FUTURE AUTOMATIC IDENTIFICATION TECHNOLOGIES


ABSTRACT

Scientific Generics has wide experience of automatic identification technologies, including tagging and tracking, and their optimal application in industrial, retail and business environments. This work has included investigation of novel technologies and of applications which may play significant roles in the automatic identification market of the 1990's. Insight has also been gained into the effects which the changing cost structure of different identification technologies will have on existing and emerging markets. The paper will present important conclusions about future automatic identification technologies, supported by experimental and market research data.
INTRODUCTION

Today a critical aspect of many value-added operations is the management (collection, manipulation and distribution) of information. An important sub-set of this information is object or person-related (e.g. type, privileges, price, origin, destination, processing requirement or quality control data). Automatic identification is a technological tool to address the problem of acquiring such data directly from the object or person - which may need to be specially augmented with a mark, label or a tag - without the need for human intervention (e.g. for entering information on a keypad). This is in contrast to the option of tracking each object and monitoring its exact location and attributes using a central computer. Hybrid solutions also exist where object type alone is read from the object using automatic identification techniques and this is used as a pointer in a central database to address attributes.

Automatic identification is particularly attractive in environments where the items to be identified are many and their location is difficult to predict - examples are people with particular privileges in a large company, airline luggage and containers in transit. It is also ideal for answering object related questions except 'where is the object?'

Tracking is appropriate in an organised world where a relatively small number of objects have to be dealt with - examples are fully automated factories (no human interaction) or automated warehouses. Hybrid solutions require a bounded world (where a database can be informed about all objects to be handled) but allow for unpredictable locations. Examples are supermarket goods and manufacturing facilities with human intervention.

SUPPLY AND DEMAND

The following forces are driving the demand for automatic identification:

a) Increased demand for item-specific data (e.g. for statistical process control, traceback, routing).

b) Pressure to increase both speed and flexibility in operations (e.g. just-in-time manufacture, batch size = 1).

c) Trend towards paperless operations and elimination of transaction and ownership documents.

d) Requirement for automatic communications between different data processing systems such as MRP, CAD/CAM, MIS, EFTPOS.

e) Requirement to reduce labour content in value adding operations.

f) Requirement for security/confidentiality in particular for financial transactions.

g) Requirement for increased reliability of identification procedures.

h) Emergence of new markets (e.g. token based privileges and services provided via telephone lines).

The 'supply side' of the penetration of automatic identification into new markets is being influenced by the points outlined below:

a) Technology innovation

The evolution of new technologies to a state where they become suitable for a particular automatic identification application, introduces new sources of technology-based, competitive advantage either by merit of improved performance or cost effectiveness. Such advantage can be made defendable by using patents or proprietary know-how relating to product or manufacturing process.
b) Marketing of technology "bundles"

These technologies must be 'bundled' together to form marketable automatic identification packages - for example the classic bar-code system at a supermarket checkout is a bundle incorporating optical communication while the information storage is split between the identification contained in the printed bar code and the item-specific information (price, text description etc) which is stored on a data-base linked to the cash register where the information processing is carried out.

c) Technology transfer

This involves a 'migration' of technologies from markets where they have previously become established into new markets. It may require significant changes in the mode of application of the technology to suit the market being addressed - or an "education" of the market towards higher awareness of the benefits of the technology.

d) Strategic moves.

These include the formation of alliances with sources of know-how, suppliers, customers or even with competitors. The use of standards and legislation to influence market dynamics is another important strategic move.

TECHNOLOGY INNOVATION

Key Technologies

The key technologies used in automatic identification can be categorised as follows:-

a) Direct Sensing (of the required attribute, e.g. weight, size, colour).

b) Communication (between a 'label' and reader/writer).

c) Storage of Information (on the 'label')

d) Information Processing (on the label or centrally)

Table 1 summarises some individual technologies and their applications which are currently being used or researched for automatic identification.

Direct Sensing

This is a category of automatic identification technology in the sense that today we often identify an object in order to find out a factor (such as type or colour) which tomorrow could be sensed directly.

Major advances are currently being made in the development of low-cost sensors to measure a wide range of physical quantities. Many sensors are integrated into semi-conductor devices so that interrogation becomes extremely cost effective. Examples of the quantities sensed in such a manner include:

- light intensity and distribution (opto-electronic sensors)
- pressure/weight (silicon mechanics)
- distance and location (phased array radar)
- speed/acceleration (laser gyroscope)
- chemical properties (ion selective electrodes)
- electrical properties
Optoelectronic sensors deserve special mention as they cover a diversity of sensing tasks - from the familiar bar and OCR scanners to devices [3] for the recognition under industrial conditions of more general optically characterised properties such as defects, dimensions, orientation and type. The advent of integrated circuits including transputers for low level picture processing will result in vision tasks which previously required tens of thousand of pounds of investment being executed in the near future for a cost of a few thousand pounds.

**Communication**

Here again, advances in microelectronics are preparing the way for future developments. Transponders for both radio-frequency and microwave communication can be integrated into thick-films semi-conductor devices - these will be extremely cost effective when manufactured in large quantities.

The requirement for "transmitting" tags to have their own built-in energy source (e.g. a replaceable battery) has been removed by beaming not only data but also energy to the tag. This energy is used to activate the tag when it is required to respond.

Opto-electronics has also opened up major new opportunities in communication by enabling pulses of light to be used as the communicating medium - this eliminates interference, safety and legislative problems associated with all forms of electromagnetic communications.

**Information Storage**

By using appropriate materials different magnetic states can be induced and sensed at a distance. This can form the basis of a low cost product security system for retail environments and maybe extended to form an automatic checkout.

Compact disc technology - also available in credit card format - enables up to 600 Mbytes of data to be stored on an ISO sized credit card costing a few pence. This is currently being investigated for uses such as the storage of medical records. Already write-once (WORM) media are available, which given the huge data capacity of a card, can allow many thousands of write operations before the media fills up. Magneto-optic media currently being researched for recordable CD applications will eventually become available for AI applications.

**Information Processing**

Two great pressures are driving the need for advanced information processing in automatic identification. The first is the need for security - as ever more value is transferred on the strength of an automatic identification process. This has led to the development of on-card encryption algorithms such as DES (or the more secure RSA). Looking further into the future investigators [1] are seeking to replace the stealable PIN number with a biometric scan (automatic identification of a fingerprint, retinal or hand blood vessel pattern or voice pattern).

A second pressure is for information processing to assist the user-friendliness of AI technologies. Examples are the intelligent mapping of data in 'write-once' media such as WORM or certain EEPROMS and the management of the communication channel including checking of data integrity and automatic retry after a communications failure.

**MARKETING OF TECHNOLOGY BUNDLES:**

The marketability of any particular 'bundle' of technologies as an automatic identification package depends upon its perceived cost/benefit profile from the point of view of the purchaser. This in turn can be broken-down into-

- **Cost**  
  Opportunity cost compared to current procedure. [Variable cost per operation + capital and maintenance cost]

- **Reliability**  
  [How often does it work? What modes of failure?]

6/4
- Value-added [e.g. shorter queues, fewer mistakes, lower costs, better information management]

- Standards [Some technologies are only viable if many players use same method]

- Legislation [e.g. Laws on microwave and RF emissions]

- Fraud [Is it possible to defraud the system? Is it worthwhile?]

Table 2 assesses some of the relevant attributes for a sample of the best known current and future technology bundles.

TECHNOLOGY TRANSFER

Technology transfer is influenced by factors such as

- confidence and familiarity

- falling costs (e.g. due to product or process innovation or to economies of scale in manufacturing)

- the establishment of standards (e.g. for interfaces to automatic identification equipment or for communication methods)

- emerging demand

To demonstrate technology transfer between different segments of the automatic identification market figure 1 presents the market for RF-tags in a simplified form relative to axes price and performance.

RF-tags are predicted by Cutter Information Corp [2] (See Figure 2) to grow from 6% of the US automatic identification market in 1987 to 23.4% in 1991. The RF-tag market was initiated in the early '80's by the emerging demand for two very different products:

a) A tag with a range of circa 0.8m read/write capability, memory size of 2K bytes and environmental protection suitable for shop floor, to identify automobile bodies during manufacture. Price circa £60.

b) A tag with a range of circa 0.8m read/only (later read/write) capability memory size of a few bytes and price £5 for personnel security.

Both products are now well established. As the applications and technologies of these products have become familiar they are now being introduced (in amended form where appropriate) into new markets as outlined below:-

<table>
<thead>
<tr>
<th>New market</th>
<th>Amendment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal tagging</td>
<td>(smaller, cheaper)</td>
</tr>
<tr>
<td>Machine-tool cutter identification</td>
<td>(very small, short range)</td>
</tr>
<tr>
<td>Factory automation</td>
<td>(cheaper)</td>
</tr>
<tr>
<td>Transportation</td>
<td>(longer range)</td>
</tr>
</tbody>
</table>

In addition to the transfer between market segments, the mode of use also can be expected to change. At present tags are usually so expensive that they have to be 'recovered' after use thereby imposing a significant handling cost. In future an identification tag (for example for manufacture of an automobile) will become 'dispersable' remaining with the vehicle after it leaves the factory, passes through the showroom to its owner and out on the roads - it may provide vehicle service history or even enable payment of tolls and taxes. At the next stage the tag becomes disposable - like today's bar code. The rate at which dispersable and disposable tags replace recoverable ones depends on their cost and value relative to the value which they add to their 'hosts'.

6/5
STRATEGIC MOVES

The existence of a capable and cost-effective bundle of technologies is not in itself enough to guarantee a market success. Another crucial factor is the will of a group of key players to make this happen. This group will need to use their own commitment and resources to bring influence to bear in such areas as finance, product design, manufacturing, distribution, retailing, marketing and user-lobbies. Today the global nature of the markets for many automatic identification products together with the entrenched positions of some major players require major alliances before new technologies can reach the market place.

An important factor is the attitude to 'standards'. From one point of view an open standard procedure, interface or communications method may be seen as being in the interest of all concerned by widening market acceptance and providing second sources for products. On the other hand players who wish to defend their own competitive advantage will be in favour of 'closed' standards available only to a chosen few - to the detriment of their competitors.

A major future market at present awaiting the appropriate strategic move is that for financial smart cards. Technologies are proven, prototypes built and large-volume cost predictions attractive - but this is not enough to guarantee market success.

SUMMARY

We have analysed the factors influencing supply and demand for automatic identification. This has led to a discussion of how new technologies are moving into different areas of automatic identification through technology innovation and technology transfer. Both of these mechanisms have been illustrated with examples. In addition to technology, the marketing and strategic factors affecting the future of automatic identification have been considered.

REFERENCES


**TABLE 1 - SOME AUTOMATIC IDENTIFICATION TECHNOLOGIES**

<table>
<thead>
<tr>
<th>Direct Sensing (measured property)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical</td>
</tr>
<tr>
<td>Tactile</td>
</tr>
<tr>
<td>Radioactivity</td>
</tr>
<tr>
<td>Ultrasonics</td>
</tr>
<tr>
<td>Other EM-radiation</td>
</tr>
</tbody>
</table>

**Communication**

<table>
<thead>
<tr>
<th>Optical (visible, IR, etc)</th>
<th>Inductive</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave</td>
<td>Capacitive</td>
<td>Acoustic (ultrasoneics)</td>
</tr>
<tr>
<td>Tactile</td>
<td>Radioactivity</td>
<td></td>
</tr>
<tr>
<td>Magnetic field</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Information storage**

<table>
<thead>
<tr>
<th>Semiconductor</th>
<th>Optical (CD-ROM, hologram)</th>
<th>Magneto-optical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic (bulk properties)</td>
<td>Mechanical</td>
<td></td>
</tr>
</tbody>
</table>

**Information processing**

<table>
<thead>
<tr>
<th>Semiconductor (transputer)</th>
<th>Optical (hologram)</th>
<th>Resonant circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface acoustic waves</td>
<td>Neural nets</td>
<td></td>
</tr>
<tr>
<td>Attribute</td>
<td>Bar Code</td>
<td>Magnetic Stripe</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td>Data Density</td>
<td>1-7</td>
<td>3-15</td>
</tr>
<tr>
<td>Read Distance</td>
<td>1-20</td>
<td>1</td>
</tr>
<tr>
<td>Tag or Label cost/ performance</td>
<td>1-10</td>
<td>2-5</td>
</tr>
<tr>
<td>Reading Equipment cost</td>
<td>1-15</td>
<td>1-5</td>
</tr>
<tr>
<td>Read/Write</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Robustness</td>
<td>5-10</td>
<td>2-7</td>
</tr>
<tr>
<td>Reliability</td>
<td>1-5</td>
<td>3-8</td>
</tr>
<tr>
<td>Security</td>
<td>1</td>
<td>5-10</td>
</tr>
</tbody>
</table>

1 = Lowest Score (good for costs bad for performance)

25 = Highest Score (bad for costs good for performance)
FIGURE 1 - SEGMENTATION OF THE MARKET FOR RF-TAGS

End-user
Price (per Tag)

100
75
50
25

TRANSPORTATION
FACTORY
AUTOMATION

SMART LOG-BOOK
FOR AUTOMOBILES,
MACHINERY ETC.

MACHINE TOOL
CUTTER ID

PERSONNEL ID

MEDICAL

ANIMAL ID
SMART CARDS

Performance (range/memory/read/write)
Market Segment

Existing
Trends
Future
Figure 2 - The Evolution of Smart-Tags

RF I.D. Equipment Sales
Western Europe (in Million US $)

Access
Control

Reuseable
Disposable

Manufacturing

Financial

1980  1990  2000

1  AIM forecast

2  SGL prediction

'Aim' and 'Cutter' forecast that sales of RF I.D. equipment to more than treble in Europe and USA between 1987 and 1992.