KLICT Position paper

Traceability in Food Processing Chains

State of the art and future developments

Version: 1.0

20 October 2003

Raoul Vernède (Raoul.Vernede@wur.nl)
Floor Verdenius (Floor.Verdenius@wur.nl)
Jan Broeze (Jan.Broeze@wur.nl)

Agrotechnology & Food Innovations bv
PO box 17
6700 AA Wageningen
The Netherlands

Content:

Figures:

Boxes:

<u>Tables:</u>

This paper was produced on behalf of KLICT (www.klict.org), which aims to improve the Dutch knowledge infrastructure. It combines knowledge on traceability with current trends in the food processing industry, and sets research targets for the coming years.

Abstract
With the acceptance on February 21st 2002 of the General Food Law, the EU confronts the food sector with the notion of traceability. This paper investigates the developments and current state of traceability in the food processing industry and surveys technological developments. The main components of traceability systems include technology, process, information and organisation. This subdivision helps in analysing a sector, as well as in setting up the design process for a new system.
In the food sector in general, legislation and globalisation have been the driving forces for implementing tracking and tracing systems. Sectors that have a long history in these areas, e.g. the meat industry and the large multinational companies, therefore have made a head start in setting up and implementing traceability systems. Small companies and sectors with low legislative pressure have a backlog. Future developments are subject to the further development of legislation. Moreover, consumer concerns may lead to increased effort by the food processing industry. The major driving force, however, should be the promise of yet unseen incentives for the industry itself. In designing and implementing traceability systems, particular goals of the industry itself can be served, e.g. in the areas of quality control, logistics and commercial image. This, however requires a more active attitude of the sector with respect to traceability.

Keywords: Traceability, Tracking, Tracing, Food processing industry

Samenvatting
Met het aannemen op 21 februari 2002 van de General Food Law heeft de EU de voedingssector indringend geconfronteerd met het begrip traceerbaarheid. Deze paper onderzoekt de ontwikkelingen en huidige toestand van traceerbaarheid in de voedselverwerkende industrie. Om te beginnen worden technologische ontwikkelingen verkend. Belangrijke componenten van traceerbaarheid betreffen technologie, proces, informatie en organisatie. Deze onderverdeling helpt bij het analyseren van de sector, alsook bij het opzetten en ontwerpen van traceerbaarheidssystemen.
In de voedingssector zijn wetgeving en globalisering over het algemeen de belangrijkste factoren die de invoering van traceerbaarheidssystemen bepalen. Sectoren met een lange traditie op één van deze gebieden, bijvoorbeeld de vleesindustrie en de grote multinationale voedingsmiddelen-concerns, hebben daarom een voorsprong als het gaat om de implementatie van traceerbaarheidssystemen. Kleine bedrijven, en sectoren met lage wettelijke druk, hebben op dit gebied een achterstand. Toekomstige ontwikkelingen hangen sterk samen met verdere wetgeving. Daarnaast kan onrust en bezorgdheid bij de consument de verdere proliferatie van traceerbaarheid versterken. Een belangrijke factor zou ook het eigen belang van de industrie kunnen zijn. Door traceerbaarheidssystemen te implementeren, kunnen doelen die de industrie zelf belangrijk vindt, op het gebied van kwaliteitsbeheer, logistiek en consumentenimago, worden gediend. Dit vereist echter wel een pro-actieve houding ten opzicht van traceerbaarheid.

1 Introduction

May 18, 2021, 8:19. Before starting his working day, Robert contacts the on-line supermarket to order ingredients for the evening meal: fresh tuna steaks, a microwave pasta dish and a fruit salad. He specifies the amounts (4 persons), the time of consumption (this evening) and food safety concerns (peanut allergy of his 4-year old son) to ensure a proper delivery

With the acceptance on February 21st 2002 of the General Food Law, the EU confronts the food sector with the notion of traceability. Before this date, traceability was seen as an issue where an industry could not distinguish itself on a voluntary basis, without any obligation to do so. Although some nations had further reaching regulations in the area of traceability due to for instance HACCP obligations, there was no general obligation on traceability for all players in the field.

The General Food Law (GFL) introduces the obligation for all players in the food sector to introduce traceability systems. Roughly spoken, the food sector consists of fresh chains and industrial chains. The first are characterised by trading a fresh, unprocessed, agricultural product. The latter are characterised by food processing operations at an industrial scale. Without underestimating the complexity of traceability in fresh chains, the industrial chains pose the biggest challenges for implementing traceability, due to sequences of diverging and converging operations. What are in this context the consequences of the GFL for the production and distribution chains that include food processing industries?

The purpose of this paper is to assess the state of art of traceability for the food processing industry, to characterise future developments and to identify and define items for further research.

After a definition of *traceability* and the *food processing industry* in Chapter 2, Chapter 3 elaborates potential components of traceability systems. Chapter 4 discusses relevant legislation and self regulation in agro and food. In Chapter 5, the current state of the art is surveyed. The conclusion, that there is still much work to do in order to lift traceability of agro and food to a level that complies with legal requirements, leads to the discussion of potential business incentives for enterprises for implementing traceability systems in Chapter 6. Chapter 7 describes several approaches that are helpful in analysing the traceability requirements, systems design and implementation of solutions. Chapter 8 concludes with future developments and a research agenda.

2 Scope & Terminology

May 18, 2021, 18:05. After finishing his work, Robert empties his home delivery box. The supermarket delivered his order in the afternoon. When opening the package of the fish, he smell of the fish makes him feeling unsure: is it really fresh?. Moreover, the fruit salad contains banana and mango slices that seem fairly unripe; is it really meant for instant consumption? Or should it be kept for another day or two.
Robert generally orders his food from AB-online; they offer good quality products at reasonable prices, and he has good confidence in the quality of their products. But now, for the first time since he became a client (two years ago) he decides to use their product traceability system.

According to the General Food Law (*see Box 1*), traceability systems have to be introduced in all agro-food chains (Beumer et al., 2003). The scope of this obligation includes a variety of logistic systems. It includes, for example:

- A farmer selling milk directly to a consumer
- An international export chain for vegetables as organised by a large auction
- Production of fresh cut and minimal processed food ingredients
- Production of ready-to-cook meals
- A meat production chain, including maize production, cattle breeding, slaughtering, boning and meat processing.

The scope of this paper is *traceability in the food processing industrial chains*. In order to specify that scope, the concepts *traceability* and *food processing industry* are defined below. Traceability is often placed in close connection with transparency. In this paper, traceability is seen as a tool to realise various chain- or company goals; transparency can be one of such goals (Hofstede, 2002).

2.1 Traceability

The concept of traceability originates from logistics. In its original meaning, traceability can be defined as *'The ability to follow (in real time) or reconstruct (off-line) the logistic route of singular or compound products'* (Van Goor et al., 1996). In logistics, the main concern is efficient control of logistic processes. Consequently, most tracking & tracing actions that stem from logistics are justified by improved process planning and control.

Moe distinguishes between chain traceability and internal traceability (Moe 1998), dependant on whether or not the traceability covers more than one organisation.

Article 18

Traceability

1. The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.

2. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed.

To this end, such operators shall have in place systems and procedures which allow for this information to be made available to the competent authorities on demand.

3. Food and feed business operators shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand.

4. Food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.

5. Provisions for the purpose of applying the requirements of this Article in respect of specific sectors may be adopted in accordance with the procedure laid down in Article 58(2).

Box 1: Article 18 of the General Food Law on traceability

Due to various food incidents (van Dorp, 2003b; Opara & Mazaud, 2001) and under influence of consumer organisations and authorities, the focus of traceability in the food sector has shifted towards prevention and reactive control of food safety aspects. HACCP realises a preventive set of measures, while traceability ensures executable measures for reactive control, such as recall management, damage control and liability. In article 18 of the General Food Law (EG nr. 178/2002, cited in Box 1), traceability is defined as *'The ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stage of production, processing and distribution.'* The extension compared to the logistic definition of van Goor is that the GFL specifies the type of produce it refers to. The purpose of the GFL is to enhance control on food safety. In the current formulation, this is realised by offering the ability to efficiently recall a product in case of incidents. In Figure 1, the concept of traceability is further elaborated. Chapter 3 gives an extensive description of the components of traceability systems.

2.2 Food Processing Chains

This paper discusses traceability in production and distribution chains that include industrial food processing as a major chain element. The food processing industry is a large and heterogeneous sector. An overview of the sector can be found in the Dutch Standard Business Classification 1993 (SBI '93, as published by Statistics Netherlands, CBS, 1993). This classification illustrates the size and heterogeneity of the sector: 35 different industrial branches, varying from poultry slaughterhouse to starch production and from beer brewing to producing diet products.

Food processing industrial chains include an industrial actor according to the SBI93. The sector is characterised by different, diverging trends. On the one hand, there is a trend towards complex supply chains with a global arena, a tendency for concentration, small margins, global competition and high volumes. On the other hand, there is an increasing number of small highly specialised producers, with a small market of niche products, regional products, a higher price level and low volumes.

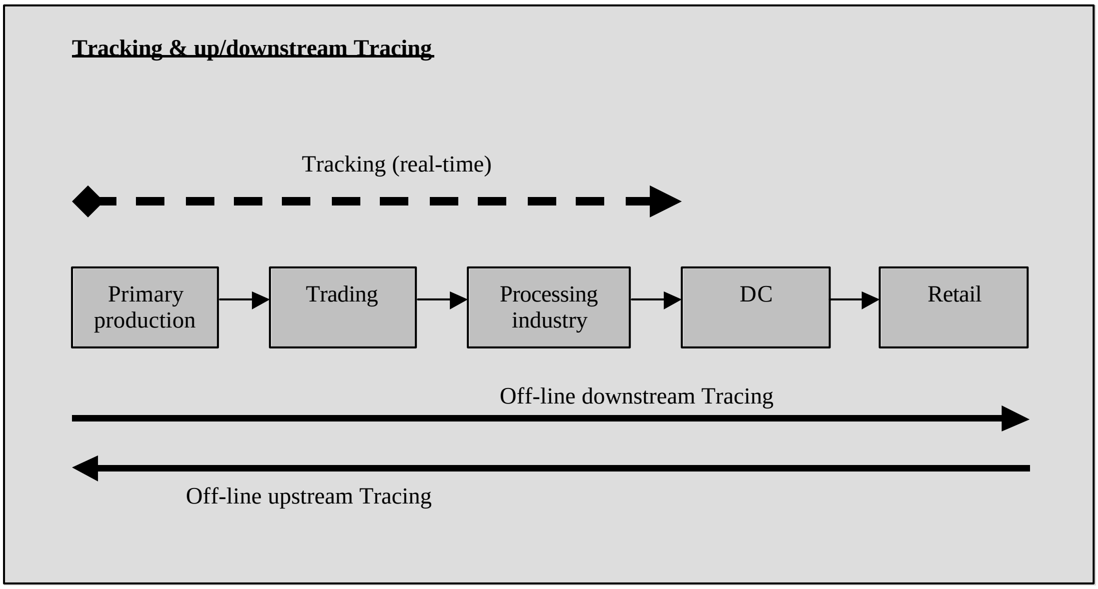


Figure 1: Tracking & up/downstream Tracing

Traceability: Definitions & terminology

Traceability: The ability to track and/or trace product flows in a production and distribution chain. Traceability implies that product flows are uniquely identifiable, that at critical points in the production and distribution processes, the identity of product flows is logged, and that the information is systematically collected, processed and stored.

Tracking: relates to the ability to follow products in real time. Typically, in monitoring a distribution process, one may want to know the current location of a product. An early implementation of a tracking system is implemented for courier services. The whereabouts of parcel can be obtained at any time.

Tracing: relates to the ability to reconstruct the historical flow of a product from records that are stored in a database. Typically, when a consumer encounters a defective product, one may want to know the history of that product. This requires the analysis of registration and production records in a traceability database. Tracing comes in two types: upstream and downstream.

Upstream tracing: In the case of upstream tracing, the history of a product is reconstructed from the 'final destination of a product' back to the origin in the chain. The example above is a case of upstream tracing. The important question here is: What are the origins of my product, and can I identify which circumstance in that history is responsible for the defect at hand.

Downstream tracing: In the case of downstream tracing, some 'raw material' is taken as starting point, and the affected product at the end of the chain are identified. If a batch of flour is polluted with dioxin, which products are affected?

Recall action: A recall action is the action of withdrawing a product that is suspected to carry a defect from the market. In general, a recall action consists of at least one upstream tracing (to detect which production phase/raw product causes the problem at hand) and one downstream tracing (to detect where possibly other affected products can be found).

Lot size: Amount of products that is identified under the same identifier

Smallest Traceable Unit (STUNT): is the smallest batch of identifiable product in a production and distribution chain that can successfully be traced. The size of the STUNT depends on the size of product batches and on the synchronisation mechanism for convergence during production.

Box 2. Traceability: Definitions & terminology

3 Components of tracking and tracing systems

May 18, 2021, 18:09. Robert logs on at AB-online, and goes to the traceability desk. A woman's voice instructs him to put the product packing wrapper for the item he wants to trace in front of his webcam. He starts with the tuna steaks. Automatically, the product identification is extracted from the package, and entered into the database. Two minutes later, also the fruit salad has been identified. and entered in AB's svstem.

Introducing tracking & tracing systems in food processing companies or chains is sometimes regarded as just a matter of technology: "Introduce some tags and related software and traceability is realised". The reality is a bit more complex. It appears to be crucial to embed tracking & tracing into the whole business and chain in order to realise its respective goals. A complete tracking and tracing system consists of the following components (see also Figure 2): technology, process & information and organisation. The design of these components connects with an analysis of the strategic objectives of tracking & tracing, so that the ultimate implementation matches the relevant business goals.

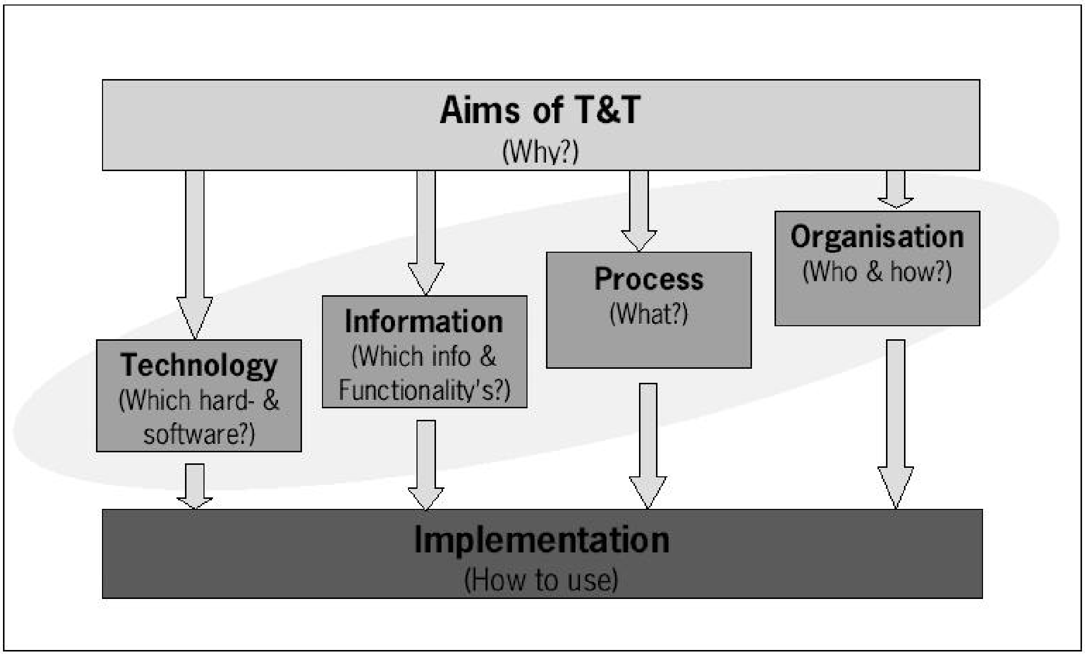


Figure 2: Tracking & Tracing in its context

3.1 Technology

Tracking and tracing systems can employ different technologies. Major tracking & tracing modules are (1) identification, (2) registration and (3) data processing, as visualised in Figure 3. *Infrastructure* refers to topics like the harmonisation of bar-coding, network- and web-interfaces and arrangements on data- and product-ownership, transparency and liability between chain partners. The required technology and data-processing depend on the requirements and goals of the stakeholders. This aspect will be elaborated in more detail in Chapter 6 when incentives for tracking and tracing systems are discussed.

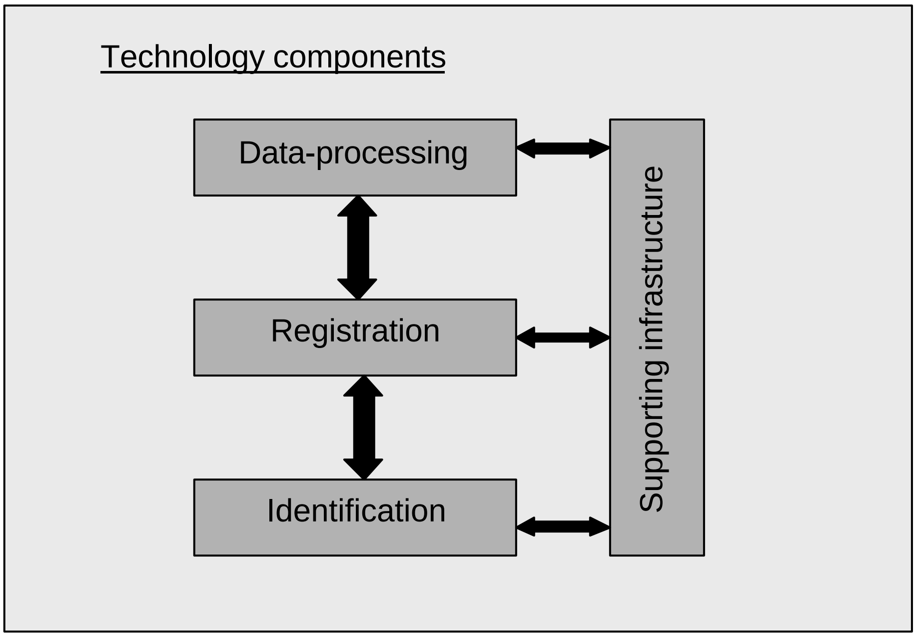


Figure 3: Technology components of a tracking & tracing system

3.1.1 Identification

In order to track and trace individual products or batches of products, these need to be made identifiable. Common technologies for identification can be grouped according to the method by which the encoded data is stored (AIM, 2002). The following three main groups can be distinguished: (1) Optical storage, (2) Magnetic storage and (3) electronic storage. As a fourth category can be added: biological storage (Figure 4). This last category in which the identity is measured by some aspects of the make-up of the specific product, is also referred to as primary identification (FoodTrace, 2003). See Figure 6 for a more detailed clustering of data carrier and extraction technologies (AIM 2002).

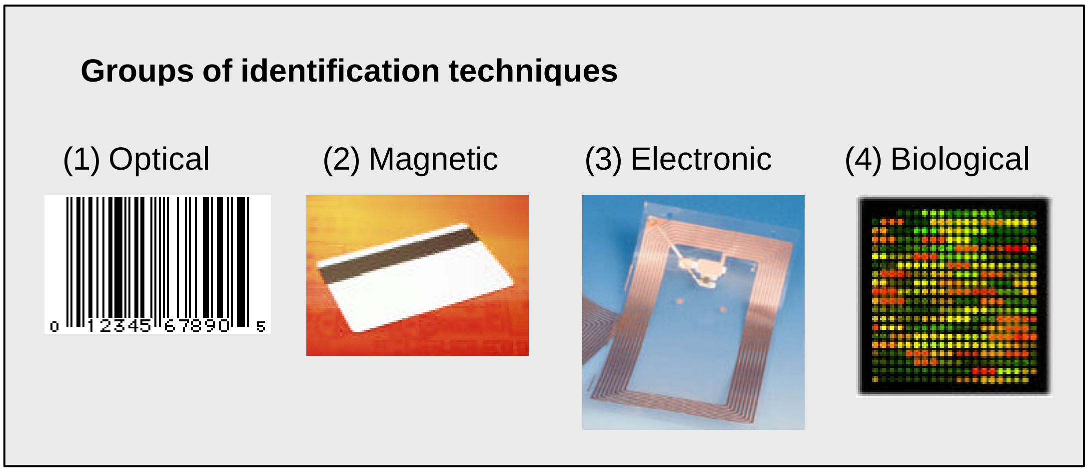


Figure 4: Types of identification

1) *Optical storage.* The most simple way of identification is just labelling the product unit with an alpha-numeric label. This label serves as key in the batch administration. Different types of bar code labelling are also used: linear and multi-row barcodes and matrix codes. For barcodes most commonly the EAN-UCC standard is employed for standardisation thus facilitating electronic data interchange (EDI). The GTIN (Global Trade Item Number) (EAN 13) forms the basis for worldwide identification through bar coding. The more advanced EAN 128 code (symbology and application identifier standard) makes it possible to include additional information such as expiry date, batch or serial number. Moreover, with a SSCC (Serial Shipping Container Code), transport units (pallets, containers) can be identified worldwide using the EAN 128 code.
   Optical coding can also take place in the product itself as demonstrated recently by two types of 'carved' tagging of meat (Bi-coder and Dot-code, both developed by TNO Nutrition and Food Research, see Figure 5).

Two examples of recently developed techniques to 'biotag' food products. The left picture shows bacon with the carved Bi-coder, the right picture shows the Dot-code in larger meat units (TNO Voeding, 2003).

Figure 5: Bicode and Dotcode

2) *Magnetic storage.* The best known examples of this group are the commonly used bank-cards. However, most cards today are not only magnetic but also contain a chip. Magnetic strips are also commonly used for boarding cards at airports for the purpose of identifying passengers quickly and other security access purposes. The information on magnetic card can easily be damaged or erased under influence of strong magnetic fields.
3) *Electronic storage.* This group includes smart-cards, touch memory and RFID. An RFID tag, also known as transponder, is a small microchip with an antenna. In reaction to a radio signal, the chip performs a simple process (e.g. send the id-code). In order to read the tags, reader-antenna units are required. RFID tags are divided into passive (without a battery) and active tags (with a small battery). A critical aspect of standardisation is the used radio frequency. Currently, different frequency areas are in use: low (< 1 MHz), medium (1-500 MHz) and high (> 500 MHz). The higher the frequency, the longer the reading distance is, varying from only a couple of centimetres up to several hundreds of meters for high frequency active tags. The allowed frequencies and sending capacities differ between Europe and the rest of the world.

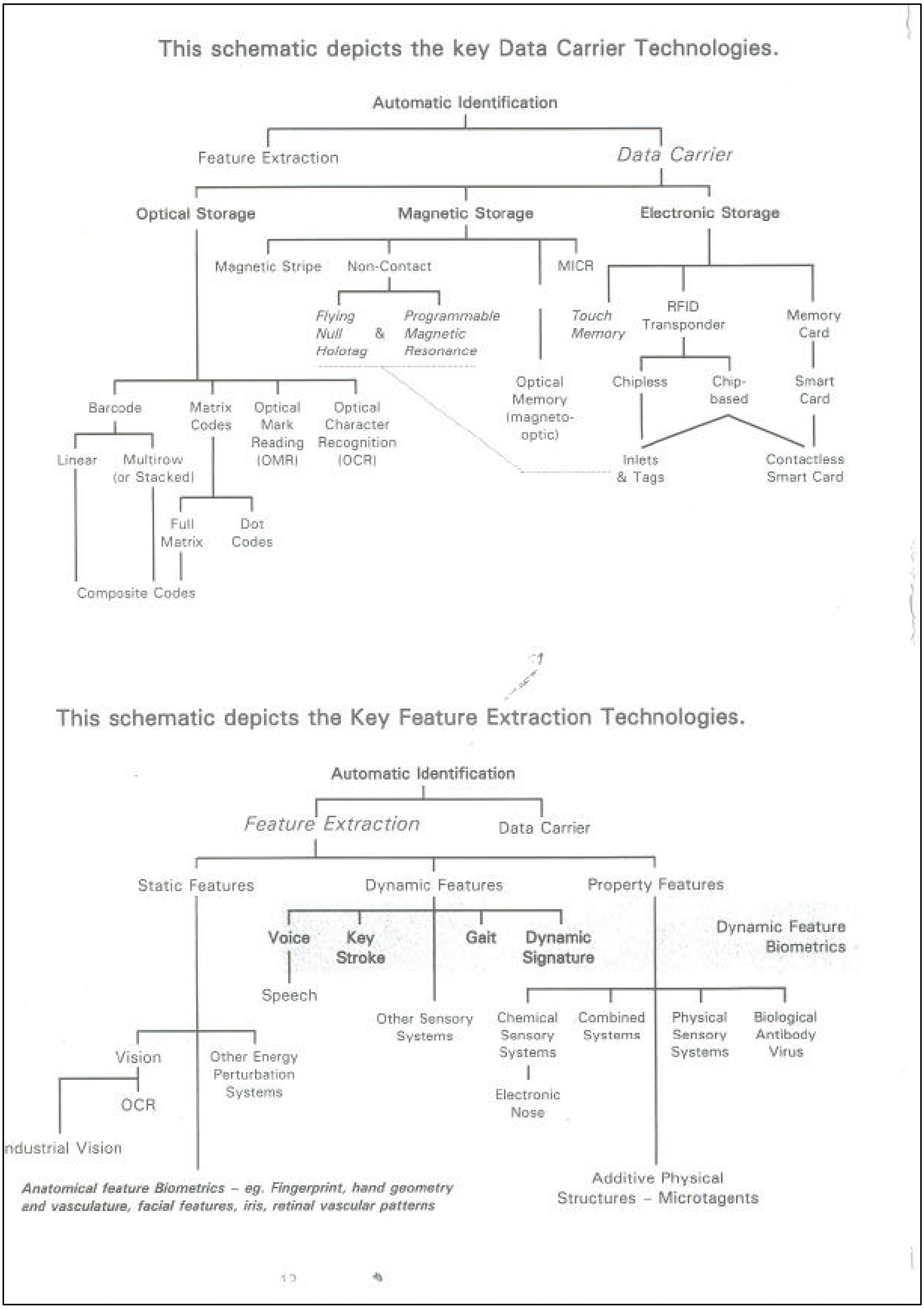


Figure 6: Data carrier and extraction technologies.

4) *Biological storage*. Bio-tagging, the exploitation of 'biological' characteristics for identification purposes, is a next step in the development of tagging technology. Biotagging comes in various forms: *active* and *passive*, *natural* and *synthetic*, and tagging based on *physical*, *biochemical* and *genetic* information carriers. Active biotagging occurs when the tag is applied by humans, an example being the use of antibodies for (synthetic) peptides as biological 'barcode' in animals (Urlings, 2002). Passive biotagging, in contrast, applies biological mechanisms that are inherently present in biological material, for instance the use of skin patterns (Frysian pedigree cattle) and DNA fingerprints when identifying livestock (Agriholland, 2003). The contrast between natural and synthetic often, but not always, coincides with passive versus active. The information carrier is physical when the product itself is used as carrier of a code. Biochemical tagging deploys biochemicals as code carriers, as is the case in the example of tagging livestock with immunological codes, while genetic tagging deploys DNA-related material (including RNA and others) to carry the code, as is the case in the DNA fingerprinting example.

Combining several approaches may increase safety, and give the best of all worlds, an example being the combination of a barcode and RFID tag. Some actors in logistic chains, e.g. couriers, read the barcode, while other access the identical information through the RFID tag, allowing massive and fully automated processing in warehouses.

3.1.2 Registration & administration

May 18, 2021, 18:12. Robert receives two reports for the products. He sees his tuna is caught by a Japanese fishing factory on May 10, near the Azores. He also can check that it has been stored under –3°C during four days, that it was auctioned in Zeebrugge on May 14, and processed into steaks by MarocFish, a company in Casablanca, on May 15. It arrived at AB-on lines' warehouse on May 17. Everything looks well organised, and the necessary conditions are adhered. Moreover, the traceability systems of the involved actors have been approved by Harold's Certification Office. The tuna is OK. Concerning the fruit salad, AB needs some more time. The suppliers are not well-connected, and establishing a report takes some time.

In order to make products identifiable and traceable the products need to be equipped with a tag. Its whereabouts need to be followed through the logistic and production process. Relevant data need to be registered and administered into a database. The registration method is strongly connected with the applied identification technology. Moreover, requirements in organisations may further determine the registration tools.

1) Alfa-numeric labels be registered by humans (keyboard, voice response technology) and automatically using an OCR reader. Bar codes can be read manually, using a hand-held device, or with automatic reading

devices. Optical contaminations caused by dirt of physical damages of the tag hinder reading. Physical tags, such as the Bi-coder and Dot-code on carcasses, can be read automatically, deploying a vision system

2) Magnetic tags can be read with relatively simples reading devices. Dirt influences the reading capabilities.
3) RFID tags can only be registered by using a reader–antenna combination. These vary from small hand-held devices to fixed stations. Setting up a running and stable RFID system requires the effort of specialists.
4) Reading bio-tags is more complex, and strongly depends on the applied label technology. DNA code, on the other hand, requires the intervention of a laboratory. Some of the biochemical codes are, or are expected to become, readable with so-called dipsticks.

Table 1 gives an overview of three traceability purposes and the related identification and registration technology.

Table 1: An overview of available tag technologies and their characteristics

Tag-type	Label	Barcode	RFID	Biotag
Information	ID	Id + additional information	ID + additional information	ID
Static/Dynamic	Static	Static, expandable	Dynamic	Static
Data capacity	Typically 10-100 characters	13 characters for product coding(EAN 13) Information formatting based on Application Identifier Standard (EAN 128)	Up to several kB	Limited
Product bound	No	No	No	Yes
Re-usability	No	No	Sometimes	No
Multiple read	No	No	Yes	No
Disturbance sensitivity	Low	Low	High	Unknown
Registration	Manual/ Automatic	Manual/ Automatic	Automatic	Manually dipstick or in a laboratory
Access speed	High	High	Medium	Low
Registration speed	Low	High	High	Low

3.1.3 Data processing

> **May 18, 2021, 18:22am**. AB-online alerts Roberts Internet terminal. They have been able to trace down all ingredients of the fruit salad. The bananas were imported from the Ivory Coast. The batch was composed of small deliveries from seven growers. All the growers comply to environmental regulations, but three of them do not comply to AB's quality standards. Moreover, the mango import could be traced down to two growers in India. Due to mis-harvests in the Singapore area and logistic problems, their delivery was put forward to replace some delayed shipments. The result was that the fruits are slightly immature. Adequate temperature control resulted in an acceptable ripeness anyway. However, AB's food quality expert system signals that combinations of some unripe fruits, such as banana, mango and papaya, may enhance the unripeness experience by consumers. An automatic refund is transferred to Robert his account to compensate for this production failure.

Once items are correctly identified, registered and administered into a database, information needs to be processed and analysed.

With regard to data processing of tracking and tracing information in a supply chain, the following scenarios are distinguished (see also Figure 7):

(a) *Distributed data storage and processing.* Chain actors maintain their own data and exchange data on request by means of product batch identity.

(b) *Centralised data storage and processing*. Information is stored and processed in a central database. Chain actors have access to the subset of information relevant to their business. Security of the central database is crucial. The central infrastructure can be maintained by a dominant chain actor (the chain director) or by an independent facilitator (trusted third party). Web-based applications are gaining popularity, especially when many small and medium-sized actors are involved (Wilson & Clarke, 1998). Larger chain actors may deploy interfaces such as XML (Extensible Markup Language) between their own ERP-system (Enterprise Resource Planning), WMS (Warehouse Management System) or LIMS (Laboratory Information Management System) and a central database. In case of calamities, the key-holder is authorised, in conformity with laid-down procedures, to access the database and extract relevant information.
In the food production chain, a combination of options (a) and (b) is common especially for products 'entering' another chain such as processed meat which is used in pizzas or frozen ready-to-eat meals. In these cases, the key-holder is authorised in specific cases to access a decentralised database of an individual company.

(c) *Portable data files.* All relevant information travels physically through the supply chain, on paper or electronically on e.g. RFID tags. Step by step information is added. In this scenario, intelligence is placed at the lowest level. This approach is in practice often combined with central systems as mentioned before.

Aspect	Location	Condition	Quality
Relevant information items	**Identity, location, time**	**Conditions**	**Dynamical Quality**
Physical carrier	• Granularity • Information carrier • Code type	• Granularity • Information carrier • Information type • Condition • Measurement interval • Measurement technique	• Granularity • Information carrier • Information type • Quality indicator • Measurement interval • Measurement technique
Registration		• Registration interval • Registered information • Registration method • Registration focus	

Table 2: Important aspects of identification and registration techniques

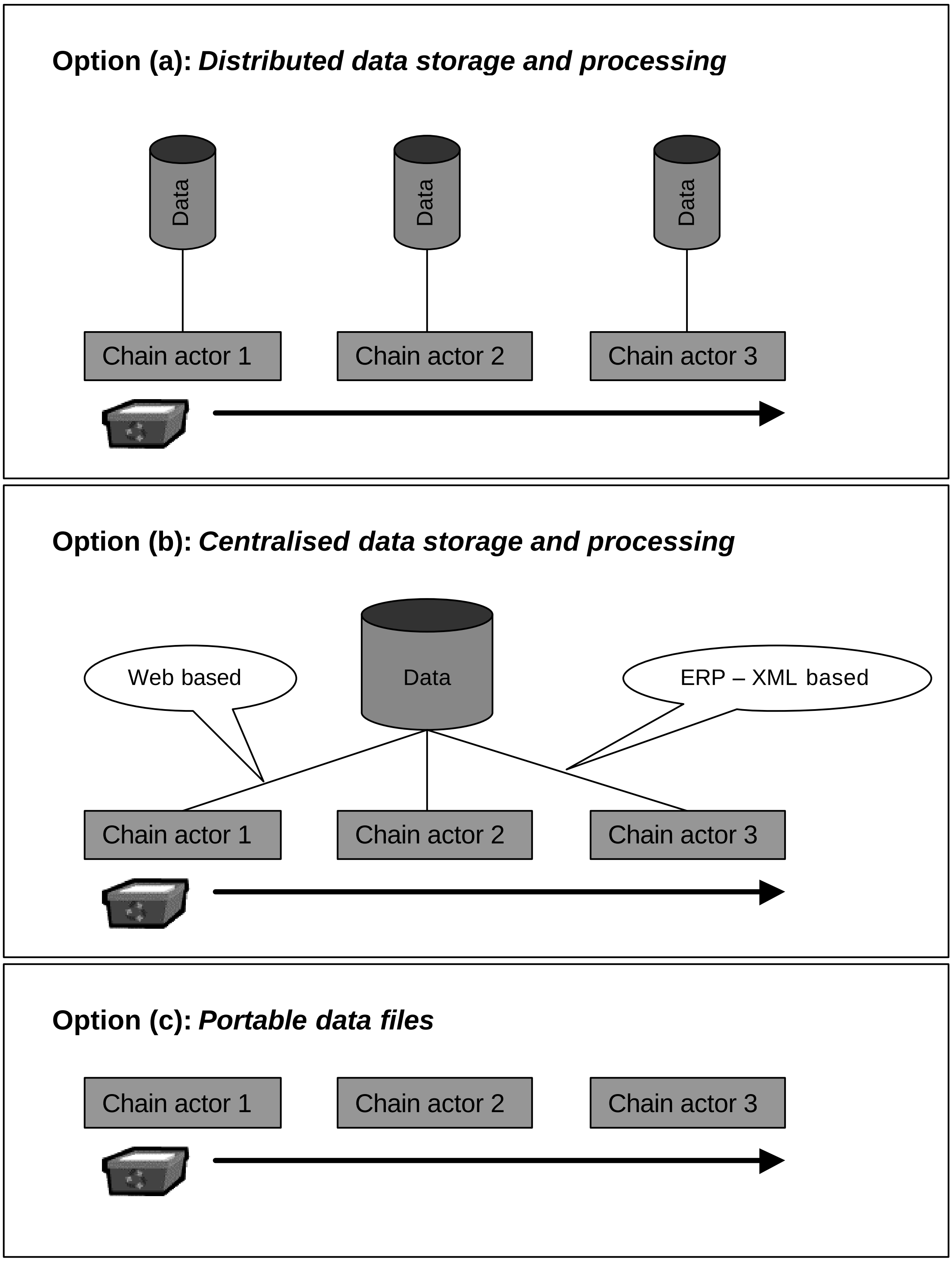


Figure 7: Possibilities for data-processing

3.2 *Process & Information*

Food processing chains deploy various types of processes. Traceability is about information. Three types of information play a central role: information on products (type, identity, product descriptors), information on product flows (weight, volume, number), and information on processes (type, process data) (Moe, 1998).

For traceability purposes, it makes a large difference whether product flow has the character of discrete identifiable products, e.g. pizza's, apples, boxes of rice, or that the product has the character of a (semi-) continuous product flow (e.g. commodities such as corn, tapioca or flour and liquids such as milk or vegetable oil). Individual products can be equipped with a tag, and followed through the process with scanners. In the case of semi-continuous products, the flows can only be followed by registering process settings. The exact history of a batch of milk powder, for instance, depends on the accuracy of a prop-flow model for emptying a silo in a production process. Information decoupling points (see Figure 8) (Trienekens & Beulens, 2001) convert semi-continuous flows into discrete flows and vice versa. Consequently, information decoupling points are of great importance for maintaining traceability.

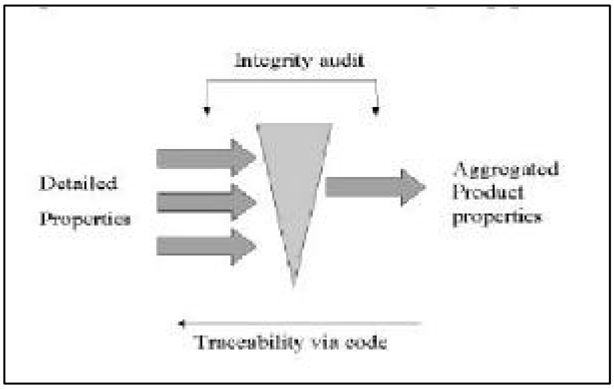


Figure 8: Information decoupling point

Another focus point in process and information for traceability lies in processes. Processes can, amongst other, be characterised by their product flow. Divergent processes (where product flows diverge into a larger number of product flows, e.g. the boning of carcasses, or the subdivision of grain in bran and granules) and convergent processes (where several product flows are combined in a compound product, e.g. the composition of a pizza from dough, tomatoes and mozzarella) play a special role from a traceability point of view; in these processes, product identities are created and deleted.

In order to keep proper track of product flows, the notion of registration points is helpful. In order to follow products in a production chain, it is necessary to establish the presence of a product (time, location and product identity). This requires the product to pass a scanner. The point in the process where a product identity is registered has been called registration point (Ketelaars et al., 2002). To realise traceability as accurate as possible, it is necessary to include a registration point after every process. What and to what detail information needs to be registered in a specific process depends on the requirements of the (chain) organisation.

To ensure traceability of product flows, and to support logistic optimisation, scanning product identity may suffice. The need to register a product is especially required before and after convergent and divergent processes. To support product quality management, it may be necessary to include large-scale information on process circumstances, recipes etc.

In the food processing industry, the main focus is on realising elementary product traceability. Many studies (DLV (2001a/b), TNO-Nutrition and Food Research (2002/2003), and FSA(2002)) signal that specific sectors are under way in realising traceability based on a proper process and information configuration. Examples are the meat sector and the large multinational food industries. Legislation helps to push a sector towards traceability. Recent food crises however indicate that both the internal organisation and the interface between organisations still falter.

3.3 Organisation

Notwithstanding the importance of a proper technology and process configuration, a major aspect in traceability is control and organisation.

With control, we refer to the processes that direct the various traceability processes in a chain: logistic, information, quality. An important issue here is how to configure the chain and interconnections of organisations, and how to ensure final and correct information exchange.

An issue that is often encountered in practice is the desired co-operation in a chain where enterprises with opposite control mechanisms are forced to co-operate. Examples are an auction, where a push market is transformed into a pull market, and a slaughterhouse, where an animal is subdivided into meat products. The consequence of such a situation is a fairly complex logistic system.

Apart from the mismatch in control strategies, there is also the risk of a mismatch between control strategy and feasibility of traceability. A chain that is currently unable to trace raw materials to the grower (e.g. because an intermediate trade link is not able to provide the necessary information) will be confronted with serious limitations in guaranteeing downstream traceability of compound products containing that raw material.

To be able to control a logistic chain, it is important to configure the internal and external organisation such that efficient co-operation is facilitated. Often, the most powerful actor, not seldom a retail organisation, will impose the traceability requirements as a chain director onto the rest of the chain. Important organisational issues that arise in a chain are:

- Which actor is responsible for a product in which part of the chain? The same for process, activity, registration point and data item.

- Which functions fall within each chain organisation? How are these functions linked?
- Which certificates (Identity Preservation certificates of bulk products; DLV & SGS Control, 2001a) suffice to meet the major requirements of my clients?

4 Legislation and self-regulation in agro and food

May 19, 2021, 6:04. Roberts son appears next to his bed. The boys' face is covered with small red pimples, and the boy is complaining about itch. Robert immediately thinks of the pasta dish. It should not contain any peanut component! He activates his bedroom terminal, logs in at AB, and enters the food safety desk. He describes the complaints, and his suspicion. The ingredient list of the product batch of yesterday is checked automatically. No peanut ingredient is found. An automatic search is initiated to check the food procedures. Moreover, a report is send to the local food safety authority.

The public concern on food safety and food quality has generated an increasing interest for traceability. Governments have established national legislation on food safety and traceability. In the General Food Law, European legislation takes a start. Furthermore, voluntary standardisation and branch specific self-regulatory initiatives are accomplished. This chapter deals with legislation, standardisation and branch initiatives respectively.

4.1 Legislation

The EC Regulation 93/43 of 1993 on the hygiene of food requires from all producing and processing food companies to work in compliance with HACCP principles (Hazard Analysis and Critical Control Points). This requirement relates to all preparation, processing, manufacturing, packaging, transporting, distributing and tracking activities. The regulation also requests basic tracking and tracing capabilities in case of food contamination through recalls.

The General Food Law (GFL) (EC Regulation 178/2002 of 2002) is a next step in enforcing food safety and traceability for food products. Each EU member state has the responsibility to translate and to incorporate the defined standards in the national framework. National laws may also be more specific about practical aspects (e.g. how and who will monitor the law) or even specify stricter demands.

Currently, the national Dutch Food Authority VWA (Voedsel en Waren Autoriteit) is studying the implementation of EC regulation 178/2002 in The Netherlands. At present, several aspects on the actual implementation of the law remain unclear. An important question is the required size of the smallest traceable unit. Another issue is how to define an adequate traceability system.

For the organic sector, specific requirements for production and traceability are laid down in the EC regulation 2092/91 on organic production methods.

4.2 Certification schemes

Confronted with increasing demands on product liability, product quality and food safety, various food sectors have established initiatives to standardise their quality, food safety and traceability systems. These certification schemes

partly overlap with national laws. Commercial forces, e.g. the demands of retail-organisations are strong driving forces in establishing and implementing these schemes (e.g. EUREP/GAP). Prominent initiatives include GMP^+, BRC, EUREP/GAP and SQF.
GMP^+ (Good Manufacturing Practices) is implemented in the animal sector. It requires traceability of feed. BRC (British Retail Standard) specifically for UK-market offers an extended developed checklist for food-safety. For the primary sector, EUREP-GAP (Euro Retailer Produce Good Agricultural Practices) was developed, which pays attention to food-safety aspects as well as working conditions and environmental aspects.

Legal framework of Tracking and tracing

Global

Codex Alimentarius: No general requirements are laid down with regard to tracking and tracing. In the context of food safety, initiatives exist for specific sectors (e.g. fresh fruits and vegetables) to lay down specified requirements for *"adequate record keeping, written procedures, control, limits, monitoring results, etc".* In 2001, it was decided to give four committees the mandate to elaborate the term "traceability" within their respective frameworks. It concerns Codex Committee on Food Hygiene (CCFH), General Principles (CCGP), Food Labelling (CCFL) and Food Import and Export Certification and Inspection (CCFICS).

European Union

General Food Law (GFL): It concerns the EC Regulation 178/2002, which aims at harmonising food safety related laws for the European union. The scope of the GFL are all chain actors of the food production chain including animal feed processing units. Article 18 of this law requests that at all stages of production, food ingredients have to be traceable.

Liability: It concerns EC regulation 820/97 in which each chain actor (inclusive primary production since 2001) can be held liable by the consumer for damage as a consequence of inadequate products

General Product-safety: It concerns EC Directive 1992/59 requiring that all food products need to be safe and that adequate recall procedures are present.

Batch/Lot Identification: It concerns EC Directive 238/1991 which defines a lot as "a batch of sales units of foodstuff produced, manufactured or packaged under the same conditions.

Organic production methods: It concerns EC Regulation 2092/91 and lays down the criteria for organic production methods. It also specifies how organic products have to be administered and labelled.

Hygiene of foodstuffs: It concerns the EC Directive 93/43 requiring that all food business operators shall identify any steps in their activities which are critical to ensuring food safety and ensure that adequate safety procedures are identified, implemented, maintained and reviewed on the basis of the HACCP principles.

Box 3: Legal framework of tracking and tracing

The more recent schemes SQF (Safe Quality Food) and Supply Chain Certificate emphasise the chain aspects and demand specific tracking and tracing capabilities for the certified chain.

4.3 Normalisation and standardisation

The recent attention for traceability has resulted in a multitude of systems, terminology, technology, working protocols and regulations (Verdenius & Beumer, 2003). The developed solutions are hardly ever compatible. This heterogeneity threatens broad implementation of traceability. Moreover, chain actors as well as consumers lose understanding and confidence.
Several parties have recognised this threat, and a number of standardisation initiatives have been established.
Since 1961, the Codex Alimentarius has been developed by the FAO and the WHO (FAO/WHO, 1963). It can be seen as the root of all norms and standards in the areas of food safety and traceability.

The FAO has been the main initiator of the Codex. It is strongly driven by the desire to protect consumers but it lacks guidelines and standards for actual implementation. Several factors increased the pressure on commercial actors to implement traceability systems. This has resulted in the desire to internationally standardise arrangements on traceability. The most suitable organisation to take up such voluntary initiatives is the ISO. In several ISO standards, aspects of traceability have been the subject for standardisation. The ISO 8402 standard (*Quality management and quality assurance system – vocabulary*) defines relevant terms such as *product liability* and *traceability* in a quality management environment. Although these definitions are very general, they are often referred to in ISO 9000 and HACCP contexts.

ISO 22000 is an ongoing effort to standardise food safety management systems, and a first operational version is due at the end of 2004. It can be seen as complementary to existing sector initiatives. The focus of ISO 22000 is restricted to food safety issues, but it will contain traceability directives. It is expected to minimally cover HACCP, the Codex and those quality management system aspects that are relevant to food safety. Moreover, it is expected to cover a minimal set of good practices requirements, related to manufacturing, agricultural, distribution and veterinary.

Standardisation of traceability systems has been the main goal of ISO/TC 34. Based on an Italian initiative, a first draft for a traceability standard has been compiled and distributed to the ISO member countries. The main goal of this standard is to provide general principles for the design and development of traceability systems in the food sector. The current draft is composed of a set of definitions and a set of requirements for a traceability system. It focuses on the desire to actively prove the origin and appropriate handling of a product, e.g. in order to gain commercial confidence from consumers (regional products).

The more common need to passively document the history and flow of products through the production and distribution chain is yet to be added to the current draft. A first version of the standard will be published in 3-5 years.

The Global Food Safety Initiative (GFSI) set up by the main European retailers tries to harmonise the different certification schemes by means of benchmarking. A specific certification scheme has to comply with a minimum of aspects with regard to food-safety and traceability.

NEN and ISO initiative on tracking and tracing

At the end of 2001, the Technical Commission on 'Agricultural Food Products' from ISO (ISO/TC 34) proposed to set up an international norm for traceability. The first draft was initiated by Italy.

The scope of the norm is:

> *This standard defines the principles and specifies the requirements for the implementation of a chain traceability system for the whole food chain (from farm to fork). It may be a technical tool for the enforcement of a specific regulation. It applies in all those cases when it is necessary to prove by documents the development of a product and the specific responsibilities through the identification and the recording of the flows of materials and the organisations which enter the manufacture, sale and supply of the product.*

The draft standard states that in order to set up a traceability system, it is necessary to establish:

- the product or the relevant component(s) for which the chain traceability should be carried out;
- the organisations and the flows of materials involved according to the peculiarities of the product;
- the procedures for identification of a product inside and among the involved organisations;
- the procedures for recording (documentation) of the flows of materials;
- the procedures for the segregation or separation from other products, of the product when necessary;
- the organising details between the involved organisations;
- the procedures and the responsibilities for the data management;
- the official agreements between the different involved organisations for the implementation of the traceability system;
- the suitable procedures for the system management and control.

NEN is investigating the need for a Dutch contribution to this norm. It considers setting up a national platform formulating the contribution from the different stakeholders (Kolsteren & van Woerden, 2003; Heumer, 2002).

Box 4: NEN and ISO initiative on tracking and tracing

5 State of the art of tracking & tracing systems

The current state of the art for tracking & tracing systems can be assessed from recent studies by among others DLV, Q-Point, TNO, Rijnconsult and Agrotechnology & Food Innovations bv. Interviews with different food processing companies and other stakeholders such as certification agencies and ICT companies complete the overview as presented below.

5.1 Food industries' attitude towards tracking and tracing

Food safety matters remain "hot". Due to globalisation, this attention is worldwide. This is to a large extent maintained by recent food crises. The modern consumer is sensitive to dangers and risks related to food and personal safety. National governments as well as the EU have picked up this consumer concern. The General Food Law and the EFSA (European Food Safety Authority) result from this concern. National initiatives, such as the Dutch Food Safety Authority (VWA Voedsel en Waren Autoriteit) and the British Standards Agency are set up. These authorities gather together expertise and have to regain consumer confidence.

Businesses feel their responsibility with regard to food safety and transparency of production and processing. But in practice, most businesses take an acquiescent attitude. Food productions chains in general do not focus on traceability. Systems that exceed company boundaries are still exceptional. Day-to-day aspects dominate the agenda's.
But also the unclear, changing and disharmonised demands of buyers and the government contribute to the passive role of the food industry. For example, different (international) retailers demand different quality assurance and food safety systems (e.g. BRC, HACCP, EUREPGAP, IFS). And concerning legal obligations, the implementation of the GFL remains especially unclear. Many of the practical aspects still have to be specified. Some companies believe that the implementation of the GFL will take some more time and that surveillance will even come later. Companies might adapt the strategy of complying to unavoidable demands, while postponing the implementation of new demands as long as possible.

Individual food companies perceive little added value for implementing detailed tracking and tracing systems. The collective benefits for chains or networks are also beyond perception. One of the areas where improvements show directly is logistics. Tracking and tracing is therefore often placed in the context of a logistic optimisation of the supply chain. It is thus integrated and becomes a module of a logistic software package.

Companies realise that, even though citizens indicate the importance of tracking and tracing and safe food, consumers are hardly influenced in their choice. An even smaller consumer group is willing to pay additional costs (Erasmus Food Management Institute, 2003). Operational retail systems such as Peters Farm, enabling the consumer to trace the origin of a specific food product, are not really appreciated in practice. In theory, consumers like to have the information but in practice, the information is hardly requested and used.

Food companies try to balance between preventive measures, quick as HACCP-based systems, and the curative and reactive approaches such as traceability. Especially in Europe companies focus on the system approach, apparently assuming that in well-controlled systems little will go wrong.

5.2 Actual performances of tracking and tracing systems

In general, the Dutch food processing industry performs good on traceability, when compared to other countries in the world. The level of traceability however, varies substantially over the different sectors. Recent studies for fresh products (DLV, 2002) and meat (Consumentenbond, 2001) indicate that traceability can be improved in those sectors. One of the issues to improve is the size of the smallest traceable unit. In case of a recall, the number of products involved will be too large.

A number of large Dutch food processing industries and the Dutch government are planning to scale up existing traceability systems and back-bones to other companies in the sector. The Platform for Transparency and ICT (Platform Transparency and ICT, 2003), a combined initiative of companies such as Nutreco, Dumeco, Seafood Partners, the Wageningen University & Research Centre and the Dutch Ministry for Agriculture, Nature Management and Fisheries will facilitate this (see Box 5).

Platform Transparency and ICT

At the end of 2002, the Dutch minister of Agriculture has installed the Platform for Transparency and ICT. The Platform, under supervision of Prof. dr. Aalt Dijkhuizen from the Wageningen University and Research Centre, aims to improve food safety. This goal can be reached through good information exchange among all partners in the food production network. Currently, three projects have been envisaged in the poultry, pork and fish sector. By promoting this initiative, the government and the concerned companies hope to use the experiences of these pilots for the whole sector. It will thus promote the image and transparency of the food-sector. In doing so, a generic back-bone would be created for tracking and tracing systems.

The project will last 4 years, and is supported by the Dutch government with 1 million Euro. Based on the first results of the three pilots, new initiatives will be set up in other sectors.

Box 5: Platform Transparency and ICT

Most applied ICT tools for traceability are still tailor-made. The available standard products mainly aim at large industries. Typically, they are part of Manufacturing Execution Systems (MES) and ERP systems. Adequate support for small and medium enterprises is lacking. In practice, industries aiming at traceability have to link different software packages in order to fulfil the traceability requirements. The resulting solutions are often considered sub-optimal. New technologies such as RFID systems are not yet widely used and many companies are apparently not convinced of the advantages.

Another major issue is the traceability of Genetically Modified Organisms. Due to various causes, including political and economic trends, traceability remains hardly feasible (Borchgrave, 2002). This is especially true for food components made of commodities, such as soya-beans and maize, with long and complex transport, storage/handling and processing chains (DLV, 2002).

In Figure 9, food processing companies are analysed in two dimensions, based on product characteristics. One attribute refers to the shelf life of products. This factor predicts the focus of traceability systems in the sector. For fresh persihable products, the main gain in traceability lies in better control of food quality and food safety; the motto is to transport as fast as possible. For durable products, the main focus lies in optimalisation of logistics.

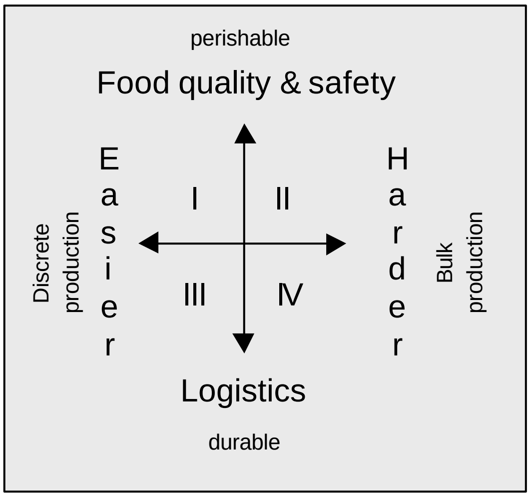


Figure 9: Analysis of food processing companies in terms of product characteristics

The second attribute refers to products and processes, discriminating between discrete products and bulk products. This attribute relates to the effort needed to make products traceable. Discrete products, processed in discrete steps, can be equipped with identification tags. Mixing problems do not occur, and the traceability effects of divergent and convergent processing steps can be easily managed. Bulk products, including commodities, however suffer from fundamental identification and traceability problems. Tags cannot be attached, and product flows are harder to follow. Many processes use continuous or semi continuous product flows. Often, batches of raw materials are mixed before processing. In order to maintain traceability in these processes, either the process settings need to be reconfigured, or the traceability requirements need to be relaxed in specific steps.

Although no one company purely represents a certain type of company, these two dimensions enable us to project the food processing industry into four quadrants:

I. Processors of fresh produce into fresh products, examples being the fresh cut vegetables, minimal processed food, some dairy products.
II. Processors of bulk produce into fresh products, examples being the processing of dairy, meat, bread and pastry
III. Processors of bulk raw materials for non-perishable products, such as products produced by large multinationals (e.g. Nestlé, Unilever and Coca Cola), large agro-industries and the animal feed industry
IV. Processors of discrete raw materials for non-perishable products, such as the production of preserved vegetables and fruit.

In general, one can say that the following factors facilitate the traceability of food-products:

- The degree of (physical) integration of chain links into one company (such as Nutreco). In case the management decides to set up a traceability system, no agreement needs to be gained with the other chain links since they all belong to the same company. Also aspects of cost and benefits sharing and privacy aspects (e.g. production figures) are more simple.
- Discrete production processes are more easy to track and trace, as individual product-entities are present through the entire production and distribution chain. For commodity products and semi-continuous processes such as corn, soja, milk or sugar production, detailed traceability is more difficult and complicated.

Short chains with a constant configuration over time have a better traceability than long and complex chains and networks with flexible connections.

VIP (Virtual Integration Poultry-chain)

To provide poultry consumers with information on product origin, the different actors in the poultry production chain have to work together. Bringing the independent companies to work together is a long and difficult process. One possible solution is to create a virtual network for the different actors. The Dutch feed producer De Heus, Brokking Koudijs has initiated a virtual network called VIP (Virtual Integration Poultry-chain).

VIP covers the chain from the breeder till the slaughterhouse. Each link enters information concerning the poultry, such as date of birth, amount of feed used, sicknesses, treatments, et cetera. In this way, the next link in the chain knows the history of a specific lot of poultry. The system is accessible by internet and one of the functions it offers is tracking and tracing. At the moment, the system is operational and used by all chain partners.

More information: www.de-heus-vip.nl

Box 6: VIP (Virtual Integration Poultry-chain)

6 Incentives for tracking and tracing

May 19, 2021, 10:00. AB contacts Robert. There has been no traces of peanuts in the production of his pasta dish. Moreover, all cleaning and disinfecting measures have been adhered. They apologise for any inconvenience, and offer Robert and his son a guided tour at the production site of the food producer that supplied the microwave pasta dish, in order to overcome the excitement. Robert is satisfied on how his complaints were treated, and decides to remain a customer of AB-online.

With the perspective of the General Food Law in 2005, with increased liability matters and with increased pressure from retail, more and more food processing companies pay attention to tracking and tracing and recall-management. Often, a defensive attitude towards tracking and tracing prevails, and one does not see the added value that is offered by pro-active tracking and tracing. Good traceability and transparency can be a competitive advantage for industries. Tracking and tracing is not the aim but the vehicle to realise certain business and chain goals.

From the perspective of the consumer, two points of view towards traceability can be distinguished (Peupert and Theuvsen, 2003). On one hand, traceability can be employed to safeguard *consumer health* and safety of food. On the other hand, traceability can be seen as a tool to regain and maintain *consumer trust* and confidence. Traceability in this context means conveying all information about process and product characteristics throughout the value chain that might be relevant to consumers and their buying decisions at point of sale.

Within the context of transparency of chains and network, tracking & tracing systems merely relates to *history transparency* (Hofstede, 2003), and to a less extent to *operations transparency* and not to *strategy transparency*. The three types are distinguished depending on whether transparency is aimed at the past, present or future.

Depending on the level of supply chain integration, different requirements will be imposed on the tracking & tracing system (Dorp, 2003). Three layers can be distinguished: (1) item coding (the physical layer), (2) information architecture (the information layer) and (3) planning and control (the control layer).

Figure 10: Possible incentives for tracking & tracing

Figure 10 gives an overview of possible incentives that can result from traceability.

For some aims of tracking & tracing, such as recall-management and logistics, information on product identity, location and processing time suffices.

Other aims, such as quality management, additional information on process conditions, recipes and handling are required. This is often referred to as quality oriented traceability. The most obvious condition is temperature, but also parameters like relative humidity (for example for flowers) or ethylene concentration (for example for fruits) may play a role.
Principally, one would ideally like to directly measure product quality. This is possible with existing technologies (see Box 7). New technologies on genomics, metabolomics, and proteinomics, offer the promise to do so in the future.

It becomes thus clear that the traceability goals directly influence the technology required. And that companies and chains normally start with identification and then move up higher and start to utilise tracking and tracing also for other purposes. This pyramid concept is visualised in Figure 11.

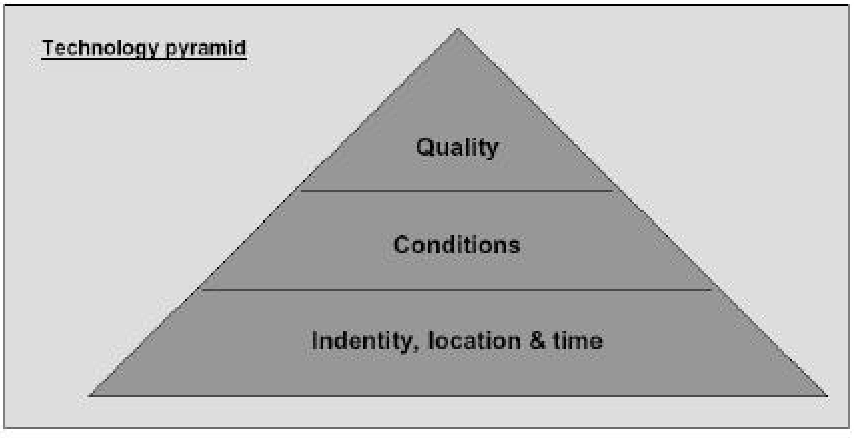
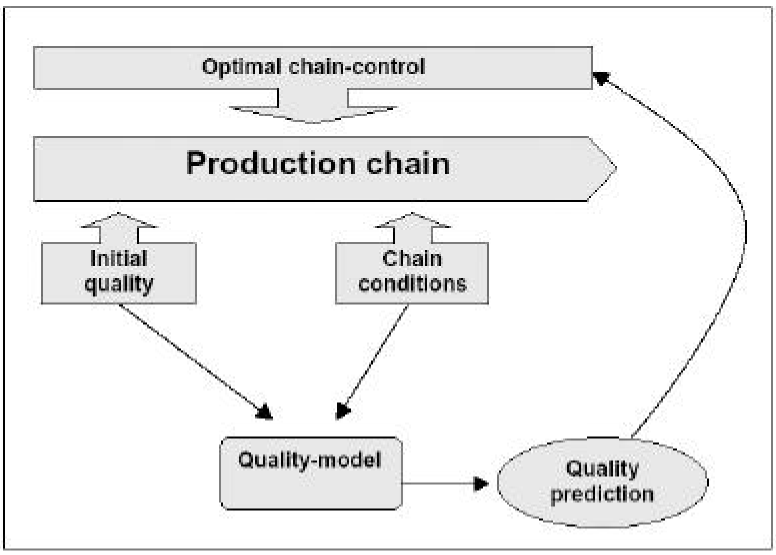


Figure 11: Technology pyramid

Quality Tracking & Tracing

A special form of tracking is the so called quality-oriented tracking and tracing (see also Ketelaars, et al., 2002). The idea is that if one can measure and thus quantify the initial quality of products, one should be able to predict the quality at the end of the chain if one knows the conditions under which the products were further processed, stored and transported. Based on this information, different processes can be optimised such as logistics. Based on the predictions chain, links might also decide to differentiate product qualities for different retail channels.



Box 7: Quality-oriented tracking and tracing

7 Implementation of tracking and tracing systems

This chapter introduces different approaches for realising tracking and tracing systems. Then it looks back at lessons learnt and tries to outline some generic conclusions in relation to the implementation of such systems in the food branch.

7.1 Approaches for realising tracking and tracing systems

If an organisation or chain implements traceability it goes through a change process. In this process, various approaches can be deployed. It is possible to distinguish four types of orientation when looking at the implementation approaches of tracking and tracing systems.

Policy orientation

The policy orientation, based on tailor made scenario analyses is primarily focused on the options decision makers have before starting the introduction and implementation of traceability systems. These options should be within the boundaries of technological and economical feasibility and legal requirements. They also must fit within strategies, policy and technological, commercial and political environment of the organisations or companies concerned. They may well include options to realise added value related to products or production processes. Through the scenario approach advantages and consequences of different options for traceability systems can be made visible. An example of the approach developed by TNO Nutrition and Food Research is shown in Box 8.

System orientation

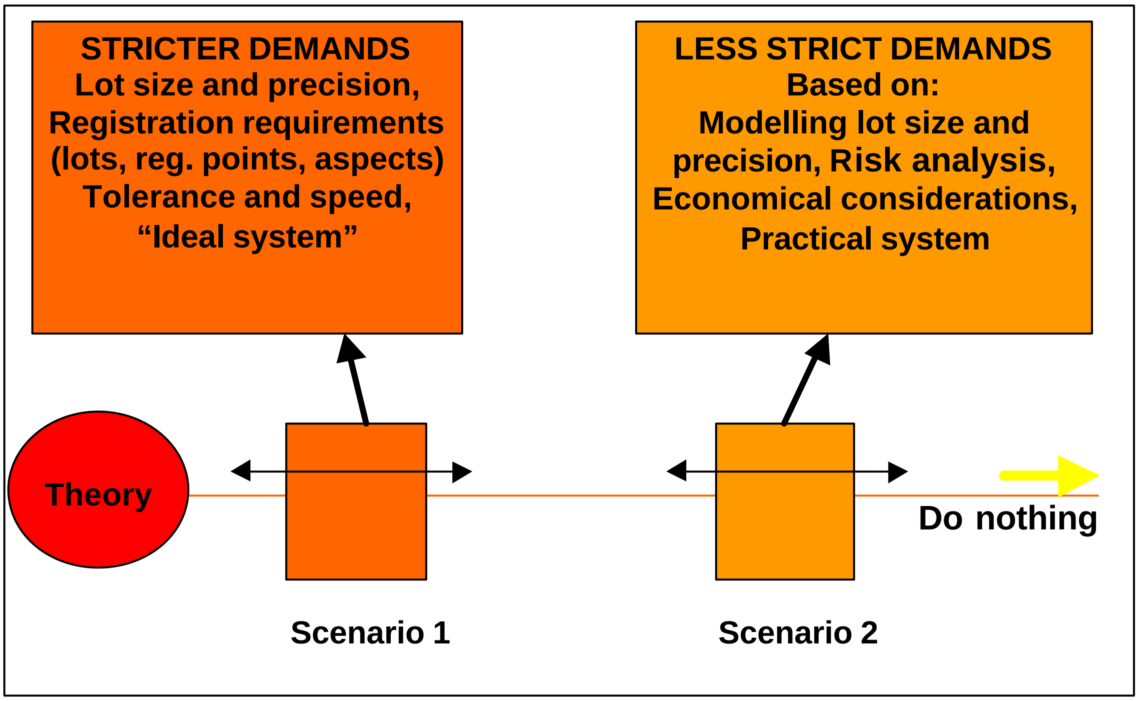
In a system-oriented approach, the main focus is on the resulting (technological) system. The approach typically focuses on technology and processes. It can offer schemes to analyse and design systems, and deliver an overview of what characteristics the final system and production process should have. An example of a system-oriented implementation approach is the *FoodPrint* method as developed by Agrotechnology & Food Innovations bv (see Box 9 for more details).

Reference models of specific sectors can act as a helpful tool for analysing and design traceability systems (Beers, 1994). An example of a project in which a reference model is developed and used is the GIQS project currently performed by Agrotechnology & Food Innovations bv and Chain Food.

Policy orientation: TNO traceability scenarios

The scenario approach for traceability is a policy tool for decision makers on the choices to be made upon introduction and implementation of traceability systems. The principle of this approach is that advantages, disadvantages and bottle-necks of strict and less strict implementations of traceability are analysed in order to define suitable options. Within limits of technical feasibility and legal requirements, elements and strictness of these scenarios are free to choose, depending upon relevant management and operational conditions. So they can be considered as defined points on a continuous scale (see the scheme below).

Traceability scenarios on a continuous scale



The scenario approach is primarily developed for managers and decision makers at a high aggregation level (Ministry of Agriculture, Nature and Food quality; Food Safety Authority etc.). It was developed in the framework of a study for the Ministry of Agriculture, Nature and Food quality and tested successfully in a feasibility study on traceability for the cereal sector. The scenario approach in particular is suitable for sectors, branches and chains in the food industry, who want to analyse the consequences of and options for the introduction of traceability for their affiliates. The approach however, is also adaptable to the needs of individual companies and their managers. This approach assists companies to define aims and options with respect to traceability in line with their strategy and policy, thus resolving an important bottleneck for the introduction and implementation of traceability.

Box 8: Policy orientation: TNO traceability scenarios

Process orientation

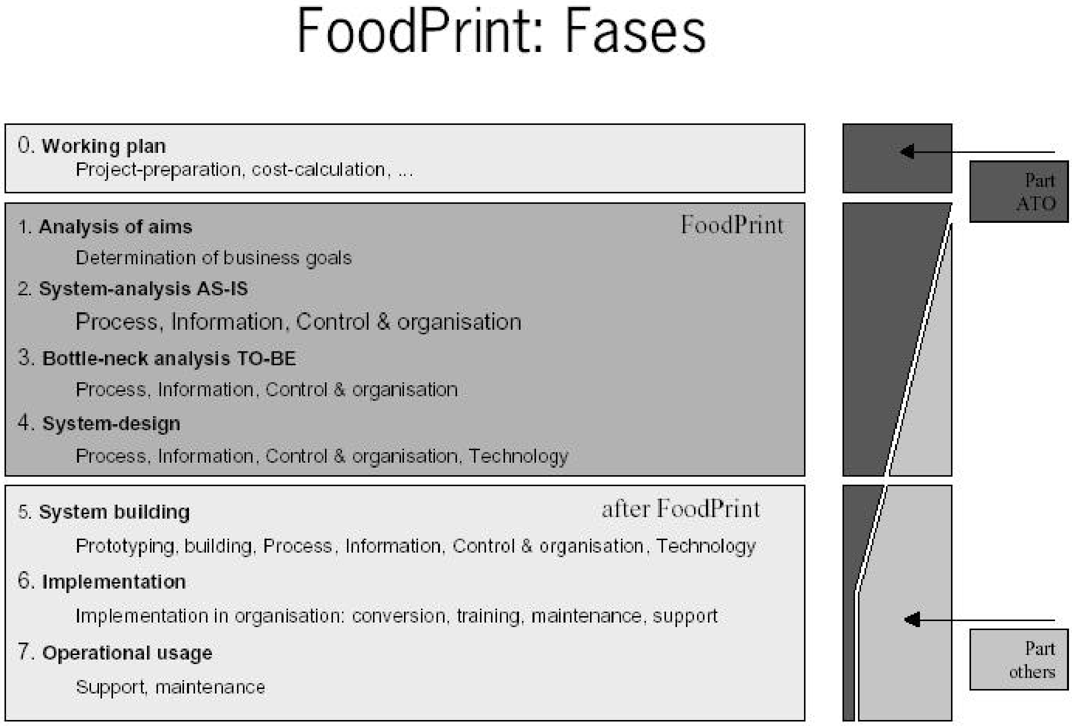
In the process orientation, the main focus is on how to implement a tracking and tracing system and not so much on technical details of the system. The approach is comparable to setting up a HACCP system. It comprises aspects of for example the idea of setting up a tracking and tracing team that then investigates wishes and practical restrictions for implementing a traceability system. The team concludes with a concrete plan and implementation proposal. Focus thus lies not so much on the output but on how to come to a tracking and tracing system. An example of a process-oriented implementation approach is the ITI method as developed by DLV (see Box 10 for more details).

Product orientation

In the product orientation approach, one defines what characteristics products should have when the tracking and tracing system is in operation. The product orientation is more in line with the zero-tolerance approach of, among others, the USA. Focus lies on the final product and its characteristics; for example, absence of human hazards and not so much on the system by which this is guaranteed. In the EU, focus lies more on the system and less on the product. Governments control and supervise the assurance-systems and assume that appropriate systems guarantee the output.

System approach: Agrotechnology & Food Innovations' ***FoodPrint***

FoodPrint is a systematic tool for design of tracking and tracing systems. In too many companies, the sole aim of tracking & tracing is viewed in the perspective of recall management. *FoodPrint* offers the possibility to translate company aims and missions into practical tracking & tracing solutions. Traceability thus becomes an instrument for companies to realise its strategy and enables companies to reduce product losses and shrink, realise commercial advantages and to innovate new products.



As mentioned, *FoodPrint* starts with a thorough analysis of company aims which are then linked to concrete and measurable tracking and tracing targets. Next, the current AS-IS situation is analysed and by means of a bottle-neck analysis, the TO-BE situation is evaluated. This finally results in system-design which can then be operationalised by an ICT system integrator (see also picture).
During the process, FoodPrint differentiates among the following modules: process, organisation, information and technology.

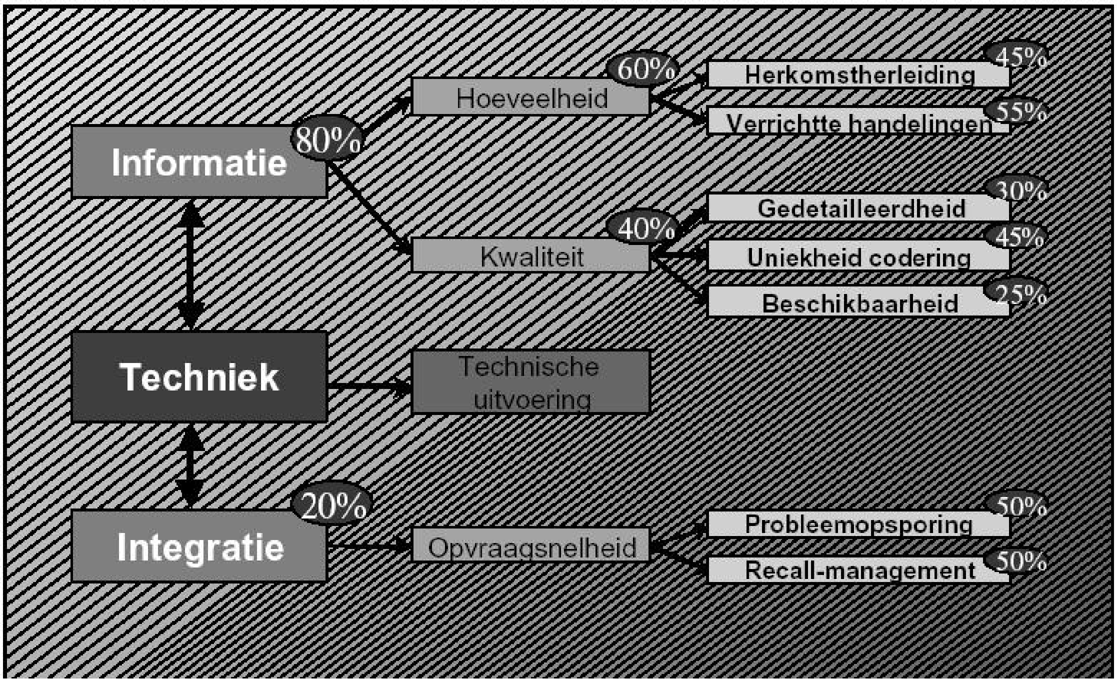
Box 9: System approach: Agrotechnology & Food Innovations FoodPrint

Process-orientation: Q-Point ITI

Benchmarking of different tracking & tracing systems of for example a certain branch can be done by using the ITI-approach (DLV, 2001a). ITI stands for Information, Technology and Integration and gives specific scores to different components of a tracking & tracing system (see figure below in Dutch). It thus quantifies the presence and scale of operational implementation of different tracking & tracing systems. By doing so, performances of tracking and tracing systems can be roughly compared or benchmarked. Benchmarking has for example been done for Dutch vegetables and fruit processing sector (DLV, 2001b).

Besides this, a 8-steps approach for the implementation of a tracking and tracing system is available:

1. Setting up tracking and tracing team
2. Prepare product- and process descriptions
3. Inventory of information wishes of chain-partners
4. Indicate current tracking and tracing situation
5. Proposal for ambition level
6. Prepare design for tracking and tracing solution
7. Prepare technical design
8. Implementation



Box 10: Process-orientation: Q-Point ITI

7.2 Lessons learned

What are the lessons to be learned from the variety of tracking and tracing systems implemented? What are the critical success factors and which points need special attention when setting up a tracking & tracing system for a chain?

- ⇨ *Legal framework.* As long as the legal framework in relation to requirements for traceability of food remains uncertain, companies remain reluctant to act. This is especially true for the implementation of the General Food Law. Questions like “What is the required size of a STUNT?” or What is the required timeframe for a recall?” need to be answered before companies will invest in a system. A comparison can be made to the implementation of EC Directive 93/43 of 1993 on the hygiene of food and the implementation of HACCP-based hygiene systems. It has taken many years for companies to have such a system operational and also control was lagging behind. Consequently, a coherent legal framework is essential.
- ⇨ *Cost responsibility.* There is a discrepancy between the citizens’ desire for security and safety, and the consumers’ willingness to pay for traceability. The concrete short term financial incentive gives a stronger stimulans for consumer behaviour than the more idealistic citizens’ responsibility (Dijksterhuis, 2003). Moreover, the consumer confidence in the reliability of tracking & tracing information, sustainability of production methods and , environmental friendliness also determines the buying behaviour of consumers. In such a situation, additional traceability costs are shifted into the chain. In a free market, this will result in a minor driving force for implementing tracking & tracing systems. A level playing field with a crisp definition of minimal traceability requirements makes it possible to account for traceability costs in consumer prices.
- ⇨ *Concern of consumer for safe food.* Food safety is an important subject that involves primary emotions with consumers. Tracking and tracing systems are a powerful tool to safeguard food safety and to recall products in case of incidents. As agreed between several international retailers, food safety should be a non-competitive aspect of food. Rapid alert systems based on or at least related to tracking and tracing systems of individual businesses will further safeguard quick response to food contaminations.
- ⇨ *Cost–benefit ratio*. In general, the cost–benefit ratio for tracking and tracing systems is normally too small, taking into account the traditional incentives such as recall management. Promotional aspects are important factors for companies in deciding to set up a system. By setting up a traceability system, companies and chains can express their social and environmental vision and responsibility.

  In case companies or chains perceive the ability to realise more goals by means of a traceability system, the financial balance becomes more positive.

- ⇨ *Technological developments*. Even though a wide range of technology exists, many of the devices are still at the beginning of their development and have not been proven in practice. This is especially true for RFID tags and the respective reading units. RFID tags able to measure conditions such as temperature are even less available.
- ⇨ *ICT backbone*. A wide range of software applications exist but the efficient interchange among all these systems is especially critical. This is especially true for smaller to medium-size enterprises (SME). Only tailor-made systems are available and easy to adapt back-bone system for a specific branch or sector.
- ⇨ *Focus on internal traceability, less on chain traceability*. Today, most focus for the implementation of tracking and tracing systems is at the level of the individual company. In more rare cases, traceability systems involve several to many chain actors. Sharing information and the costs to build and maintain a traceability system among several chain-partners is not easy. For companies with vertical chain integration, this is easier as the decision to set up a traceability system is taken centrally. With vertical integration, this one company possesses and thus controls the whole or a large part of a production chain from farm to fork. The legal framework focuses on chain actors' responsibility and liability and thus does not facilitate shared traceability systems.
- ⇨ *Show cases*. Even though some cases of successful traceability systems exist, many companies and production chains are not convinced of the benefits it can bring. The Dutch Platform Transparency and ICT tries to change this by providing generic examples.

  The additional benefits companies and chains can realise from traceability systems apart from food-safety and logistics, is not clearly demonstrated yet in practice. It should for example be demonstrated that joined investments in a good traceability in the beginning of the chain can be profitable for the end of the chain.

  Proven quality oriented tracking and tracing systems are not yet available.
- ⇨ *Driving incentives*. It becomes clear that companies and chains successfully set up a traceability system if:
  (a) the company has a vertical or horizontal integration (see before) (example Nutreco) or at least where clear and durable interactions among chain partners exist,
  (b) requirements are laid down by the retailer on the dedicated and preferred suppliers (example of BRC and EUREP-GAP by CSI) or
  (c) one chain actor 'believes' in the concept and is willing and powerful enough to set up a system (example VIP), and
  (d) the governement provides stimulation (e.g. platform Ketentransparantie & ICT), clear legislation (e.g. General Food Law) and prompt and predictable enforcement.
- ⇨ *Focus on logistic optimisation.* Traceability is up to now often integrated into logistic packages and not seen as the core functionality. This approach is understandable since logistic optimisation brings clear and quick financial benefits to businesses. One risk in focussing too much on logistic aspects is that the possibilities for traceability are not fully employed.

- ⇨ *Trust and power*. Sharing tracking and tracing information among and with others is potentially a sensitive matter. Companies need to trust the actors behind the information system storing the tracking and tracing information. Fear exists that confidential information is abused and that competitors would profit as a result. Information is often regarded as power and influence: Who has the information also has the power to influence others. Proven data security systems are required to safeguard privacy of confidential information. The most powerful link in the chain normally tries to play an important role or even monopolises such a system. By doing so, it directly forces the other links into a more dependent and unappreciated situation.
- ⇨ *Preference for small production units:* Historically, a trend for large production units (e.g. tanks, containers) has been observed. Under pressure of traceability requirements, the implementation of smaller production units becomes more popular. Smaller units make it possible to avoid mixing of batches, thus enhancing traceability.

8 Future developments and research agenda

May 22, 2021, 23:30. Before falling asleep, Robert thinks about his son doing shopping in 2046. He fantasises that his son does not need to worry about food safety and quality. And with a relieved smile he falls asleep.

Technical innovations, market developments as well as a changing legal framework will result in new functions of T&T systems.

8.1 Components of tracking and tracing systems

Extrapolating from recent developments, all components of tracking and tracing systems will be further developed: technology, process & information and organisation. Some expected developments:

- *Tags, transponders and other registration devices*. Because of technical innovations (and increasing popularity), prices of these components fall. The reduced costs will further lower the threshold for broad introduction of such components. Besides product identification and registration additional functions will become available, including climate and product quality development registration. Harmonisation and world-wide standardisation for tags/transponders will facilitate wide implementation of the technologies.
- *Biotagging*. As explained in section 3.1.1 biotagging will become important in food production chains with convergent and divergent product flows (like in the meat industry) where other hardware solutions fail. Biotagging comes in various forms: *active* and *passive*, *natural* and *synthetic*, and tagging based on *physical*, *biochemical* and *genetic* information carriers.
- *Product and process information will be linked.* Through the combination of product information with process conditions (think of climate conditions during storage and transport, processing temperatures, etc.) added value of tracking and tracing systems can be further exploited. With adequate models for product quality development and microbial growth, predictions of food safety and quality can be used for decision support ('Quality-oriented tracking & tracing'). Innovations in the field of genomics will be linked to this development for online measurement of product quality attributes.
- *Traceability information and quality monitoring will be integrated with business management information systems.* On one hand this development is necessary to utilise T&T information for business optimisation (creating added value). On the other hand, this will be necessary to minimise operational costs for information management systems. Because of the internal character of business management systems, this development will not yet be extrapolated to the chains: for chain traceability chain-specific solutions will remain necessary; web-based applications will become dominant for that purpose.
- *Information will be made available for consumers.* T&T information will become a growing important marketing tool. The availability of T&T

information demonstrates the transparency and consumer awareness of the (chain) actors. Active presentation of information on origin and production characteristics (authentication) may help to gain trust in specific (niche) markets. Web applications on the Internet will allow revealing the information for individual products based on their identification code).
- *Further standardisation:* Currently, standardisation aims at a technical level (UCC/EAN for barcode, EPC standard for RFID systems). This trend is expected to proceed, end to be extended to the information level.

Some expected effects of these developments:
- *Batch sizes can be cut back*. Traditionally size of scale was of large importance for competitive production. Now there is a trend towards relatively small-scale, connectable facilities allowing batch sizes to be downscaled to small Least Traceability Units. This also facilitates product differentiation.
- *Scaling-up of business*. Because of the increased rationalisation and availability of quality-related information, exceeding size of scale at business level will result in additional advantage. Here, product differentiation will enhance the need of adequate T&T systems.
- *On the other hand, also small-scale business development will be boosted*. Small-scale business can profit from less complex business and chain organisations, with less demanding control mechanisms.

Technical research issues
- Product quality knowledge and models for estimating product quality development and (microbial) safety from measurable product and process data.
- Innovations of tags (cost price, additional functions) and related information systems

8.2 Legal and social framework

Extrapolating from recent developments we see:
- *Legislation becomes more strict and clear about batch size and recall time*. The General Food Law is the first step, but requirements will become stricter.
- *Retail and industry imposes demands on suppliers and buyers*. Reacting to the legal requirements and expected developments, retail and industry, transparent suppliers are favoured.
- *Development of T&T systems will lead to various social consequences*. It is often said that processing industries and logistic companies profit most from the developments, whereas other actors pay for it. Claims can be put down to the responsible party more easily. Additional costs, however, shift to the primary producers and consumers.
  Furthermore, since legislation is primarily aimed at large-scale rationalised enterprises, SME's experience the largest disadvantages.
- *Enterprises are sensitive to sector-wide developments*. Since incidents in a sector damage the image of an entire sector, enterprises should either try to introduce uniform standards for T&T in a sector or to distinguish themselves from less strict competitors. In the latter case, the distinction

should be actively communicated to the customers to reduce the impact of incidents of competitors to the image of other enterprises.

Legal research issues

- To what extent does the development, content and specificity of legislation influence the introduction speed and quality of T&T solutions?
- Which demands to legislation can be formulated to speed up the process toward fully transparent chains?
- What will be the consequences for developing nations; how can producers in developing nations profit from the developments?

8.3 Incentives

Here, we distinguish between internal incentives (related to the production management) and external incentives (related to market developments).

Internal incentives aim at increasing added value and reducing operational costs. We foresee the following developments

- Development of more high-quality knowledge-intensive products, such as special care products, diet food etc. Tracking & Tracing systems with integrated quality management support successful development of these products.
- Increased product quality knowledge can be exploited at decision-taking level for improving operational margins. Some examples:
    - By replacing first-in-first-out concepts by ‘worst-quality-first-out’ the percentage product loss can be reduced.
    - Prices can be directly related to product quality.
    - Processing can adjusted to the actual product quality to optimise end product quality.

Relevant external incentives:

- Market orientation and regionalisation. Internationalisation has a large impact on market developments. Because of the increasing price-competitive imports from developing countries (Southeast Asia, South America), North Western European production chains have to distinguish from other production chains. This leads to both specialisation and regionalisation. Distinction is possible in various fields, amongst others through the formation of transparent sustainable production chains. Sustainability of the production methods should be adequately communicated with the consumer to justify a higher price; here transparency of the production chain is of utmost importance.
- One drawback of this development is the threat of protectionism. In contrary to the ambition of the WTO, open trading may be hindered.
- Growing demand for special products (like diet food, functional food) increase the need for guaranteed (raw and processed) product quality and composition. T&T systems can fill in this need.
- Various other specific attributes that can be economically exploited are:
    - product safety

- regional origin
- high levels of animal well-being
- ecologically soundness
- etc.

Development of adequate T&T systems is a crucial for this development of our production chains.

References & Interviews

References

- Agriholland (2003). Varkensvlees via DNA terug te leiden naar de producent (http://www.agriholland.nl/nieuws/artikel.html?id=35261)
- AIM (2002). Global yearbook & buyers guide.
- G. Beers, A.J.M. Beulens and J.H. Trienekes (1994). Global reference information models for product chains in agriculture: a case of apples and pears. Management studies and the agri-business 1994. Management of chains. Management studies, Wageningen University, pp. 205-215.
- H. Beumer, H.J. Cnossen, P. Sterrenburg, A.W. Barendsz, R. van Dijk, H. Logtenburg & S.H.W. Notermans(2002/2003). Verkennende studie naar traceerbaarheid in agro food ketens (in Dutch). TNO research on behalf of ministry of LNV.
- H. Beumer, H.J. Cnossen, F. Verdenius (2003). Traceerbaarheid: einde aan vrijblijvendheid (in Dutch) in: VMT nr 10, 2003, pp. 10-13.
- R. de Borchgrave (2002). Feasibility and economics of «non-GMO» supply chains in agro-feed/food. Presentation at workshop "Tracking & Tracing: Productveiligheid, Productkwaliteit en Traceerbaarheid in de Agrosector", Wageningen, 21 maart 2002.
- Consumenten bond (2001). Press release. (http://www.consumentenbond.nl/nieuws/persberichten/Archief/2001/62026?ticket=nietlid)
- Erasmus Food Management Institute (2003). CBL Debat Voedselveiligheid Nationale Foodweek 25 maart 2003 (in Dutch).
- DLV & SGS Control (2001a). Traceerbaarheid en handhaafbaarheid van GGO's (in Dutch). Report ref.: Rom0133/LvG
- DLV (2001b). Benchmark Tracking & Tracing AGF 2001 (in Dutch). Productschap Tuinbouw.
- C.A. van Dorp (2003a). A Traceability Application based on Gozinto graphs. Proceedings EFITA 2003 Conference 5-9 July 2003, Debrecen Hungary.
- C.A. van Dorp (2003b). Tracking and tracing business cases: incidents, accidents and opportunities. Proceedings EFITA 2003 Conference 5-9 July 2003, Debrecen Hungary.
- G. B. Dijksterhuis (2003), De gespleten consument, in: H. Dagevos, L. Sterrenberg (eds), *Burgers en consumenten - Tussen tweedeling en twee-eenheid*, Wageningen, pp 123-134
- FAO/WHO (1963). Codex Alimentarius, (http://www.codexalimentarius.net/).
- FSA (Food Standards Agency) (2002). Traceability in the food chain.
- FoodTrace (2003). Compendium of data carriers for traceability (www.eufoodtrace.org).
- S. Heumer (2002). Traceerbaarheid en de Codex - De stand van zaken (in Dutch) in: VMT nr 24, 2002, p. 38-39.
- G.J. Hofstede (2002). Transparency in Netchains. KLICT position paper.
- G.J. Hofstede (2003). Transparency in Netchains. Proceedings EFITA 2003 Conference 5-9 July 2003, Debrecen Hungary.

- N.J.J.P Ketelaars, J.L. Top & F. Verdenius (2002). Utilising the added value of tracking & tracing (in Dutch) in: VMT nr 13, 2002, p. 30-33.
- O.J.M. Kolsteren & M.V. van Woerden (2003).Rapportage Traceerbaarheid in de voedselketen. NEN
- T. Moe (1998). Perspectives on traceability in food manufacture, trends in food *science and technology 9*, pp 211-214
- L.U. Opara & F. Mazaud (2001). Food Traceability from field to plate. Outlook on Agriculture, Vol. 30, No. 4, pp. 239-247.
- Rijnconsult (2002). Organiseren van Traceren (in Dutch). Report ref.: VrtMwn 2002473.
- M. Peupert and L. Theuvsen (2003). Proceedings EFITA 2003 Conference 5-9 July 2003, Debrecen Hungary.
- Platform Transparency and ICT (2003). Speech Veerman: (http://www.minlnv.nl/actueel/speech/2002/speech071.htm) and Article Agriholland: (http://www.agriholland.nl/nieuws/artikel.html?id=32700)
- Productschap Diervoeder (2002). Tracking & Tracing Mengvoeder (in Dutch). Kwaliteitsreeks nr.82.
- Q-Point (2003). Praktische implementatie Tracking & Tracing in de groenten en fruit. Productschap Tuinbouw.
- TNO Voeding, 2003, patent NL 1004006 & 1012625
- J. Trienekens and A.J.M. Beulens (2001). The implications of EU food safety legislation and consumer demands on supply chain information systems. Proceedings IAMA Symposium 2001.
- B. Urlings (2002). Biotagging van Boer tot Consument, presentation at workshop Tracking & Tracing, Wageningen, March 21, 2002.
- F. Verdenius & H. Beumer (2003). Traceerbaarhied: eisen en standaarden (in Dutch) in: VMT nr 12, 2003, p. 19-22.
- C. van Wagenberg, K. Lokhorst, L. Wijnands, L. Puister-Jansen & M. van Krimpen (2002). Tracking en tracing in de mengvoerketen; een kritische beschouwing (in Dutch). Report ref.: 5.02.13 LEI.
- T.P. Wilson and W.R. Clarke (1998). Food safety and traceability in the agricultural supply chain: using the internet to deliver traceability. Supply Chain Management Volume 3, Number 3, pp. 127-133.

Interviews and contributions

- Friesland Dairy & Drinks, Mr. Martin Wijsman (Manager Food Safety & QA) (Ede)
- Llyods Register Quality Assurance Ltd. Mr. C.A. Groenveld (Global Product Manager Food) (Rotterdam)
- Sogeti, Mr. P de Mos and Mr. Ing. E.J. Reinerie
- TNO-Voeding, H. Beumer, MSc