1. Introduction

NEC launched the first industrial computer called "FC-9801" based on the PC-9800 series in February 1985. Since then, our industrial computers have contributed to the construction of control/monitoring systems for production sites and social infrastructures by enabling high reliability, long-term supply and long-term maintenance support procedures.

During this process, we realized that there was a need to improve efficiency in the use of computers in the production management and job systems sectors. Factory workshops that are exposed to large amounts of dust and vibration and harsh outdoor environments where the computers may become wet when exposed to rain showers would also be targeted.

This paper describes how the commercialization of rugged notebooks started and how the market was developed and our products were enhanced by following a user-centered design process.

## 2. Needs for Notebook Models for Factory Computers

Factory computers have previously been used for the collection of production achievements data and other control functions in factory environments or they have been embedded in machine tool and medical instrument systems for use as their input/output terminals. However, in factory workshops, there are many factors that may induce failure if they are allowed to get into the machines, such as the metallic powder and water splashes produced by metal machining or chemical powders. In addition, traditional factory computers have by placing emphasis on extendibility not been suitable for outdoor use, because the terminal for outdoor usage basically necessitate countermeasures to deal with wind, rain and extreme temperatures.

Furthermore, factory computers of the desktop and compact types are not suitable for portable use.

In order to solve these issues and to develop new markets, NEC has developed the "FC-NOTE," an all-in-one factory computer featuring resistance to extreme temperatures, humidity, dust and water splash as well as to vibration and the impact of being dropped.
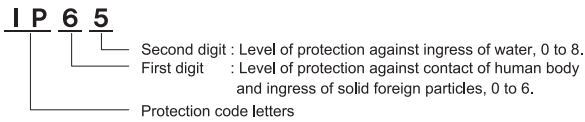
### 2.1 Launch and Market Response of the First Rugged Notebook "FC–NOTE"

In August 2004, we announced the first rugged notebook model called the "FC-NOTE N11F." It featured a 12.1-inch LCD panel with a screen enabling touch screen input without the removal of a work glove. The FC-NOTE N11F was

## IP Classification Codes

The IP (International Protection) code is the indication of the ingress protection rating of electrical equipment and cabinets against intrusion of solid foreign particles and water defined as based on international standard IEC 60529

I P 6 5

Second digit : Level of protection against ingress of water, 0 to 8.
First digit     : Level of protection against contact of human body and ingress of solid foreign particles, 0 to 6.
Protection code letters

| Descriptions of first digit | Descriptions of second digit |
|---|---|
| 0: Not protected. | 0: Not protected. |
| 1: Protection against solid objects larger  than 50 mm. | 1: Dripping water (vertically falling drops) shall have no harmful effect. |
| 2: Protection against solid objects larger  than 12 mm. | |
| 3: Protection against solid objects larger  than 2.5 mm. | 2: Protection against dripping water when the enclosure in tilted up to 15°. |
| 4: Protection against solid objects larger  than 1 mm. | 3: Protection against spraying water. |
| 5: Dust protected. | 4: Protection against splashing water. |
|    Ingress of a small amount of dust does not interfere  with the satisfactory operation of the equipment. | 5: Protection against water jets. |
| 6: Dust tight. No ingress of dust. | 6: Protection against powerful water jets. |
| | 7: Protection against immersion up to 1 m. |
| | 8: Protection against immersion beyond 1 m. |

Fig. 1   IP code and its contents.

equipped with dust/splash resistance at a level of IP51 ( **Fig. 1** ). It could therefore be used in dusty workshops as well as outdoors. The magnesium alloy cabinet was capable of withstanding the impact of dropping from a height of 90 cm and an operating temperature range from -20 to +55°C was possible without using a cooling fan.

Although the FC-NOTE N11F seemed to have adequate specifications for meeting user needs, the market response to it was unexpectedly low.

The primary cause was a price that could not meet market needs. The lack of competitiveness in the pricing brought us successive failures in business talks regarding the deployment of a large quantity of products. In addition, the design of the product did not permit fine tuning of the specifications (customization) to satisfy user's particular requests.

Therefore, we decided to newly develop a replacement model for the original rugged notebook and launched the "Shield-PRO N21S" in December 2006.

### 2.2 Development of the ShieldPRO as a Reflection of User Needs

Before developing the ShieldPRO N21S, we performed a thorough investigation of user concerns and information sharing of prospective users in an attempt to reflect the opinions of the FC-NOTE N11F users and of prospective customers regarding the product development.

Firstly, members of the development team visited user sites together with the sales promotion staff in order to hear customer opinions directly. They were also able to investigate usage situations and to sort out any unresolved issues.

Secondly, on a regular basis, all of the development members read the inquiry mails received from users and customers considering purchase in order to share information on current issues and on what was required of them.

We also carried out a periodical questionnaire of registered users each year to survey their satisfaction levels from multiple aspects, including product satisfaction, marketing, maintenance and repair. The information thus obtained by this survey served as tertiary support information.

As a result, we were able to confirm that apart from issues related to the price, customers who mainly used the computers outdoors for field maintenance or vehicle servicing often needed further improvement of dust/splash resistance, extension of battery life, improved display brightness and a reduction in the weight. Moreover, we also found that customers who mainly use the devices in factories and for defense/fire-fighting purposes have more precise needs that are specific to industrial computers such as confidence regarding their long-term supply and long-term maintenance support ( **Table 1** ).

Based on the market needs identified above, we defined six explicit user-centered design targets for the ShieldPRO N21S, as follows.

1) Dust/splash resistance at the IP54 level for outdoor use.
2) Long-hour battery life (8 hours or more).
3) -20 to +50°C operating temperature range for use in cold climates or on vehicles.
4) Ample selectivity including a backlit keyboard.
5) Convertible design enabling both notebook and tablet type use.
6) Long-term supply/maintenance system for security and equipment embedding applications.

We challenged a variety of new designs in order to achieve the above targets. For example, with regard to improved dust/splash resistance, we developed new splash-proof keyboards and double-skinned magnesium-alloy cabinets with the aim of improving resistance to the IP54 level. We also prepared special dust/splash-resistant cables and connectors for the LAN as well as serial interfaces and power connectors, in order to maintain dust/splash resistance even when cables are connected. For the drive time, we succeeded in an impressive increase from the previous 5 hours to 8 hours by realizing the coexistence of high performance and low power consumption supported by the Intel Core Solo ultra-low voltage type microprocessor.

Table 1   Market needs for rugged notebooks.

| Needs / Usage | Resistance | | | | | | Conditions | Other Requirements |
|---|---|---|---|---|---|---|---|---|
| | Dust | Splash | Vibration | Impact | Temp. | Humidity | | |
| Portable factory terminal (Inspection, picking, production management, etc.) | ✓ | | | ✓ | ✓ | | Light weight, use with work gloves | Backlit keyboard (for use in warehouse, etc.) |
| Fixed factory terminal (Production management, equipment control, etc.) | ✓ | ✓ | ✓ | | ✓ | ✓ | Fixing bracket, tablet type terminal | Long-term supply/ long-term maintenance, dust-protected cables |
| Equipment embedding (Control panel, medical equipment terminal, etc.) | ✓ | | ✓ | | ✓ | | Tablet type terminal, Software keyboard | Long-term supply/ long-term maintenance, English OS (overseas) |
| Car-mounted use (Truck, forklift, etc.) | ✓ | ✓ | ✓ | ✓ | ✓ | | Use with work gloves, wireless LAN | Silicon disk |
| Field maintenance terminal (Electricity, gas, city water, vending machines, etc.) | ✓ | ✓ | | ✓ | ✓ | ✓ | Light weight, long-hour operation, shoulder belt | Outdoor legibility, communication card (splash resistant), easy battery replacement |
| Shops (Servers, shop terminals, etc.) | ✓ | ✓ | | | ✓ | ✓ | 24-hour drive | Keyboard cover, AC adapter unplugging prevention |
| Police (Crackdown on illegal parking, etc.) | ✓ | ✓ | | ✓ | ✓ | ✓ | Light weight, long-hour operation, shoulder belt | Keyboard-less operation, fingerprint authentication (particularly overseas) |
| Fire fighting (Ambulances, fire engines) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Ignition startup | -20 to +50°C operation |
| Defense | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Nonreflective coating | -20 to +50°C operation, backlit keyboard, long-term supply/ long-term maintenance |

For the LCD panel, we developed jointly with NEC LCD Technologies, Ltd. an LED backlit LCD panel capable of an instantaneous bright display even at low temperatures. The previous cold-cathode tube type backlight had been troubled by the problem of poor visibility in low-temperature warehouses and in snowy environments due to a noticeable drop in brightness below zero degrees centigrade. We succeeded in solving this problem with the LED backlight of the ShieldPRO N21S. This model has also greatly improved workability by increasing the viewing angles by 50° horizontally and 60° vertically. To respond to the need for minimizing the weight in consideration of outdoor use, we reduced the weight to about 2.5 kg, which is the lightest among the competing rugged notebooks that are equipped with 12.1-inch panels.

Furthermore, we have designed a durable rotary hinge to implement a convertible computer with which the display panel is attached by a rotary hinge so that it may be used either as a notebook or as a tablet type terminal. In addition, we have also designed an LCD panel lock mechanism based on actual drop testing so that it could optimally withstand the specified dropping impact.

In order to secure the long-term supply and maintenance, we have adopted a CPU for the embedded equipment and designed suitable circuitry by adopting components that are expected to be supplied for as long a period as possible. For the OS, too, to support the embedded systems we selected "Windows XP Professional for Embedded Systems" among the Microsoft products; because this OS was expected to be supplied for a long period for use with embedded equipment.

All of the above selections led to increased cost, but we decided to challenge our competitors by making such an innovative choice in order to fulfill the expectations and requirements of users for efficient factory computers.

We also prepared generous selection menus for use with the backlit keyboard, English OS and suitable types of memory capacity, hard disk, silicon disk and battery as well as the use

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Use in fish markets
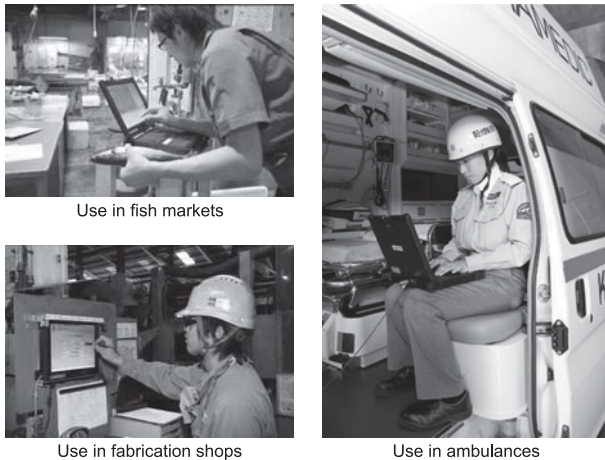
Use in fabrication shops

Use in ambulances

Fig. 2　Various applications of ShieldPRO N21S.

of wireless and fingerprint authentication. Thereby, users could select detailed specifications according to their applications needs even when purchasing only one unit.

As a result of the development as described above, the ShieldPRO N21S has radically expanded application fields from those of the FC-NOTE N11F, to include production management terminals for chemical and steel manufacturing factories and terminals for use in the development and servicing of automobiles as well as in outdoor and car-mount applications for defense, fire fighting and policing duties ( **Fig. 2** ).

By the way, we named the series "ShieldPRO" in consideration of the association with its similarity to the Japanese pronunciation of the word "Sealed" as well as to represent the initial letters of the following six words.

- Secure
- Hard
- Innovative
- Environment-friendly
- Lightweight
- Durable

This naming is intended to improve product recognition and to support the development of new markets that are different to those of traditional industrial computers.

## 2.3 Application Analysis of ShieldPRO and Efforts Aimed at Product Enhancement

After making the first steps toward the development of new markets with the ShieldPRO, we were able to identify the is-

sues of concern to individual users in more detail.

For example, the main requests from users of the Shield-PRO from both outdoors and inside factories included: the impossibility of one-touch battery replacement, insufficient battery drive time, insufficient screen brightness, the frequency of losing the touch pen stored at the bottom of the case, the difficulty in identifying the direction of turning the screen when changing from the notebook design to tablet design, the necessity of a shoulder belt for long hours of portable use and the necessity of holding communications using a FOMA card even in rainy weather. Minor requests that might be detected only by actual users were also addressed from users operating the ShieldPRO inside factories. These included issues such as: a mechanism for preventing the AC adapter from slipping out of the body, the need for a mechanism for fixing the ShieldPRO to an arm, the rise in temperature of some of the parts after long hours of keyboard operation and the need for a software keyboard for using the ShieldPRO in place of a panel type computer. There were also strong requests from car-mount and security users regarding: insufficient capacity of the silicon disk when required, issues regarding the vibration resistance and the need for a removable fixing method.

We therefore developed a successor model, the "Shield-PRO N22A" ( **Photo** ) that was designed to feature the following modifications, aiming at improved convenience of use.

**1) Redesign of cabinet**

To improve the ease of use outdoors, in factories and for car-mount applications, the cabinet of the ShieldPRO N22A was newly designed.

We first designed a mechanism allowing the battery and HDD to be replaced easily without affecting the dust/splash resistance by simply opening a cover on the side panel. A sealing material was applied around the cover to ensure the splash performance and the lock mechanism was
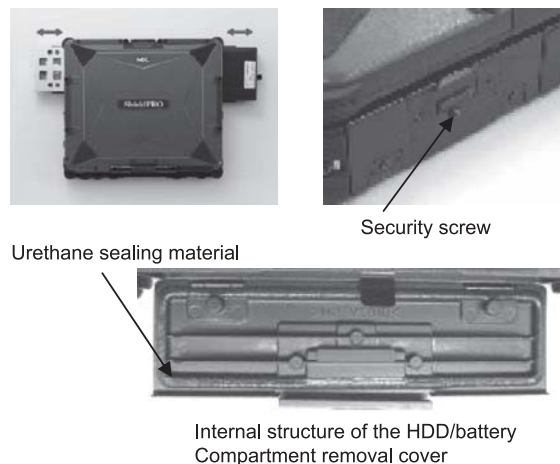


Photo　ShieldPRO N22A.

Urethane sealing material

Security screw

Internal structure of the HDD/battery
Compartment removal cover

Fig. 3   Construction of the HDD/battery compartment removal cover.



← Interface cover achieving
IP65 level dust/splash
resistance while considering
the operability even when
the operator wears work gloves

← PC card slot cover permitting
the use of a communication
card, such as a FOMA card,
even in rainy weather

Fig. 4   Interface covers with improved dust/splash resistance.

redesigned to enable opening and closing by a user wearing work gloves. We also provided the cover with a screw lock mechanism for users who do not want the cover to be opened or closed too easily ( **Fig. 3** ).

In addition, we prepared a long-hour battery operation model with a 12-hour battery drive capability together with an optional long-hour battery having the same size as the standard battery. This new cabinet facilitates battery replacement, even in outdoor situations necessitating long hours of battery drive, such as in field maintenance and during schemes to control illegal parking. At the same time, the maintainability of the HDD replacement has been greatly improved.

**2) Improved interface covers**

To achieve higher dust/splash resistance (IP65 level), the ShieldPRO N22A adopted a more closely fitting interface cover than in the previous model, but this has caused the difficulty sometimes in opening the cover. Therefore, we cooperated with NEC Design & Promotion and studied the cover design options for ease of opening, even for a hand wearing a work glove. At the same time we considered the need for a balanced design of the main body.

As a result, we succeeded in creating a cover that could also reduce the risk of sideward damage even if the device is dropped.

In addition, we prepared a PC card slot cover as an option in order to provide dust/splash resistance even when a communication card such as a FOMA card is used ( **Fig. 4** ).

These improvements have made it possible to conveniently connect a USB cable in a factory workshop without removing work gloves and to transmit images using a communication card in the field in rainy or dusty environments.

**3) Extension of the LCD bright area**

For the ShieldPRO N22A, we increased the maximum brightness to 750 cd/m $^2$ and enabled the brightness adjustment in sixteen steps down to the minimum brightness of 1 cd/m $^2$ . This has resulted in a sharp display when the device is operated under bright daylight as well as in low light at night or in a warehouse. The LED backlight contributes to the implementation of a minimum brightness of 1 cd/m $^2$ without irregularities.

Anyone who has experienced a visiability problem when using a cell phone in bright outdoor light may understand how important it is to improve the display brightness. On the other hand, with regard to defense and police usage in which the terminals are often used outdoors at night, a user tends to suffer from a loss of view of the surroundings after watching the display panel unless the brightness is sufficiently low. The expansion of the LCD brightness range has solved these problems.

**4) Improvement of details for more convenient usage**

With the previous model, the touch pen was stored at the bottom of the case, which made it necessary to lift the case lid to access the touch pen which sometimes resulted in the loss of the touch pen. Therefore, we improved the design with the ShieldPRO N22A by installing the touch pen case

Indication of rotation direction for conversion from notebook design to tablet design

Canopy for hiding unnecessary arrow

Indication of rotation direction for conversion from tablet design to notebook design

Fig. 5 Explicit indications of panel rotation direction.

Table 2 Improvements to the ShieldPRO based on user needs.

| Improved features of ShieldPRO N22A | Advantages, New Usage and Fields, etc. |
| --- | --- |
| CPU enhancement (Intel Core Solo → Intel Core2 Duo) | Increase in processing speed, compatibility with virus checking software |
| Change of heat radiation mechanism location (Side of keyboard → Bottom of body) | Improved operability of keyboard input |
| Improved dust/splash resistance (IP54 → IP65) | Expansion of police/defense usage, ease of use under rainy weather |
| Increased display brightness (300 cd/m² → 750 cd/m²) | Improved operability of field maintenance |
| Improved ease of battery/HDD replacement | Improved operability of field maintenance |
| Addition of long-hour battery (12-hour drive) model | Expansion of field maintenance and police usage |
| Change of touch pen storage location (Bottom → lower left of display panel) | Improved operability of field maintenance and factory usage |
| Addition of an brightness sensor | Improved operability as a single terminal for outdoor/indoor usage and of field maintenance usage |
| Addition of panel rotation direction indication arrow | Improved operability as a single terminal for outdoor/indoor usage and of field maintenance usage |
| Addition of shoulder belt | Expansion of field maintenance and police usage |
| Addition of IEEE1394 interface | Expansion of image transmitting usage such as video camera connections |
| Addition of dust/splash resistant cover for the card slot | Use of communication card in rainy weather (for news reporters and meter readings, etc.) |
| Increase of silicon disk capacity (8 GB → 32 GB) | Expansion of car-mount and building-automation usages |
| Change of top cover design | Appealing a high quality design to the consumers in the shops |
| Change of interface locations | Improved operability when using the fixing furniture |
| Addition of dust/splash-resistant cover (for the power connector) | Improvement of dust/splash resistance and prevention of plug disconnection during non-mobile mode usage |
| Adding software keyboard (attached as standard) | Easy key input during tablet mode usage |
| Improved wireless LAN directivity (use of dual antennas) | Improved data exchange during mobile mode usage |
| Addition of Bluetooth® | For use of printer/scanner in an office in which wireless LAN cannot be used |
| Improved operability of keyboard cover removal/attachment | Improved convenience of washing keyboard cover |
| Enhancement of customization (24-hour compatible HDD, server OS, special top cover coloring) | Considerations for usage as a server in a severe environment or appealing a high quality design to the customers in the shop |

at the lower left of the screen so that the pen could be taken out easily and by tying of the pen to the case with a string so that the loss of the pen could be prevented.

For users who use the same terminal in either notebook or tablet modes according to the scene of use, we marked an arrow on the rotary hinge so that they could easily understand the direction in which the display panel should be rotated. The arrow is marked so that the correct rotation position is indicated whether the terminal is used in the notebook or tablet type design ( **Fig. 5** ).

**5) Long-term supply/maintenance**

We designed the ShieldPRO N22A assuming that the new chassis would continue to be used for a long period without changing the basic construction. This was because many embedded system users are dissatisfied with repeated system which occurs by the change of the chassis in a short time and that the N22A should also meet the long-term supply/maintenance requirements of which we have developed the know-hows through factory computer business. The ShieldPRO N22A is designed to be supplied for four and a half years from June 2008 to December 2012 and to be maintained until December 2018. The supply period and maintenance period are specified explicitly on the FC series website so that users can continue to adopt the product with a secure mind.

**Table 2** lists the issues that were improved based on the opinions provided by the ShieldPRO users, including the issues already described in the above.

## 3. Results of Expansion of the ShieldPRO New Usage

The ShieldPRO N22A was eventually launched in May 2008, bringing users the new usages that had previously been unavailable.

One of these is its use as a simplified image transmission

terminal. By using the ShieldPRO together with a video camera and special software, a news reporter at an accident or disaster side can distribute video image via a network such as FOMA. Such video image distribution solution is being studied by the disaster countermeasure offices of local governments.

A large number of ShieldPRO terminals have been adopted for the illegal vehicle parking control terminals of police departments. In Japan, we may often see official patrols checking illegally parked vehicles using a ShieldPRO with a shoulder belt.

The increasing capacity of the silicon disk and vibration resistance led to the case studies to install ShieldPRO to forklifts and pickup carts of the parts/components in factories.

In addition, ShieldPRO customized model with a large-capacity HDD with 24-hour continuous operability and/or server OS were used for the servers of fast food chains and in the ETC toll collection systems on the expressways. Thanks to the excellent dust, vibration and temperature resistance, the Shield-PRO could be used safely as a server or terminal in the environments which ordinary servers has some difficulties in the operation, for examples, locations including oil, dust, vibrations of large vehicles and extremely high and low temperatures.

As seen above, we have developed a very wide range of usage for the ShieldPRO by improving the product in accordance with user needs. In addition, members of the development team continue to accompany sales staff on visits to users in order to obtain a deeper understanding of user needs and to monitor results. In this way we are able to learn from actual cases and to thereby introduce a wider range of usage to support sales staff and customers. This makes it possible to continue to develop additional innovative usage and to create enhanced value for customers.

## 4. Conclusion

Information terminals represented by the notebook PC are now facing a major turning point. Tablet PCs featuring high mobility and operability are available at low prices, and smart phones and tablet terminals adopting Android as their OS are rapidly forming a new market. Although the notebook PC that already has a history of more than two decades will not be replaced completely by these terminals, however, it is highly probable that many of the terminals for specific jobs will tend to be replaced by simpler, lower-priced ones.

To support this trend, we plan to enhance the rugged notebook ShieldPRO product line by adding new category models which does not exist now. By offering and releasing a new information terminals continuously that can be used securely even in severe environments, we would like to contribute to society.

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User-Centered Design in SI/Software Development

Development of Design Patterns for HI Design

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User-Centered Design Employed for the Smartphone "MEDIAS (N-04C)"

Human-Friendly UI Design for "Cloud Communicator"

User-Centered Design Activities for PCs

**Product development case studies/Innovations**

User-Centered Design for Projector Product Planning

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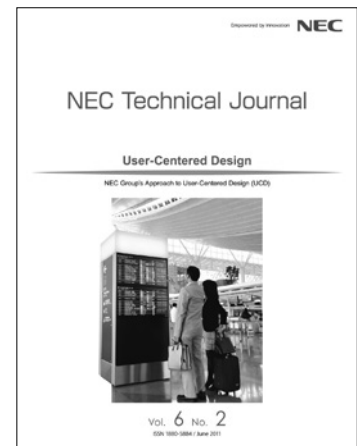
Vol. 6 No. 2

## Vol.6 No.2
**July, 2011**

Special Issue TOP