Full proposal

CROSS-CHAIN ORDER FULFILLMENT COORDINATION FOR INTERNET SALES

Summary

The internet has completely changed the ways in which people communicate. Gradually, the internet is now also getting a firm grip on the physical goods flows. More and more consumers are ordering products via the web instead of buying them in a retail store. From a logistics point of view, this sales channel switch has an enormous impact. Deliveries to traditional brick-and-mortar stores can be made in relatively large quantities at regular intervals. Consumers then buy the product in the store and provide an important logistics service: they transport their own products to their own homes for free. With the internet, products are ordered in small quantities by individual consumers and the web store has to arrange for transporting the products to the consumers' home address. It is almost needless to say that this significantly increases logistics costs.

From the consumers' perspective, there seems to be a desire to increase online ordering, provided that some circumstances are improved. An important limiting factor for consumers is the delivery process. In many web stores, the consumer has no influence on the timing of delivery. As a result more than 30% of all orders cannot be delivered at the first delivery attempt. Besides planning, there is also the issue of speed. Information gathering and ordering is so fast on the web, that even a delivery time of 24 hours feels like a lifetime. Faster is better.

In this project, we will develop new concepts, models and solution methods for a number of problems in the internet order fulfillment.

- New design methods will be developed for shaping the distribution network.
- New models and solution procedures will be created for efficiently merging flows of multiple web stores to individual consumers.
- New concepts for delivering products to consumers' homes will be tested.

An important role in this project will be played by the cross-chain control center (4C), which has a coordinating role, spanning across multiple supply chains. To highlight one innovative aspect in this project for the future role of an 4C, we mention the plans for "instant order delivery". This concept has the potential to bring down delivery times of internet orders from 24 to under 3 hours. To this end, the cross-chain control center will do a real-time check for achievable delivery options during the consumer's ordering process on the website. If the requested product is available at a nearby brick-and-mortar retail store and a delivery can be scheduled within the required time, then this ultra-speed delivery option is presented to the consumer on the website.

The consortium contains universities as well as companies with extended experience in internet sales. This combination will ensure results that blend academic rigor and practical applicability. Consortium partners Neckermann.com and Centraal Boekhuis are already active as 4C and are open for innovation. The Dutch public libraries are in search for a new network design and coordination concept for book transports between library branches. Scanyours.com is an eBusiness consultancy company and mYuice has its expertise in SAP implementations for Small and Medium Enterprises. The involved knowledge institutes are Rotterdam School of Management, University of Amsterdam, and VU University Amsterdam.

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Part A: Orientation and Project Goals

Motivation

Most retail and rental organizations consider the internet a vital component of their sales strategy, and for good reasons. In 2009, internet sales in The Netherlands have shown a 17% growth compared to the year before, which is even more notable when compared to the 7.4% decrease in traditional retail sales over the same time period[1]. At least one product was purchased online by 8.6 million people in the country (on a total population of 16 million) in 2009. The average number of products purchased online was 6.2 products at an average value of 737 euro, which is an increase of respectively 15% and 13% compared to the previous year. Similar trends have been noticed for the rest of Europe by the research center Forrester.[2]

Some companies may sell their products exclusively via the web to consumers, others have a multi-sales-channel approach and sell both via physical outlets as well as on the web. But even retailers who sell their products solely via physical stores tend to have a significant internet presence to support their marketing efforts by supplying online information such as product pricing, product characteristics and store locations. Studies show that 95% of the consumers with internet access use the web to investigate purchasing options before buying the product[3].

Retail operations are among the most important, dynamic and difficult operations to manage[4]. A decreasing consumer loyalty combined with an increasing product and price awareness through website visits, results in higher demand fluctuations. Furthermore, variability may be introduced in the supply chain by consumers' preferences for delivery times. Studies demonstrate that 86% of the online shoppers prefer to be able to select delivery times as part of the online ordering process[5]. Another reason for variability might be the consumers' inability to choose the correct product online. As an example of the latter issue, one may think of a consumer ordering a piece of clothing in two sizes, and returning the one that does not fit. In the supply chain design, it must be decided which variability to accommodate and which variability to reduce. And, of course, to identify the means to achieve this. Given the pervasiveness of the internet as new channel and the new challenges it poses, it is surprising how little research to date has addressed the design of supply chains with online sales channels[6].

We intend to study the design of supply chain networks where shipments in small quantities have to be made from many suppliers to individual consumers. Considering the small volumes involved, a service provider will typically accommodate the operations for multiple web stores in one network with shared facilities. As a result, cross-chain coordination is needed to fulfill the requirements of both consumers as well as suppliers. Trade-offs may need to be made between different web stores that ship via the same network. Priorities may need to be set, and sharing of limited resources must be regulated. Furthermore, branding is an important issue. If a consumer orders via the website of one company, then the packaging and invoice should contain the name and logo of that company and not of another company that is serviced via the same network. Important sources of information in these types of supply

[1] www.thuiswinkel.org
[2] Keuning, W. (2010), De online shop groeit, crisis of niet, *De Volkskrant*, 29 maart 2010.
[3] Blauw Research (2009*), Multichannel Monitor 2009*, September 2009.
[4] Hill, A., Collier, D., Froehle, C., Goodale, J., Metters, R., Verma, R. (2002), Research opportunities in service process design, *Journal of Operations Management* 20, 189-202.
[5] Slegers, R. and Van Essen, N. (2010), Online shopper verwacht forse verbeteringen, www.logistiek.nl.
[6] Hill *et al.* (2002).

chain networks are documented behavior of individual consumers such as their browsing behavior and historical pattern of purchases and product returns.

The objective of this research project is to study the competitive advantage of outsourcing online sales activities to a logistics service provider responsible for coordinating e-fulfillment operations of multiple web stores (i.e., an 4C). In the path towards that goal, we will develop logistics tools to design 4C networks that efficiently coordinate and integrate fulfillment operations for delivery (and returns) of products from multiple web stores to individual consumers. Input from the marketing field, using consumers' needs and wishes, seems vital to enable a view on the impact of ordering behavior on the various design choices and vice versa.

Figure 1 depicts the physical flows organized in 4C networks for internet sales and distinguishes between the three main processes: replenishment, order fulfillment and delivery & return processes, of which only the latter two are within the scope of this project. The physical flows depicted in Figure 1 can be described as follows. Several suppliers (A-C in this example) share an 4C network for their internet sales. In such a network, one or more shared Internet Order Fulfillment Centers (IOFC) may be available (here: X and Y). The IOFC(s) may be owned/operated by one of the involved companies or may be a separate entity.

Products are stored at the IOFC until the arrival of a consumer's order. Order fulfillment operations make sure that the right product is delivered to the right consumer at the right moment in time. Either the product is transshipped directly to the home of the consumer or it is sent to a decentralized coordination point, where the product waits until the consumer picks it up (depicted with numbers 1, 2 and 3 in Figure 1). It is also possible that a decentralized coordination point holds an inventory of products, in which case only the order needs to be relayed if the product is locally in stock. The decentralized coordination points may have many different manifestations, many of which will be described later in this proposal; from a consumer's perspective some may even look like a common retail outlet. In The Netherlands, consumers have the right by law to return products within 7 days and can either send it directly back to the IOFC or bring it to a decentralized coordination point. The products are, thereafter, sent back to an IOFC. For ease of reading we depict in Figure 1 only one delivery and return option per IOFC. Clearly, also a mix in delivery options can exist for each of the IOFCs.

To make things a bit more concrete we introduce some examples of 4C internet order fulfillment concepts that are under development or in existence at partners in this consortium. The company Neckermann.com is widely known and ships products such as apparel, electronics and furniture directly to consumers based on internet, phone and mail orders. Their policy is "ordered today, delivered tomorrow". Less known is the fact that the Dutch location has recently started to serve as a logistics service provider for the online order fulfillment for the websites of clothing companies such as WE and M&S. Facilities and delivery channels are shared, while at the same time branding is carefully separated.

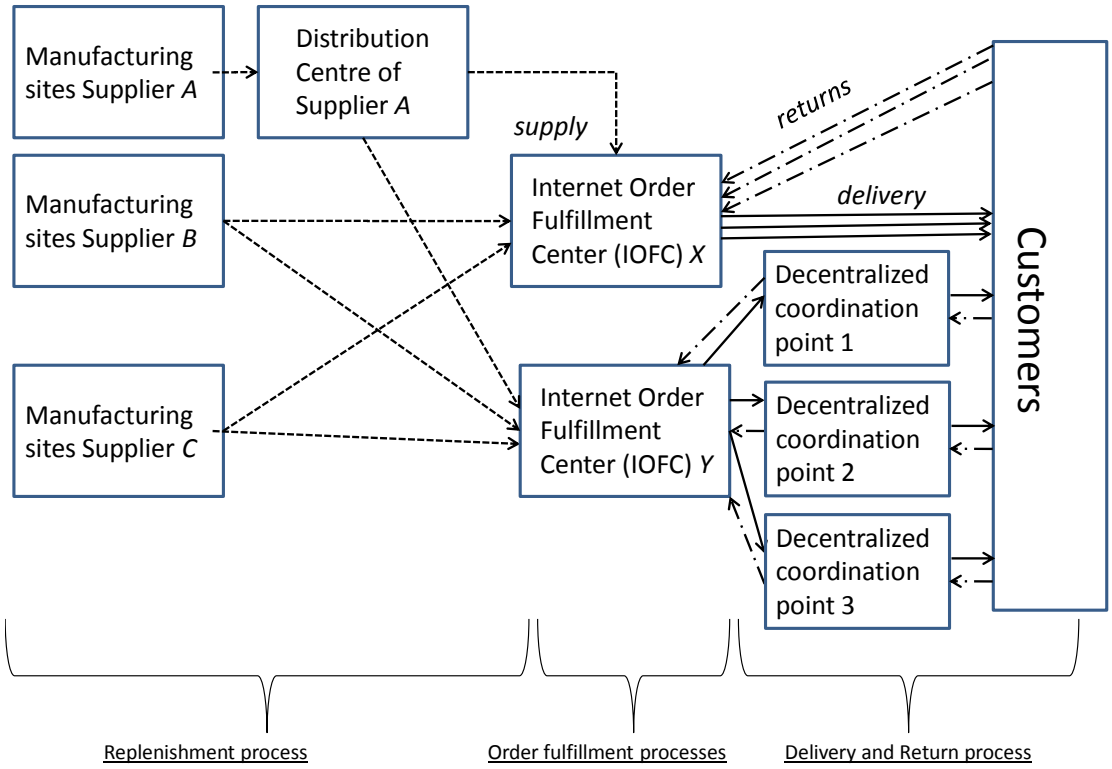


Figure 1: Physical flows in supply chains with cross-chain e-order fulfillment centers.

As a second example, consider the operations of Centraal Boekhuis a well known 4C[7]. This company traditionally has formed the link between book publishers and retail outlets in The Netherlands. Nowadays, Centraal Boekhuis also performs the order fulfillment process for the largest online book sales channel in The Netherlands, bol.com, as well as the order fulfillment activities for Van Leest, Free Record Shop, Expo and others. It is a challenge to efficiently organize such distinct operations in one organization.

In both previous examples, internet retailers compete in their front-office processes in attracting and servicing consumers and cooperate in their back-office processes with regards to e-fulfillment operations. In this way, economies of scale in handling flows of small orders can be obtained and the noted challenge of handling "thinner" flows of products can be tackled[8].

Thirdly, we consider public libraries that cooperate to match books to consumers' demand. Even though this is a non-profit sector and suppliers are not competitors, it is far from clear as to how cooperation is best achieved. In an old-fashioned view, if you visit a library, then they either have the book or they don't. In a connected library network with a coordinating 4C and with multiple central storage locations for less-frequently requested titles, books could move to where they are needed. After ordering, the books can be shipped to the consumer's home, or to a decentralized coordination point, which could be either a nearby library or a small pickup location in a store or other place.

[7] Ploos van Amstel, W. (2009), Hoe kun je inspelen op de kilometerbeprijzing, www.logistiek.nl.
[8] Van Goor, A.R. (2008), E-logistics moet leren van SCM, www.logistiek.nl.

The 4C is the coordinator in these supply chain networks and responsible for an efficient and effective organization of all forward and return shipments of products. Figure 2 illustrates how information flows related to the order fulfillment and the delivery & return processes for each web store interact and need to be integrated to achieve this. The information flows can be described as follows. A consumer uses the website of a company to browse and/or purchase a product. The order is received at the 4C and the consumer is informed about the available delivery schedule. The 4C shares orders and forecasts of orders (based on information on e.g., promotions of companies) with the IOFC to make sure that the e-fulfillment process can be executed efficiently. Based on actual orders and forecasts of returns and transactions, the 4C determines replenishment orders such that space requirements are met.

As can be noticed from Figures 1 and 2, there is a direct link between the flows of information available, the processes to be performed and the coordination of the 4C. This is explicitly noticed in formulating all decisions that should be taken by an 4C to change from a logistics service provider to a coordinator in an 4C network.

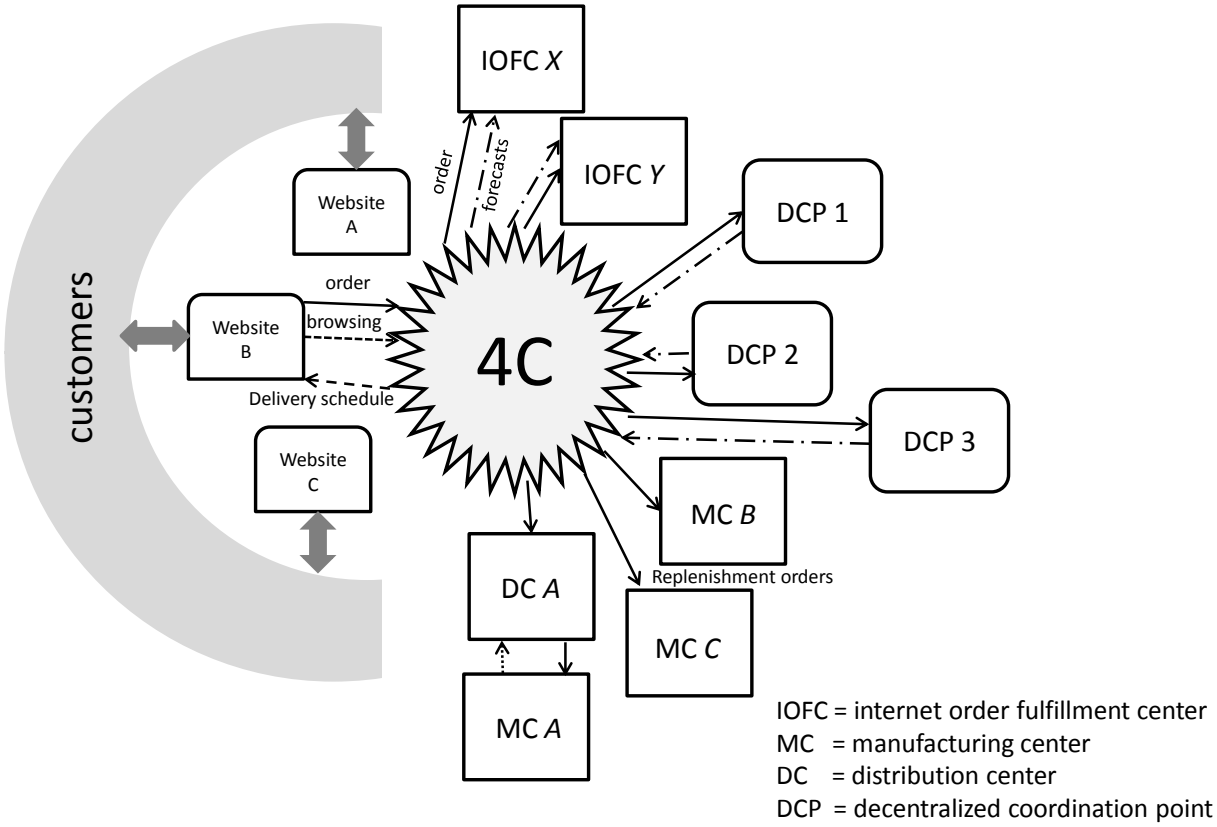


Figure 2: Information flows in supply chains with an 4C to coordinate cross-chain e-order fulfillment processes.

We distinguish between several levels in the decision making process. Decisions on the number of IOFCs and their locations are taken for the long term. The IOFCs form the backbone of the network. Based on this backbone network, decisions on the required number of decentralized coordination points and their exact geographical positions can be taken. At the same time the design of the internet order fulfillment centre should be studied. In the latter

category, decisions should be addressed such as workforce planning, sizing and layout of the center and the assortment decisions at each IOFCs. At a more operational level, control policies have to be designed and selected for the coordination of delivery workers and the coordination of the delivery & return processes. Return rates for web sales are high (e.g., up to 74% in fashion[9]). So, returned products can be resold multiple times and influence e-fulfillment decisions. Flows of deliveries and returns of multiple companies to either consumers' homes and decentralized coordination points have to be coordinated. Figure 3 depicts a decision framework showing all decisions and their relations.

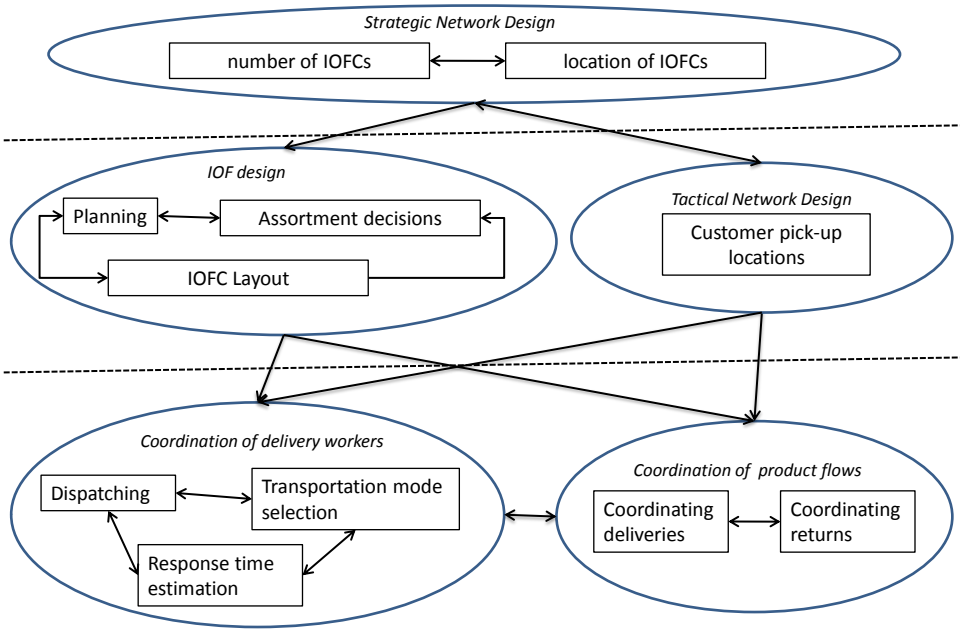


Figure 3: Decision Framework for an 4C coordinating processes for internet sales

We distinguish the following three key research themes to meet our overall goal. Each of these themes has been identified as a gap in the literature that needs attention[10,11]. These themes are related to the order fulfillment and delivery and return processes in the 4C network as depicted in Figures 1 and 2 and linked to the decisions as presented in the framework of Figure 3.

The line of research presented here, is positioned at the frontiers of scientific research. Research in the field of supply chain design for internet sales is scarce and has mostly focused on isolated problems. This project aims at bringing some of this knowledge together and expanding on it to design better cross-chain order fulfilment processes and delivery & return processes for internet orders coordinated by an 4C. In our research we bridge the strategic, tactical and operational decision levels and integrate the interests of multiple stakeholders in our single solution approach. Preliminary findings, from research and from practice, suggest that all of this is a major research challenge with a large potential impact on performance.

[9] Mostard, J., Teunter, R. (2006), The newsboy problem with resalable returns: A single period model and case study, *European Journal of Operational Research* 169(1), 81-96.
[10] e.g., Hill *et al*. (2002).
[11] e.g., Agatz, N.A.H., Fleischmann, M. and Van Nunen, J.A.E.E. (2008), E-fulfillment and multi-channel distribution - a review, *European Journal of Operational Research* 187, 339-356.

Theme 1: Network design

Recently, the European Court of Justice ruled that if a consumer returns a product to the web shop, the full payment must be returned to the consumer, including all shipping costs[12]. This decision emphasizes the importance of an efficient network for deliveries and returns. Besides the coordination and control of activities, which will be treated in the other themes, it is also important to carefully design the actual physical manifestation of the network.

Decisions on the location and number of IOFCs to store (part) of the collections available to consumers in The Netherlands are long-term decisions. The first part of this theme aims to derive methods to determine the number of IOFCs and good locations for them. Important input data will, among other things, be the required storage space for all involved companies, transaction data, consumer profiles and consumers' home addresses. Objectives under consideration are availability, accessibility, delivery times and costs.

Currently, less than 70% of all orders can be delivered at a consumer's home at the first delivery[13]. As a result, many return-to-fits have to be performed or packages have to be delivered at neighboring houses. An increase in delivery attempts and associated costs are direct results. Options as delivery time selection during the ordering process and tracking-and-tracing could assist the consumer in getting a better (perception of) delivery quality. As an alternative to direct delivery to consumers' homes, it is possible to introduce decentralized coordination points in the 4C network where consumers can pick-up (and return) their package after getting a notification of arrival. This allows the consumer to pick up the package at a self-selected time and location. For example, a gas station on the way from work to home can serve as an excellent pickup location for a consumer.

Calculations demonstrate that savings of at least €10 million can be expected if a direct delivery to the consumer is possible[14]. For example, the company Kiala offers a network of such decentralized coordination points ("pickup points") in five European countries, used by, among others, consortium partner Neckermann.com for part of their shipments. Currently 26% of the consumers selects a Kiala location when available[15]. Quite similarly, some libraries have already experimented with the concept of decentralized pickup, where consumers receive notification of arrival plus a numeric code to open the locker that contains their books at the (unmanned) decentralized pickup location[16]. Other roles for the decentralized coordination points are discussed below under theme 3.

The goal of the second part of this theme is to design methods to derive both the required number of decentralized coordination points and their exact locations to serve the 4C network best. We will come up with an integrative approach that combines Geographic Information Systems with data on consumer profiles (age, income, shopping habits, etc.).

Practical applicability of the concepts developed in this theme will be shown by formulating a structural new design for the Dutch library distribution system. More details on the this application can be found in the section "expected results" below. An elaboration on the scientific contribution of this theme can be found below in the section "orientation"; details on deliverables and planning are described in Part B of this proposal.

[12] http://webwereld.nl/nieuws/65736/webshops-draaien-op-voor-bezorgkosten-bij-retour.html#source=newsletter
[13] Slegers and Van Essen (2010).
[14] Te Lindert, M. (2009), E-fulfilment kan 10 miljoen euro goedkoper, www.logistiek.nl.
[15] www.thuiswinkel.org
[16] Vis, I.F.A. (2007), De bibliotheek komt naar u toe, *Bibliotheekblad*.

Theme 2: Merging flows

Every web shop has its own "shopping cart", an electronic analogy of the supermarket shopping carts, to collect products from the web shop before proceeding to the checkout process. If a consumer wishes to buy products from three different web shops, (s)he will have to use three different electronic shopping carts, make three payments, and will have three separate home deliveries of the ordered products. An 4C that would offer one shopping cart that can be used to buy products at multiple web shops will make the ordering process much easier for the consumer. Implementation of such a concept is, however, far from straightforward, considering the potential consequences for information sharing, contract negotiations and software interfaces between all parties involved. Furthermore, the added value of the concept is only truly complete if all products from the electronic shopping cart are also delivered to the consumer's home in one single shipment.

Consequently, several important questions arise for an 4C that coordinates and/or performs the actual logistic processes for internet orders. If multiple IOFCs are available in the network, assortment decisions have to be made to decide which products of which web stores are shipped from which IOFC. Trade-offs may exist between the assignments that are best for specific web stores and the assignment that is best from an overall perspective. Furthermore, it must be decided which products are best stored in an IOFC of the network and which products are received directly from the supplier and cross-docked at the IOFC.

Closely related to this is the layout and organization of the IOFCs, which should be arranged in such a way that it ensures a smooth order fulfillment process for all involved web stores. Despite the need for facilities to keep up with a service economy, the underlying design methods have not yet changed accordingly[17]. Existing facilities tend to keep processes for different web stores completely separated, essentially resulting in several operations just sharing the roof and a common pool of employees. This is partly done, because this makes it easier to maintain separate branding, i.e. to make sure that packaging, labeling and the invoice all contain the logo of the right web shop, not that of the 4C. The question arises whether a higher efficiency is obtainable by more integration of processes.

There are many additional complicating factors for internet order merging. Firstly, online shopping is not bound by opening hours of stores. Most consumers order in the weekend, which results in high peaks at the start of the week[18]. Secondly, companies may sometimes want to keep the exact nature of an upcoming promotion a secret - even to their 4C logistics service provider.

The overall goal of this theme is to design methods to efficiently merge flows of various web stores in IOFCs coordinated by the 4C.

Practical applicability of newly developed design and control concepts for the IOFCs will be demonstrated at the order fulfillment center of consortium partner Neckermann.com. Specifics of the shared shopping cart concept are related to consortium partner Centraal Boekhuis. More details on these applications can be found in the section "expected results" below. An elaboration on the scientific contribution of this theme can be found below in the section "orientation"; details on deliverables and planning are described in Part B of this proposal.

[17] Cross, C.S. (2006), Warehouse design eliminates slim pickings, *Industrial Engineer* 38, 10, 48-49.
[18] Slegers and Van Essen (2010).

Theme 3: Deliveries and returns

The ability to deliver products within 24 hours to the consumer's home may not always be easy to achieve for a web shop, but it is something the consumer plainly expects. But even 24 hours may seem like a lifetime to the consumer when compared to the speed of the internet itself. A true challenge would be to enable even faster delivery of products to the consumer's house, say within 3 hours after the order has been placed on a website. A smart mix of currently available distribution structures with newly added capabilities is needed to enable such a concept. We will illustrate this instant delivery concept by means of book sales.

Currently there are two main possibilities for buying a book. Either the consumer goes to a bookstore to buy the book, or the consumer buys the book online and gets it delivered to his home address the next day. The trade-off for the consumer is clear: either the consumer has to travel to the bookstore or the consumer must wait 24 hours. An intermediate form that currently exists, combines the disadvantages of the two systems: in this option a consumer goes to a bookstore, cannot find the book, orders it in the bookstore, and gets it delivered to his home address the next day. In this project we aim to combine the advantages of both systems.

To this end, we posit the following new structure. A consumer selects a book on a website. The pending order is relayed to the cross-chain control center (4C) that checks availability of the book. If the book is available in the central storage facility, then a standard 24-hour delivery can be promised to the consumer. Next to that, the 4C also checks the inventory of bookstores located in the vicinity of the consumer. If the book is in stock near the consumer, then a direct delivery can be made from the bookstore to the consumer within hours after the order. The options are presented to the consumer on the website and the order is fulfilled as desired by the consumer.

There are a number of practical and theoretical hurdles that need to be solved for this concept to become viable. The goal of this theme is to design control concepts to overcome these hurdles resulting in an efficiently delivery of requested items to consumers. Aspects that need consideration include information sharing, flexible labor planning, delivery scheduling and selection of decentralized coordination points (the bookstores in the above example). The concept will be contrasted with currently available systems such as direct deliveries and pick-up by the consumer at a decentralized coordination point.

For the concept to work, there must be a delivery organization that can respond in real time to the occurring demand. Current parties as TNT, UPS or DHL may be able to include this option in their operation. However, the required change in operational procedures must not be underestimated. For one, the consequences of route updates with additional pickup and delivery points must be determined real-time during the consumer's online ordering process to check feasibility before making promises.

As an alternative or addition, stand-by workers (think of students or elderly citizens) may be willing to work in a piece-by-piece concept. If a delivery needs to be made, the nearest available stand-by worker is sent to pick up the book at the store and to deliver it to the consumer. Real-time tracking of the availability and location of the stand-by workers can be achieved for free by means of the Foursquare or Gowalla mobile phone apps. Foursquare and Gowalla are social network initiatives based on global positioning rather than content, which is enabled by the GPS-capability of mobile phones. Since no special equipment is needed and distances are small (deliveries by bike!) this may be a cost-effective approach.

As noted already in theme 1, currently only 70% of deliveries at consumers' homes can be made at the first attempt. This percentage could be improved significantly if delivery schedules can be updated dynamically based on real-time consumer location information (at home or not) as disclosed by means of Foursquare or Gowalla. A new class of Vehicle Routing methods may emerge here. We intend to develop methods for dynamic delivery time slot determination.

There are many other aspects related to this topic that may need attention as well. Firstly, using decentralized coordination points in a 4C network for internet sales instead of home deliveries can contribute to the environment. Studies show that CO_2 emissions can be decreased by 60%[19]. Effects of the alternative strategies may need to be investigated. Secondly, consumers by law have the right to return products. The actual number of returns per product, the origin of the returns, as well as the quality of the returned product (can it be resold?) are uncertain. On the other hand, in the case of libraries, returns are known and equal to the original order with a certain time delay. We intend to design both deterministic models (for library returns) as well as stochastic models (for product sales) to coordinate the return processes from both decentralized coordination points as well as from consumers' homes.

The feasibility check for the "3-hour delivery concept" will be tested in cooperation with consortium partner Centraal Boekhuis. Return flow handling is of interest in the process of Neckermann.com and in the new network design for the Dutch public libraries. More details on these applications can be found in the section "expected results" below. An elaboration on the scientific contribution of this theme can be found below in the section "orientation"; details on deliverables and planning are described in Part B of this proposal.

Relation to Dinalog innovation themes

This project will develop design procedures, control concepts, and efficiency estimators for Cross-Chain Control Centers that direct the flow of goods for internet sales channels. As stated by the Commissie van Laarhoven[20] (translated): " A Cross-Chain Control Center [4C] is a coordination center from which multiple supply chains are jointly coordinated and controlled using modern technology, advanced software concepts and supply chain professionals; not just with respect to physical goods flows, but also related to information and financial flows, such as forecasting, financial engineering and data management." Especially, we state that it is important to realize that besides the already looming prospects of the 4C concept, its outlook for the application in the domain of internet sales may even be larger.

Nowadays, setting up a web shop is not very expensive; the cost has especially gone down since the availability of free open source web shop software such as Magento[21]. Since no significant initial investment is required, a startup of a web shop can be done without a bank loan, or even without a business plan. Sales volumes of such a startup company are, however, too small to afford a logistics network of its own. Only outsourcing or cooperation with other companies are viable options. Even though many web shops attempt to hide their delivery costs, a survey of PayPal shows that high delivery costs are the prime reason why consumers

[19] www.kiala.nl
[20] Commissie Van Laarhoven, Logistiek en Supply Chains: Innovatieprogramma, page 5.
[21] http://www.magentocommerce.com.

leave their online shopping cart without buying the products[22]. Products left in the shopping cart have an average value of $109, according to the survey. Bringing down delivery costs is therefore vital for increasing web sales. The Commissie Van Laarhoven, explicitly states that decreasing supply chain costs is one of the five important economic and societal advantages of the 4C concept[23]. In the case of internet sales, financial advantages are likely not limited to the savings in costs, but will experience a multiplier effect due to a resulting sales increase.

The themes as we have defined them above, all relate to vital facets of such an 4C for internet sales and all have a direct link to the vision and ambition statement of the Commissie Van Laarhoven. It is important to realize that for internet sales, economies of scale that result from merging logistics operations will not suffice. After all - regardless of the total volume - all transactions will remain to be in extremely small quantities, with a large percentage of orders consisting of just one single product. And each order has to be delivered to a different address. The concept of coordination is therefore of even greater importance here. Or as the Commissie Van Laarhoven states (translated)[24]: "A common control and grouping of information and goods flows of multiple supply chains in an 4C will lead to a better view on and better coordination of activities resulting in supply chain cost savings, a lower environmental pressure, new businesses with higher employment and a higher attractiveness of The Netherlands for foreign companies."

Besides the historically strong tradition of The Netherlands in the field of logistics and supply chain management, the country also has the highest percentage of internet connections in the European Union. Of all households 90% has internet access in The Netherlands compared to 65% in the European Union and 68% in the original 15 European Union countries[25]. The combination of these two facts emphasizes the potential to develop new concepts for internet order fulfillment coordination and to implement them in many national supply chains. Based on the resulting theoretical understanding and practical experience, it will be possible for The Netherlands to use the obtained "first mover" advantage[26] to achieve a dominant position in Europe in internet order fulfillment design, handling and coordination, in line with the ambition as stated by the Commissie Van Laarhoven[27].

In line with the R&D innovation agenda[28], we distinguish between management concepts that lead to structural cooperation on the one hand and models and techniques for large scale supply chain control on the other hand. The emphasis of this project will be on the second part of the R&D agenda, but with a explicit eye on the first part. Our project will result in supply chain designs for 4C networks for internet sales, methods to control and coordinate delivery & return processes, to design internet order fulfillment centers, to derive locations of decentralized coordination points and for manpower and flow planning. We will study options to introduce modern technologies such as Foursquare or Gowalla mobile phone apps in these designs and methods. Consequently, we provide new functionalities for Advanced Planning and Scheduling (APS) systems and real time monitoring systems. The performance of the developed approaches will be tested empirically by means of extensive simulation studies and by means of case studies in books, DVDs, fashion, and mixed supply chains. Next to that,

[22] "Why Online Shoppers Abandon Purchases" at https://cms.paypal.com/us/cgi-bin/?&cmd=_render-content&content_ID=brc/why_online_shoppers_abandon_purchases.
[23] Commissie Van Laarhoven, Logistiek en Supply Chains: Innovatieprogramma, page 16.
[24] Commissie Van Laarhoven, Logistiek en Supply Chains: Innovatieprogramma, page 6.
[25] Eurostat, Households - Level of Internet access at http://epp.eurostat.ec.europa.eu.
[26] Commissie Van Laarhoven, Logistiek en Supply Chains: Innovatieprogramma, page 9.
[27] Commissie Van Laarhoven, Logistiek en Supply Chains: Innovatieprogramma, page 10.
[28] Commissie Van Laarhoven, Logistiek en Supply Chains: Innovatieprogramma, page 17.

partners in the consortium will be involved in all activities to test if the designed methods can be implemented and in phase 2 will consider the actual implementation of the tools in APS systems.

Objectives and goals

In our project, we distinguish between two phases for each of the three themes described above in the section "motivation". The scientific relevance of the three themes, as well as more details on the various goals, will be explained below in the section "orientation".

In phase 1, new design and coordination methods will be investigated by developing new scientific approaches, using data and practical insights from the companies in the consortium. Phase 2 will be following phase 1 step-by-step to investigate the potential for valorization of the concepts developed in phase 1. Initially, this will be focused on investigating the feasibility of implementation in the member companies of the consortium, followed by a broader view towards The Netherlands and other countries. Phase 1 will result in PhD theses and academic publications, while phase 2 will be aimed at practical use of the methods and dissemination via professional journals, magazines and newspapers.

Phase 1 (2010-2014)

The objective of this phase is to study several innovative concepts for organizing the logistics and supply chain management of internet order fulfillment by an 4C as the responsible actors for coordinating and/or executing the e-fulfillment operations for multiple companies. More specifically, we aim to design the following methods for efficiently coordinating and integrating cross-chain order fulfillment operations in an 4C network for internet sales:

- Location models to derive the number of and locations for IOFCs and decentralized coordination points based on GIS data, marketing profiles of inhabitants of The Netherlands from databases, and profiles of web store consumers.
- Assortment models to assign products of web stores to each of the IOFCs.
- Manpower planning models to deal with uncertainty in demand caused by promotions and unbalanced demand based on 24/7 ordering by consumers.
- Layout models to accommodate operations of all web stores in the IOFCs.
- Models to coordinate delivery and return flows from the IOFCs to decentralized coordination points or consumers' homes.
- Develop concepts for 3-hour delivery promises.
- Models that can adaptively respond to the real-time information on the location of delivery workers and consumers' based on Foursquare/Gowalla technology.
- Scenario analyses to compare model alternatives.
- Evaluating operational efficiency and effectiveness of the designs and coordination schemes as well as develop the means to identify those approaches that are likely to be best.

Phase 2 (2011-2015)

In this phase, we distinguish the following main activities:

- Validating each of the tools by means of case studies at companies in the consortium.
- Develop implementation schemes on how each method can be captured in APS systems.
- Implementation of suitable tools and designs at partners in the consortium.

- Investigating the implementation potential of the developed methods in add-ons for APS (e.g., SAP) that can be used by companies dealing with internet sales.

Expected results

The amount of online sales increases significantly each year. In The Netherlands, the turnover of online sales in 2009 was 6.4 billion euro, which was a growth of 17% in comparison to the previous year. The average number of orders per consumer equaled 6.2 which was an increase of 19% compared to 2008. Four out of the five internet users in The Netherlands have performed an online purchase last year and about 700,000 new shoppers entered the online market in 2009. Consumers seem to have adopted internet as a valuable sales channel[29]. It is reasonable to expect a further significant growth of the online retail sales, not in the least from existing brick-and-mortar companies as well as from new startups. The existing companies can try to transform their processes to fit the requirements of web sales or can opt to work under an 4C umbrella. Startup companies may typically start to sell from the owner's home address, but as soon as they outgrow that stage, they will be the perfect candidates to join an 4C initiative.

This project aims at better designing and coordinating the logistics processes for online order fulfillment, which will drive delivery costs down. As explained above[30], delivery costs are the prime reason for consumers to abandon their online shopping cart. Therefore, lower delivery costs are likely to boost sales, which will cause the average sales growth of companies involved in the 4C concept to grow even faster than the market average. Adding this effect to the autonomous increase in internet sales volumes of up to 15% per year, and extending these numbers to the entire Dutch online sales industry, it would scale to a staggering potential for an increase in online sales of up to 1.5 billion euro per year. Quite obviously, many of these products would otherwise have been sold by brick-and-mortar companies, implying a mere shift in sales channels. From a logistics point of view, however, this shift in sales channel has a tremendous impact. After all, deliveries to brick-and-mortar companies are in relatively high volumes to a limited set of locations. Deliveries for online sales need to be made in very small quantities to millions of consumers' home addresses. Therefore, the relative increase in supply chain related activities and the coordination of these activities will be very substantial. As a reference, at Centraal Boekhuis currently approximately 10% of the volume concerns home deliveries, but this flow accounts for 30% of their total shipping costs. On top of this, companies have to absorb the costs of returns, including all shipping costs according to a recent ruling of the European Court of Justice.

Tangible research results will include a series of high-quality academic papers, white papers and PhD theses. All written reports will be made publicly available via the dedicated website that will be created for this project. Each of the reports will cover a subset of the objectives and goals as mentioned above. Connections of the publication strategy to the various research themes are described in "part B: activities and work packages" below. The developed concepts can be tested for feasibility in the companies of the consortium. Using actual order data from the recent past and projected demand for the future, estimates will be made for the profitability of the concepts.

[29] Thuiswinkel Markt Monitor 2009, www.thuiswinkel.org.
[30] See section "relation to dinalog innovation themes".

Clear insights can be obtained in the potential applicability of the developed concepts due to the breath of the consortium. Next to the 4C companies Centraal Boekhuis and Neckermann.com, consortium partners mYuice and Scanyours.com can play a vital role in the feasibility check. Scanyours.com for the interface with the consumers and mYuice for identifying the implementation potential in ERP software. Concepts that prove to be feasible for implementation in practice can be taken up by the consortium partners.

Some of the concepts that will be investigated in this project are likely to be appealing to other companies as well. Consortium partners will have the first mover advantage, but other companies can be expected to follow, especially if the concepts can be made available in a commonly used software formats.

Below we describe each of the partners in the consortium in more detail and indicate how they can contribute to the expected results of this project.

Neckermann.com

The company Neckermann.com ships such diverse products as apparel, furniture, electronics, toys, garden equipment, and magazines based on consumers' orders placed by mail, internet or phone. Recently, Neckermann.com has started to fulfill the orders placed at other web stores such as those of the clothing brands WE and M&S.

Each of the companies for which Neckermann.com serves as an 4C, has its own, completely distinct line of clothing. In the fulfillment process, branding must be maintained, implying that not only the products are distinct between the various sales channels that are served, but also packaging, inserts with special offers, and the paper for the invoice.

Essentially, Neckermann.com currently has a number of separate fulfillment operations within a single building. Opportunities arise to implement new facility concepts with regards to co-locating products for several web shops. This will become increasingly important if the number of web shops increases and storage space starts to become tight.

Furthermore, the dynamics of internet orders occasionally put a significant strain on the operations. Demand peaks at the start of the week or due to special promotions are common. New tools to be designed for manpower planning under such demand uncertainty would be welcomed.

Neckermann.com has proven to be a company that is very open for innovations in their processes. Effective new concepts will find a receptive ground for implementation here.

Centraal Boekhuis

Centraal Boekhuis has been the logistics partner in the booktrade for more than 135 years and forms the link between book publishers and retailers in The Netherlands and Flanders. Over 500 publishers and more than 1500 booksellers use their services. Besides the book trade, Centraal Boekhuis is also a very active 4C company for both books and other products. Centraal Boekhuis ranks 27th in the list of Logistics Service Providers in the Dutch magazine "Logistiek" of April 2010.

Order fulfillment, crossdocking and/or transportation to retailers is performed, among others, for office supplies, for CDs of Van Leest and Free Record Shop, and for gift items of Expo.

Next to that, Centraal Boekhuis performs the order fulfillment activities for the largest online book seller on the Dutch market, bol.com. Centraal Boekhuis is an experienced 4C company that strives to be ahead of market developments. New developments that are of interest to Centraal Boekhuis include the concept of a common shopping cart serving multiple web stores.

In the previously described 3-hour delivery concept, Centraal Boekhuis could check inventories of book stores near the consumer's home for availability of the book and arrange instant shipment of that store to the consumer. This concept would fit Centraal Boekhuis well, since they are experienced in the book trade, have experience with online sales, and are a supplier to the book stores. The 3-hour delivery concept would provide new dynamics to existing relations that could provide a leading role for Centraal Boekhuis, increased book sales via traditional brick-and-mortar retailers and a higher satisfaction for consumers.

The Dutch public libraries

This project has the unique opportunity to be involved in a process that aims at completely rethinking the supply chain of library books in The Netherlands. The current network was designed in a time when the number of books that people read, was much higher than nowadays. At the same time information exchange has changed dramatically in the past two decades, including the emergence of internet access to collection databases by library staff and consumers.

There are approximately 3,600 library locations in The Netherlands. From a study in a mid-size town with three library locations, it is known that they have an average of 17,423 shipments per year between these three branches[31]. If transport between locations in the country-wide network can be made sufficiently cheap, many of the rarely requested titles would only need to be stored in one or a few places in the country. These titles could be sent to other locations when needed. To this end, the Dutch libraries are considering the long term goal of introducing new central storage facilities for rarely requested titles with decentralized pickup locations at library branches and elsewhere. Also direct shipments of books to the consumers' homes could be considered.

Many aspects of library book distribution are equal to those of commercial products and much can be expected to be learned across applications. One special characteristic of library books is, however, that (almost) all books are returned, providing an excellent opportunity to investigate the optimal inclusion of returns in distribution models; a phenomenon also common in many regular web shops. Concepts and solutions developed in this project find a solid opportunity for actual application here.

Scanyours.com

Scanyours.com advises companies on eStrategy, market research and web development with the goal to enable higher returns from online activities. A core competence of Scanyours.com is to determine the preferences of internet users and to use that information to improve the interactions between the web company and consumers. Approaches used for this include online survey research and tracking of the browsing behavior of website visitors.

In this project, we will make use of existing data on consumer profiles (income, shop preferences, online buying, car ownership, etc.) from databases to develop designs that meet

[31] Boter, J. (2007), Locatie en collectie, *Bibliotheekblad*, mei 2007.

consumers' needs. However, as a result of this project, new delivery concepts will emerge with consequences for the interaction between the web shop, the 4C and the consumers. These effects cannot be predicted by means of database information on the current situation, but rather need insights into predicted future consumer behavior.

Scanyours.com can play a role in this project by generating ideas for new approaches, as well as helping to predict the effects on consumer behavior and perception as a result of the proposed changes. Furthermore, promising concepts can be brought into action, if deemed appropriate.

mYuice

The company mYuice implements and guides the implementation trajectory of SAP Business All-in-One en SAP Business One, from a software as well as a hardware perspective. The focus of mYuice is explicitly at implementations in Small and Medium Enterprises. A special aspect of mYuice that sets them apart from many other SAP vendors is that they have in-house development of add-ons for SAP, which provide additional functionality.

SAP is an Enterprise Resource Planning software, an integrated computer-based system used to manage internal and external resources including tangible assets, financial resources, materials, and human resources. SAP has a market share in the Benelux of about 40%, which makes it the market leader in ERP software[32].

Ideas, methods and concepts generated in this project will need to be implemented in a software environment if they are to be used by a larger audience. Consortium partner mYuice has the capabilities to judge whether the new tools would a valuable contribution to and can be interfaced with ERP software. Furthermore, when deemed valuable, but not suitable for the 4C partners in the consortium, mYuice may be able to find a suitable application site from its large client base. The application focus of mYuice on Small and Medium Enterprises fits well with the Dinalog agenda.

Relation to government policy

N/A

Orientation

Retail operations including e-operations are among the most important, dynamic and difficult operations to manage[33]. Consumers interfere with all stages of service processes by introducing additional variability. Frei[34] states that companies must learn to manage this involvement to deliver consistent quality at sustainable costs. In the supply chain design, it must be decided which variability to accommodate and which variability to reduce. And, of

[32] ERP markt Benelux voor 40 procent in handen van SAP, http://computerprofile-blog.com/?p=980.
[33] Hill, A., Collier, D., Froehle, C., Goodale, J., Metters, R., Verma, R. (2002), Research opportunities in service process design, *Journal of Operations Management* 20, 189-202.
[34] Frei, F.X. (2006), Breaking the trade-off between efficiency and service, *Harvard Business Review*, November 92-101.

course, to identify the means to achieve this. It must be noted that there is little research addressing the design of supply chains with online sales channels[35]. In this context, the marketing-operations interface is particularly relevant in attuning sales promises and order fulfillment since the consumer does not just buy the physical product online, but also the delivery service and possibly the after sales service[36].

In this research project, we pursue our goal by proposing new solution approaches by using, developing and integrating techniques from the fields of marketing, logistics and operations research. Implementing these techniques in ICT systems and the resulting capability of dealing with uncertainty allows companies to deal with an important challenge in making online sales profitable. The line of research presented here, is positioned at the frontiers of scientific research. Research in the field of supply chain design for internet sales is scarce and has mostly focused on isolated problems. Moreover, research on coordination and design for multiple supply chains with online sales is almost non-existent. This project aims at bringing some of this knowledge together and expanding on it to design better cross-chain order fulfilment processes and delivery & return processes for internet orders coordinated by an 4C. In our research we bridge the strategic, tactical and operational decision levels and integrate the interests of multiple stakeholders in our solution approaches. Preliminary findings, from research and from practice, suggest that all of this is a major research challenge with a large potential impact on performance (see section “expected results”).

For each of the themes as described in the section “motivation”, we will explain the available literature and the added value of our research. Where the section "motivation" gives a practical introduction to all research questions, we describe here the scientific relevance and innovative character of all goals and our approach to reach those goals.

Theme 1: Network design

In this theme, we aim to derive methods to determine the number and locations of Internet Order Fulfillment Centers (IOFCs) as well as any decentralized coordination points. In traditional supply chains, one of the most important logistics decisions to ensure a cost-effective flow of materials, is where to locate new facilities such as retailers, warehouses or factories[37]. For example, the warehouse location problem describes the problem of locating a set of warehouses in a distribution network such that costs based on fixed costs for building/renting a site and variable costs for transportation activities are minimized. Important constraints in models in literature are commonly related to the capacity of warehouses, the assignment of retailers to warehouses and limited distances of retailers to warehouses. The simplest setting is the *p*-median problem where *p* facilities have to be selected from a list of available locations to minimize the total weighed distances as represented in a matrix for delivery to the customers. Several extensions of this problem exist. However, most have in common that they consider a single-period planning horizon, deterministic demand and costs, a single product, one type of facility and location-allocation decisions. In literature, approximately 82% of the papers present solution approach for facility location problems in this category[38].

[35] Hill *et al.* (2002).
[36] Agatz, N.A.H., Fleischmann, M., Van Nunen, J.A.E.E. (2008), E-fulfillment and multi-channel distribution - a review, *European Journal of Operational Research* 187, 339-356.
[37] Bramel, J., Simchi-Levi, D. (1997), *The logic of logistics*, Springer-Verlag, New York.
[38] Melo, M.T., Nickel, S., Saldanha-da-Gama, F. (2009), Facility location and supply chain management - a review, *European Journal of Operational Research* 196, 401-412.

Facility location research is a well established research area within the field of Operations Research[39]. However, many of the theoretical models do not translate well to practice. Typically, researchers have focused on single facets of the larger supply chain design problem. A crucial, but often missing, aspect to consider is the existence of different types of facilities each having different capacities and capabilities[40]. The main challenge in our research project is to go even one step beyond this by considering several web shops that share IOFCs and decentralized coordination points. As can be noticed in the section "motivation" of this proposal, there are several characteristics to internet sales handled via cross-chain control centers that are generally not considered in the literature on facility location, that create interesting new challenges and urge for new solution approaches capable of dealing with all of these characteristics. More specifically, we mention the following new dimensions.

- There is a huge set of spatially distributed consumers and a set of IOFCs to fulfill consumer demand. The matrix containing all distances, times and costs for all possible movements between individual consumers, decentralized coordination points and the IOFCs is extremely large.
- There are direct flows from upper layers in the supply chain directly to individual consumers or via decentralized coordination points.
- There is a high amount of uncertainty in future consumer demand and costs as a result of the dynamics in consumer behavior with respect to, for example, preferences.
- There are multiple consumers and/or decentralized coordination points that will be visited in a single route starting and ending at the IOFC.
- There is a high amount of return flows from consumers directly to the IOFC(s) or to/from decentralized coordination points

Hierarchical facility location models are capable of dealing with flows between multiple layers as commonly noticed in supply chains. An overview of literature in this area shows that the possibility of direct flows from upper layers to consumers has been hardly addressed[41]. Sophisticated facility location models integrating stochasticity with location decisions to deal with uncertainty in demand and resulting in a robust supply chain configuration are scarce[42]. Melo *et al*. (2009) conclude from their literature review that very few papers address stochastic parameters in combination with other aspects such as a multi-layer network structure. In this project, we intend to find appropriate formulations and solution approaches for this problem and even intend to take it one step further by also integrating other characteristics. Namely, it is expected that the integration of reverse and forward flows leads to more complex decision making, especially when the number of layers in the problem under study increases. Only a few papers introduce models with both forward and reverse flows in facility location decisions. It can be noticed that these papers made significant simplifications to solve the problem, such as considering a single product[43] or deterministic parameters (e.g., the number of returned products[44]). Melo *et al.* (2009)[45] conclude that many relevant

[39] Melo *et al.* (2009)
[40] Melo *et al*. (2009)
[41] Sahin, G., Süral, H. (2007), A review of hierarchical facility locations models, *Computers & Operations Research* 34(8), 2310-2331.
[42] Melo *et al*. (2009)
[43] Wang, Z., Yao, D.Q., Huang, P. (2007), A new location-inventory policy with reverse logistics applied to B2C e-markets of China, *International Journal of Production Economics* 107(2), 350-363.
[44] Evans, G.W., Du, F. (2008), A bi-objective reverse logistics network analysis for post-sale service, *Computers & Operations Research* 35(8), 2617-2634.
[45] Melo *et al.* (2009)

tactical/operational decisions, such as routing are far from being integrated with location decisions. As pointed in Figure 3, we strive to study the relations between multiple decisions under study.

In the literature, extensions of the traditional facility location problem seem to have been mostly solution approach driven[46]. Dealing with all of the characteristics mentioned above in an integrative solution approach is therefore an interesting research challenge which results in outcomes that can have a high scientific value and are of direct interest for practice. Internet sales allow suppliers to be more flexible in locating stock and having larger assortments[47]. So, on one hand fewer IOFCs with a large assortment would be favorable. On the other hand, there is a direct link between the location of the IOFCs and the quality, speed and efficiency of the delivery and return processes to the consumer[48]. In our solution approaches, we intend to explicitly take this trade-off into account. Objectives under consideration are availability, accessibility, delivery times and costs. We expect that important input data will include the required storage space for all involved companies, transaction data, consumer profiles, consumers' home addresses and available decentralized coordination points. Next to that, unique consumer profiles of consumers of specific partners in the consortium can be used. The need to have decentralized coordination points illustrates the relations between both research questions in this theme.

To overcome the problem of massive amounts of data, we intend to use marketing techniques to aggregate consumer data, and geographic information systems techniques to easily represent all important data. We will build on existing knowledge on facility location models as described above, and will expand them by adding characteristics one by one and testing how they impact the decision making process. Next to that, new efficient solution approaches will be designed that are capable to deal with the formulated constraints and characteristics and provide near-optimal solutions.

Practical applicability of the concepts developed in this theme will be shown by formulating a structural new design for the Dutch library distribution system. More details on the this application can be found in the section “expected results” in part A.

Theme 2: Merging flows

In this theme, the overall goal is to design methods to efficiently merge flows of various web stores in the network. These methods can contribute to the ultimate goal of having an 4C that offers one shopping cart that can be used to buy products at multiple web shops and results in home delivery of all ordered products in a single shipment. Several important questions have to be answered before internet order merging can be implemented successfully. In this theme, we will develop models and solution approaches for (a) workforce management to deal with uncertainty in demand due to consumers' ordering behavior and unawareness of the exact nature of upcoming promotions of the web shop; (b) assortment decisions to decide which products of which web store are shipped from which IOFC; (c) layout and organization of the IOFC to ensure an efficient order fulfillment process for all web stores. We will discuss each of them in more detail below.

[46] Melo *et al.* (2009)
[47] Randall, T., Netessine, S., Rudi, N. (2006), An empirical examination of the decision to invest in fulfillment capabailties: a study of internet retailers, *Management Science* 52(4), 567-580.
[48] Agatz *et al.* (2008)

Many order fulfillment processes for web stores, such as at Neckermann.com, largely rely on manual work. This choice lowers the initial investment, and ensures a higher flexibility. Capacity, as expressed in the number of consumers' orders handled per time unit, can in such a situation be almost directly linked to the available number of employees. Successful implementations of more automated system, however, exist too, such as at Centraal Boekhuis. Fluctuations in demand with respect to the number of orders, the order size, the times of order receipts, and the requested delivery times require flexible work schedules. In the literature, few papers address manpower planning in retail settings[49]. In internet ordering, these fluctuations have an even stronger impact than in traditional retailing[50].

Next to that, web stores may sometimes want to keep the exact nature of an upcoming promotion a secret - even to their logistics service provider. In such a case, the service provider will be given advance notification of "an" upcoming action to adjust workforce levels, but the service provider will only know the exact products when they are sent to the fulfillment center and will only know the demand when it occurs. We intend to design new methods to decide on staff levels at specific time slots during the week. So far, in literature more traditional manpower planning problems have been solved with heuristic approaches, simulation or integrative approaches[51]. We intend to design a heuristic approach that will provide solutions with a low computational effort. There is a need for such efficient solution approaches that are able to accurately match capacity and demand in providing estimated delivery times or offering delivery time slots to the consumer during the ordering process. Therefore, we intend to developer new approaches to workforce management in combination with options offered to the consumer with respect to the delivery & return process.

Assortment decisions indicating what products of which web store will be shipped from which IOFC within the distribution network of IOFCs have to be made carefully. So far, supply chain designs in which each company keeps and manages its own inventory for internet sales has been studied extensively in operations literature[52]. In these papers, the focus is on inventory allocation for a single company willing to enter the online sales market and considering several allocation strategies (e.g., decentralized at retail outlets versus centralized) for keeping stocks of products to sell on the internet[53]. A closely related decision in this context is to show how to allocate inventory between traditional and online sales channels[54]. However, the 4C practice of having IOFCs that stock products of multiple web stores at the same location has been studied in a few papers[55].

Several types of power relations exist between the web stores and the logistics service provider operating the IOFC, namely powerful web stores, powerful logistics service provider or equally powerful. Next to that, the web stores compete with each other in the assortment

[49] Pastor, R. , Olivella, J. (2008), Selecting and adapting weekly work schedules with working time accounts: a case of a retail clothing chain, *European Journal of Operational Research* 184, 1-12.
[50] Agatz *et al*. (2008)
[51] e.g., Mason, A.J., Ryan, D.M., Panton, D.M. (1998), Integrated simulation, heuristics and optimisation approaches to staff scheduling, *Operations Research* 46(2), 161-175.
[52] Netessine, S., Rudi, N. (2006), Supply Chain Choice on the Internet, *Management Science* 52(6), 844-864.
[53]Bendoly, E., Blocher, D., Bretthauer, K.M., Venkataramanan, M.A. (2007), Service and cost benefits through clicks-and-mortar integration: Implications for the centralization/decentralization debate, *European Journal of Operational Research* 180, 426-442.
[54] e.g., Dai, Y., Chao, X., Fang, S-C., Nuttle, H.L.W. (2006), Capacity allocation with traditional and Internet channels, *Naval Research Logistics* 53(8), 772-787.
[55] Netessine and Rudi (2006).

decisions at the IOFCs. Netessine and Rudi (2006)[56] show that the type of power structure determines the sequence of actions to be taken by all parties involved to get an efficient system. The authors propose game-theoretic models for strategic decision making to provide managerial insights into inventory ownership issues and power relations in the context of storage of products at central locations. Issues of real-time product allocation and the related effects of risk pooling have not been studied.

In this project, we intend to come up with assortment decision models to allocate products to the IOFCs. Outcomes of the model will show the best IOFC(s) for each company and the exact products to be stored at each IOFC. We plan to extend existing literature proposing frameworks based on game-theoretic models[57] to deal with trade-offs between the assignments for specific companies and the assignment that is best from an overall perspective. Another new element to be studied in this allocation problem is the tactical question of the allocation of returns to IOFCs. The designed model will be used to evaluate several alternatives for allocating returns of companies to a specific IOFC (for example, allocation to the IOFC from where it originated or allocation to the IOFC with the highest demand).

The fulfillment process in the supply chain determines for consumers how long they must wait between ordering and delivery. This fact has significantly increased the importance of the back-end fulfillment process. As a consequence, the functional requirements for the IOFCs need to come to include capabilities to handle a higher frequency of shipments per consumer, a smaller number of items per order, increased responsiveness to changes in demand, and shorter delivery deadlines[58]. However, despite this need for these facilities to keep up with a service economy, the underlying designs have not changed accordingly[59]. There is a need for additional research that helps to identify the magnitude of the impact of layout on total cost over the life of the order fulfillment centre [60,61]. Due to the labor intensity of the order fulfillment process, any future savings in labor may more than outweigh other design cost considerations, but this obviously needs to be investigated for each and every facility design anew. An additional challenge arises when operations for multiple web stores need to be taken into account. Namely, next to efficiency and costs considerations, avoidance of errors is a vital aspect. Operations of various web stores should not be mixed up (e.g., a promotion leaflet of one company should not be added to the package of another company) to prevent effects on image and branding of the web stores. It is in this space that this project should aim to make a contribution, by defining methods that optimize the design and layout of IOFCs while simultaneously considering operational efficiency and reliability. Very roughly, we may distinguish three phases in designing facilities. The first phase consists of placing the various areas related to the various companies within the facility (e.g., Meller and Gau, 1996)[62]. The second phase consists of determining the detailed layout of each of the areas.

[56] Netessine and Rudi (2006).

[57] see for an overview Swaminathan, J.M., Tayur, S.R. (2003), Models for supply chains in e-business, *Management Science* 49(1), 1387-1406.

[58] Olson, D.R. (1994*), Designing and implementing order picking systems*. In: Perspectives on Material Handling Practice, Material Handling Institute, Charlotte, North Carolina, 1-24.

[59] Cross, C.S. (2006), Warehouse design eliminates slim pickings, *Industrial Engineer* 38(10), 48-49.

[60] Gu, J., Goetschalckx, M., McGinnis, L.F. (2007), Research on warehouse operation: A comprehensive review, *European Journal of Operational Research* 177, 1-21.

[61] Gu, J., Goetschalckx, M., McGinnis, L.F. (2010), Research on Warehouse Design and Performance Evaluation: A Comprehensive Review, *European Journal of Operational Research* 203(3), 539-549.

[62] Meller, R.D., and Gau, K.Y. (1996), The facility layout problem: recent and emerging trends and perspectives, *Journal of Manufacturing Systems* 15(5), 351-366.

The third phase consists of finding control policies that organize the processes both on a facility level as well as for separate areas. The approach to be taken herein is not the usual, myopic, analysis-based approach, but in fact ventures into developing an integrated methodology that considers several aspects simultaneously.

Practical applicability of newly developed design and control concepts for the IOFCs will be demonstrated at the order fulfillment center of consortium partner Neckermann.com. Specifics of the shared shopping cart concept are related to consortium partner Centraal Boekhuis. More details on these companies can be found in the section “expected results” in part A.

Theme 3: Deliveries and returns

The goal of this theme is to develop logistics tools to organize the delivery and return processes that trade-off costs versus service, taking the locations of the IOFCs and locations of decentralized coordination points as a given input. Consumers may opt to pick up their order themselves at a decentralized coordination point or they may get their order delivered to their home either from an IOFC or from a decentralized coordination point. Important in this respect are the interactions with the consumers during the ordering process at the website of the company. The consumer can be confronted with two important questions during ordering. Namely, if (s)he prefers home delivery or pick-up at decentralized coordination point and what lead time is desired. The available stock levels and how the current order can be best interfaced with already accepted orders are important input data in deciding which options are to be presented to a consumer. A main input for this part of the research project are the wishes and reactions of the consumers in selecting the alternative delivery and return options. ScanYours.com, a partner in the consortium, may assist in tracking such information.

In attended home delivery, the consumer must be present to receive the ordered products. In accepting the consumers' order, alternative delivery times can be offered to the consumer against varying fees. The time slots initially assigned and selected are used in designing delivery routes. At that moment, it might be decided to change delivery times against a penalty (to be paid to the consumer as is done by, for example, albert.nl) to create more efficient routes. Setting and updating these time slots for each consumer tie order fulfillment decisions to vehicle routing problems with time windows[63]. In the literature, models are available for time slot design, dynamic time slotting and dynamic pricing for delivery fees[64]. Based on these decisions, routes for vehicles can be derived that serve each consumer within the promised time windows.

Our first goal is to expand this line of research by including the option for consumers to choose between delivery at a decentralized coordination point or at the home address, and expand it with time slot decisions. It is at the discretion of the web store and the 4C to decide which delivery options are offered to a consumer. If an option is not available, then it will not be offered to the consumer. Availability is a relative term in this respect; if a delivery option is possible, but expensive at that moment in time, it is possible not to offer it. This decision can be made for each consumer and each order individually. Aspects that need to be

[63] Agatz, N., Campbell, A.M., Fleischmann, M., Savelsbergh, M. (2008), Challenges and opportunities in attended home delivery, in: *The Vehicle Routing Problem, latest advances and new challenges*, Golden, B., Raghavan, S., Wasil, E. Eds., Springer, 379-396.
[64] Agatz *et al*. (2008).

considered in this respect, include information sharing between the 4C and the decentralized coordination points, flexible labor planning at the decentralized coordination points and selection of decentralized coordination points. We propose methods for pricing of time slots in combination with a selection of delivery options.

Secondly, we aim to study the option of integrating deliveries of multiple web stores in one network. Common practice is still that most deliveries are made without prior agreement with the consumer on the delivery moment. Furthermore, delivery workers may experience unexpected delays, or be faster than anticipated. Perfect information on the location of the consumer could avoid delivery attempts at times that the consumer is not at home. As explained in the section "motivation", the location of a consumer can be tracked with modern technologies such as Foursquare and Gowalla. In the third research question in this theme, we intend to show how this information can be included in the routing of delivery trucks. Based on this information it might be decided to postpone delivery and to reschedule the delivery in the route. We expect that a new class of vehicle routing problems has to be designed. We notice close relations with a-priori routing and dynamic vehicle routing. A well-known a-priori routing problem is the probabilistic TSP in which probabilities indicate if a consumer requires service[65]. In our problem, we known that a delivery has to be made, but there is uncertainty about the time window. Furthermore, real-time information is available that can be used in routing decisions. Dynamic vehicle routing systems are capable of dealing with newly available information on, for example, new consumers, in designing routes[66]. In our problem all consumers are known, but their availability to receive the package only becomes known during the actual delivery process.

Next to the delivery of items, we have to deal with the return flows. Consumers have the right to return products. The actual number of returns per product, the origin of the returns, as well as the quality of the returned product (can it be resold?) are uncertain. On the other hand, in the case of libraries, returns are known and equal to the original order with a certain time delay. In the latter case, a detection system needs to be available to check that all items indeed will be returned. We intend to design both deterministic models (for library returns) as well as stochastic models (for product sales) to coordinate the return processes from both decentralized coordination points as well as from consumers' homes. The models allow for integrating returns of multiple companies from multiple sources such as consumers' home addresses and decentralized coordination points in delivery routes of the forward flows.

The feasibility check of the home delivery concept from decentralized coordination points will be tested in cooperation with consortium partner Centraal Boekhuis. Return flow handling is of interest in the process of Neckermann.com and in the new network design for the Dutch public libraries. More details on these applications can be found in the section “expected results” in part A.

[65] Campbell, A.M., Thomas, B.W. (2008), Challenges and Advances in a priori routing, in: *The Vehicle Routing Problem, latest advances and new challenges*, Golden, B., Raghavan, S., Wasil, E. Eds., Springer, 123-142.
[66] Larsen, A., Madsen, O.B.G., Solomon, M.M. (2008), Recent developments in dynamic vehicle routing systems, in: *The Vehicle Routing Problem, latest advances and new challenges*, Golden, B., Raghavan, S., Wasil, E. Eds., Springer, 199-218.

Part B: Activities and Work Packages

Introduction

In the path towards our goal we have made a distinction between several goals as specified in part A "Objectives and goals". We describe here several activities to reach these goals, based on the research themes specified in part A "Motivation". Next to that, we present activities related to integrative cases studies. The final activity demonstrates the implementation phase. This brings us to a total of 7 activities.

1. Network Design
2. Merging Flows
3. Deliveries and returns
4. Case 1: A shared collection for Dutch libraries (4C: newly to be founded organization)
5. Case 2: Shared resource planning for internet order fulfillment (4C: Neckermann.com)
6. Case 3: Instant home delivery for internet orders (4C: Centraal Boekhuis)
7. Implementation phase

In activities 1, 2 and 3, we will create concepts, problem formulations and solution methods for each of the goals. Effectiveness and efficiency of the approaches will be tested both from a theoretical as well as from a practical point of view. We present a case related to each of the themes in activities 4, 5 and 6. In each case we pay attention to the integration with decisions in the other themes. As a result, we will use activities 4, 5 and 6 to evaluate the design of 4C networks and to show how the strategic, tactical and operational decision levels can be bridged and how interests of multiple stakeholders can be met by using our solution approaches.

For each activity we specify in detail its goal, the planning, work distribution, expected results and scientific approach below. The links between the activities have been described in Part A of this proposal and are depicted in Figure 3. In general, we tackle our goal by proposing new solution approaches by using, developing and integrating techniques from the fields of marketing, logistics and operations research.

The following figure depicts the overall planning for this project.

ID	Task Name	Start	Finish
1	Network Design	1-9-2010	1-9-2014
2	Merging Flows	1-9-2011	31-12-2014
3	Deliveries and returns	1-9-2010	1-9-2014
4	Case 1	1-9-2010	1-9-2014
5	Case 2	1-9-2011	1-9-2014
6	Case 3	1-9-2010	1-9-2014
7	Implementation phase	1-9-2011	1-9-2015

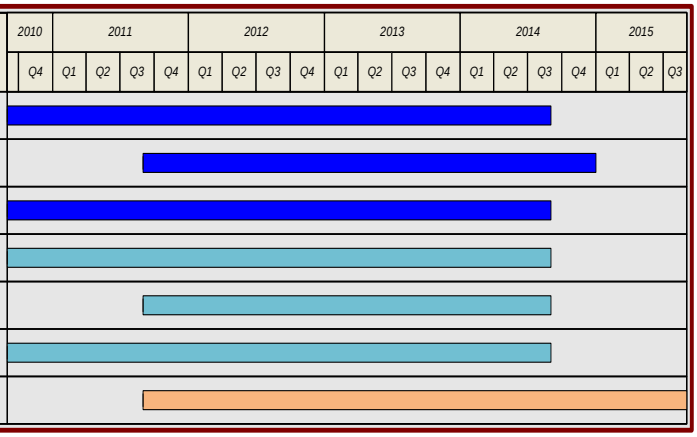


Figure A. Overall Planning

Activity 1: Network design

Description

The first part of this activity aims to derive methods to determine the number of IOFC and good locations for them. The goal of the second part is to design methods to derive both the required number of decentralized coordination points (DCPs) and their exact locations to serve the 4C network best.

Planning

ID	Task Name	Start	Finish
1	Location model IOFCs	1-9-2010	1-9-2011
2	Validation model 1	2-9-2011	2-1-2012
3	Location model DCPs	2-1-2012	31-8-2012
4	Validation model 2	3-9-2012	1-11-2012
5	Integrated location models IOFCs/ DCPs	2-11-2012	1-5-2013
6	Validation model 3	2-5-2013	30-8-2013
7	Writing Ph.D. Thesis	2-9-2013	2-9-2014

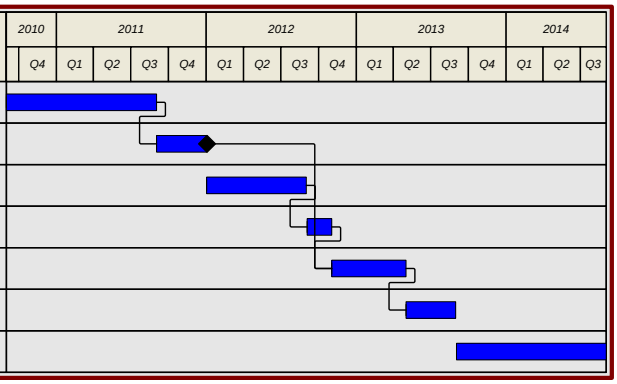


Figure A.1. Planning Activity 1

Work distribution

Research Phase	*Ph.D. candidate*	*Senior Researchers*[67]	*Companies*
Design of models	x	x	
Validation of models	x	x	x
Writing academic papers	x	x	
Writing white papers		x	
Writing Ph.D. thesis	x	x	

Customer profile data (zip codes, purchasing behavior, preferred sales channel) and the ARC-GIS software package of ESRI Nederland BV is available for this research project. Next to that, via the GeoMarketing Research Centre at the VU University Amsterdam[68] in which two of the senior researchers participate, direct contacts with the company GEODAN (geo-ICT consultancy company) exist and allow to share knowledge on GIS techniques.

Expected results/deliverables/milestones[69]

- methods to determine the number of IOFC and good locations for them.
- methods to determine the number of DCPs and good locations for them.
- Scientific paper 1: "Location models for cross-chain internet order fulfillment centers".
- Scientific paper 2: "Location models for decentralized coordination points".
- Scientific paper 3: "Integrated location models for IOFCs and DCPs".
- White paper: "Network design for cross-chain coordination of internet sales".

[67] dr. K.J. Roodbergen, dr. I.F.A. Vis, prof. dr. J. Boter.
[68] http://www.feweb.vu.nl/geomarketing/nl/index.asp.
[69] see planning in Figure A.1.

Scientific approach[70]

We aim for models that consider the trade-off and the economies of scale by having a few IOFCs and many DCPs in the delivery process. All relevant characteristics such as multi-layer networks, stochasticity, returns, direct deliveries to consumers, consumer profiles, and required storage space will be included in newly developed hierarchical facility location models and heuristic solution approaches based on consumer profiles and GIS techniques. More information on the scientific background can be found in "Part A: orientation".

Activity 2: Merging flows

Description

In this activity, we intend to develop models and solution approaches for (a) workforce management; (b) assortment decisions of companies to IOFCs; (c) design of the IOFC to deal with multiple web stores.

Planning

ID	Task Name	Start	Finish
1	Manpower planning models	1-9-2011	30-4-2012
2	Validation model 1	1-5-2012	29-8-2012
3	Assortment decisions	3-9-2012	30-4-2013
4	Validation model 2	1-5-2013	30-8-2013
5	Layout models	1-1-2013	1-1-2014
6	Validation model 3	2-1-2014	3-4-2014
7	Academic papers/White papers	4-4-2014	31-12-2014

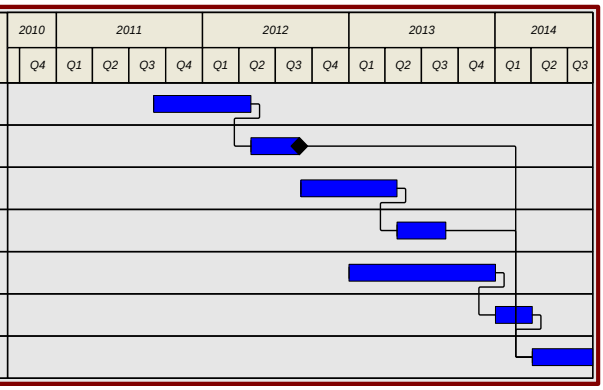


Figure A.2. Planning Activity 2

Work distribution

Research Phase	*Senior Researchers*[71]	*Companies*
Design of models	x	
Validation of models	x	x
Writing academic papers	x	
Writing white papers	x	

Expected results/deliverables/milestones[72]

- models for workforce management.
- models for assortment decisions of companies to IOFCs.
- models to design the IOFC to deal with multiple users.
- Scientific paper 1: "Workforce management under demand uncertainty in online sales".
- Scientific paper 2: "Coordinated assortment decisions for distinct retailers".
- Scientific paper 3: "Multi-user layout models".
- White paper: "Order fulfillment operations in internet sales".

[70] see section "Orientation" in part A
[71] dr. K.J. Roodbergen, dr. I.F.A. Vis
[72] see planning in Figure A.2

Scientific approach[73]

We will use techniques from Operations Research and game-theoretic approaches to plan order fulfillment operations from an overall perspective in IOFCs for multiple web stores with their own interests. More information on the scientific background can be found in "Part A: orientation".

Activity 3: Deliveries and returns

Description

The goal of this activity is to develop logistics tools to organize the delivery and return processes that trade-off costs versus service, taking the locations of the IOFCs and decentralized coordination points as a given inputs.

Planning

ID	Task Name	Start	Finish
1	Home-delivery versus pick-up	1-9-2010	1-3-2011
2	Validation model 1	2-3-2011	1-6-2011
3	Integrate cross-chain deliveries	1-6-2011	30-12-2011
4	Validation model 2	2-1-2012	30-3-2012
5	Dynamic delivery time slot management & instant home delivery	1-9-2011	31-8-2012
6	Validation model 3	3-9-2012	1-1-2013
7	Coordinate cross-chain returns	1-1-2013	30-5-2013
8	Validation model 4	3-6-2013	30-8-2013
9	Ph.D. Thesis	2-9-2013	1-9-2014

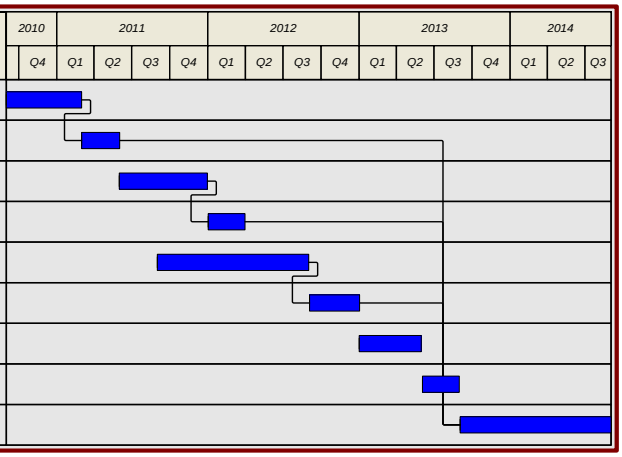


Figure A.3. Planning Activity 3

Work distribution

Research Phase	*Post-Doc*	*Senior Researchers*[74]	*Companies*
Design of models	x	x	
Validation of models	x	x	x
Writing academic papers	x	x	
Writing white papers		x	

Expected results/deliverables/milestones[75]

- Models to trade-off home delivery and delivery via decentralized coordination points.
- Models to integrate deliveries of multiple companies.
- Models for dynamic delivery time slot determination and instant home deliveries.
- Models to coordinate deterministic & stochastic product returns.
- Scientific paper 1: "Home delivery versus delivery via decentralized coordination points ".

[73] see section on "Orientation" in part A
[74] dr. K.J. Roodbergen
[75] see planning in Figure A.3

- Scientific paper 2: "Cross-chain deliveries of internet orders to consumers".
- Scientific paper 3: "Dynamic delivery time slot determination".
- Scientific paper 4: "Instant home deliveries for internet sales".
- Scientific paper 5: "Cross-chain coordination of return flows".
- White paper: "Attended home deliveries versus decentralized coordination points".

Scientific approach[76]

We will use observations and surveys to derive consumers' wishes and use techniques from Operations Research, such as Vehicle Routing Problems and stochastic programming to efficiently coordinate cross-chain deliveries and returns of internet orders. More information on the scientific background can be found in "Part A: orientation".

Activity 4: A shared collection for Dutch libraries (case)

(4C: newly to be founded organization)

Description

The goal of this case is to apply the new network design tools in setting-up a shared collection for Dutch libraries coordinated by an 4C with several IOFCs and decentralized coordination points. We study interactions with decisions related to coordination of product delivery and returns as defined in activity 3.

Planning

ID	Task Name	Start	Finish
1	Insights in current status	1-9-2010	1-9-2011
2	Data analysis	3-1-2011	1-9-2011
3	Network Design IOFC	2-9-2011	3-9-2012
4	Network Design DCP	3-9-2012	30-8-2013
5	Simulation study	2-9-2013	1-1-2014
6	Management report	1-4-2014	1-7-2014
7	White paper	2-7-2014	2-9-2014

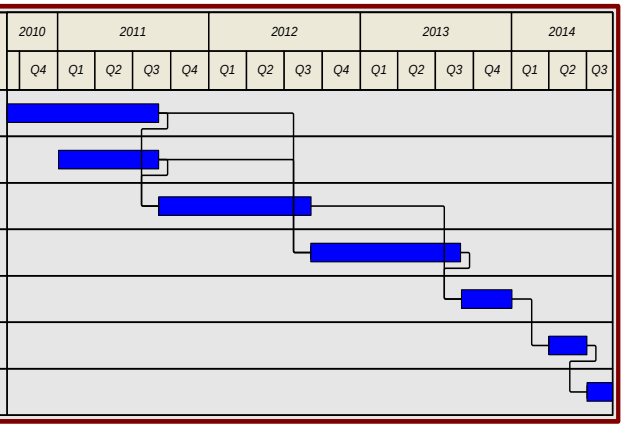


Figure A.4. Planning Activity 4

Work distribution

Research Phase	*Ph.D. candidate*	*Master students*	*Senior Researchers*[77]	*Public libraries*
Insights in current status		x	x	x
Data analysis		x	x	x
Network Design shared collection	x	x	x	
Simulation study	x		x	
Management report	x		x	

[76] see section on "Orientation" in part A

[77] dr. K.J. Roodbergen, dr. I.F.A. Vis, prof. dr. J. Boter and others

Expected results/deliverables/milestones[78]

- Design of a network for the Dutch libraries to share a collection coordinated by an 4C.
- White paper: "Network design for small deliveries in practice".
- Management report indicating the best design options.

Activity 5: Shared resource planning for internet order fulfillment (case)

(4C: Neckermann.com)

Description

The goal of this case is to apply the newly designed order fulfillment tools in improving the processes at Neckermann.com to perform the order fulfillment operations for several web stores with a distinct collection. We study the option of how to integrate new web stores in the cross-chain coordination operations of Neckermann.com. We study interactions with decisions related to coordination of product delivery and returns as defined in activity 3.

Planning

ID	Task Name	Start	Finish
1	Insights in current status	1-9-2011	31-8-2012
2	Data analysis	3-1-2012	31-8-2012
3	Manpower planning	3-9-2012	30-8-2013
4	Assortment decisions	3-9-2012	30-8-2013
5	Layout	3-9-2012	30-8-2013
6	Simulation study	2-9-2013	28-2-2014
7	Management report	3-3-2014	2-6-2014
8	White paper	1-7-2014	1-9-2014

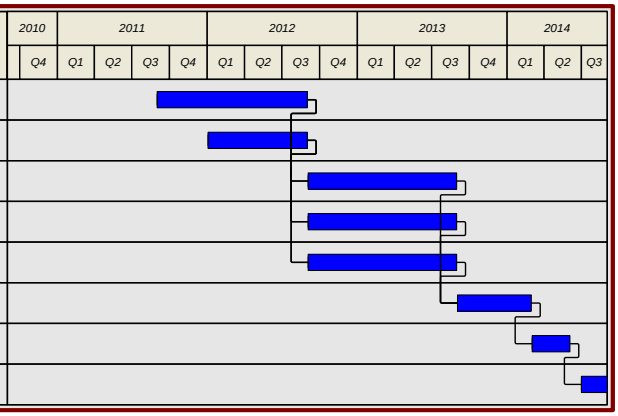


Figure A.5. Planning Activity 5

Work distribution

Research Phase	*Master students*	*Senior Researchers*[79]	*Neckermann.com*
Insights in current status	x	x	x
Data analysis	x	x	x
Shared resource planning (manpower, assortment, layout)	x	x	
Simulation studies		x	
Management report		x	

Expected results/deliverables/milestones[80]

- Design and/or improve cross-chain order fulfillment processes at Neckermann.com
- White paper: "Shared resource planning for internet sales"
- Management report indicating the best design options.

[78] see planning in Figure A.4
[79] dr. K.J. Roodbergen, dr. I.F.A. Vis
[80] see planning in Figure A.5

Activity 6: Instant home delivery for internet orders (case)
(4C: Centraal Boekhuis)

Description
The goal of this case is to apply the newly designed tools in designing a system for instant home delivery of internet orders. We use the tools designed in activity 3 and study the relation with decisions studied in activities 1 and 2.

Planning

ID	Task Name	Start	Finish
1	Insights in current status	1-9-2011	31-8-2012
2	Data analysis	3-1-2012	31-8-2012
3	Flexible labor planning in deliveries	3-9-2012	3-9-2013
4	Delivery scheduling	3-9-2012	30-8-2013
5	Simulation study	4-9-2013	3-1-2014
6	Management report	1-4-2014	1-7-2014
7	White paper	2-7-2014	2-9-2014

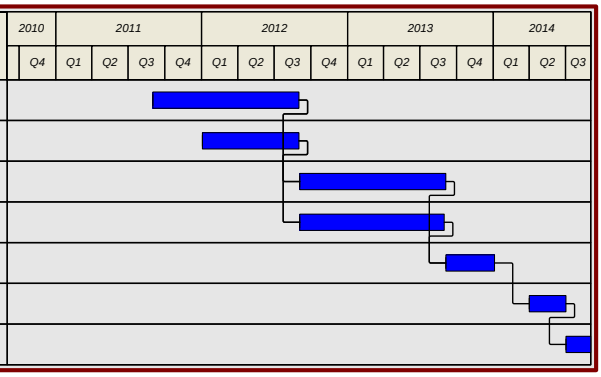


Figure A.6. Planning Activity 6

Work distribution

Research Phase	*Post-Doc*	*Master students*	*Senior Researchers*[81]	*Centraal Boekhuis*
Insights in current status		x	x	x
Data analysis	x	x	x	x
Design instant home delivery	x	x	x	
Simulation study	x		x	
Management report	x		x	

Expected results/deliverables/milestones[82]
- Design of instant home deliveries coordinated by Centraal Boekhuis.
- White paper: "Instant home delivery for internet orders".
- Management report indicating best design option.

[81] dr. K.J. Roodbergen, prof. dr. J. Boter
[82] see planning in Figure A.6

Activity 7: Implementation

Description

From the start, the researchers in the project will have direct contacts with companies to:

1) explore new fields;
2) discuss possible implementation of the newly developed design and control tools in software systems (SAP and web-based systems);
3) based on the results of step 2 (and if required, methods will be updated), implementation schemes will be designed;
4) companies from outside the consortium may be introduced, if needed, that are willing to serve as a test ground for the developed tools;
5) at the final stage of the project it will be examined what specific aspects can be implemented.

Planning

step 1: At all expert meetings, presentations and individual meetings feasibility of concepts will be discussed.
step 2: A discussion will be planned after finishing each of the models related to each of the activities 1, 2 and 3.
step 3: Implementation schemes will be designed for models resulting from activities 1, 2 and 3 after validation.
step 4: 2010-2015.
step 5: 2014-2015.

Work distribution

	Senior researchers[83]	*mYuice*
Explore new fields	x	x
Options to implement	x	x
Update models	x	x
Design implementation schemes	x	x
Optional additional testing at other companies not part of the consortium	x	x
Selection of tools to implement		x

Expected results/deliverables/milestones

See the descriptions of activities 1 through 6 and the section "expected results" in part A.

[83] dr. K.J. Roodbergen, dr. I.F.A. Vis, prof. dr. J. Boter

Part C: Consortium and Project organization

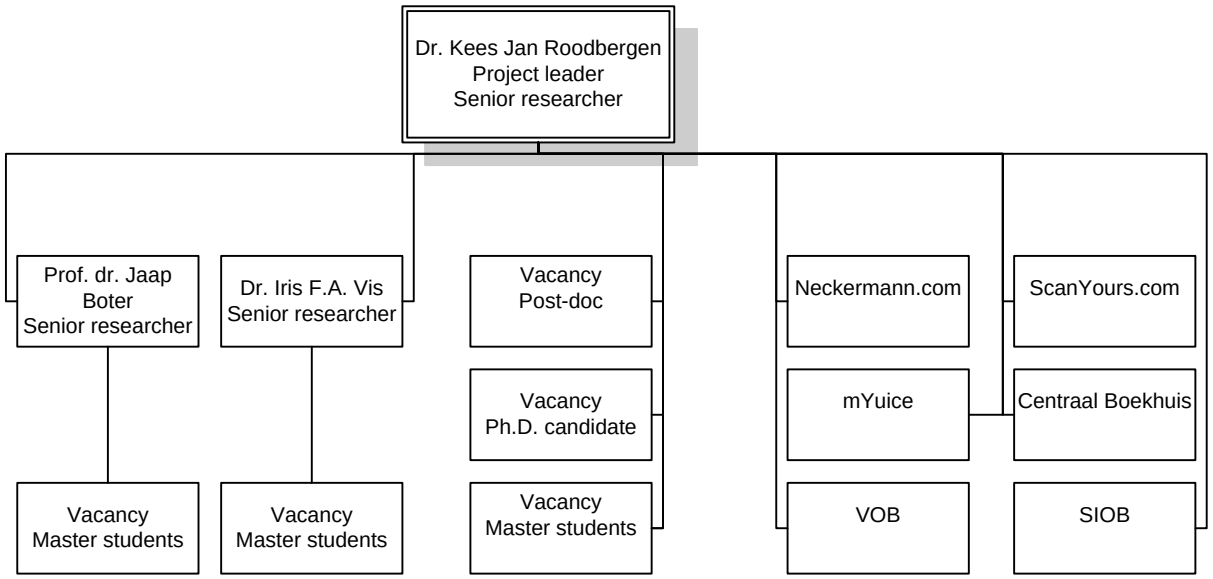
Research Team

Short CVs of the scientific researchers in this project can be found in part G. Extended descriptions of the companies, their activities, and the expected results per company can be found in parts A and B. Extended roles and inputs of researchers and companies in this project have been described in part B above. A brief overview of the roles, inputs and past performance of the companies in the consortium is discussed in the table below.

Name partner	Role and input	Specific competence
Neckermann.com	• Case in activity 5 (see part B). • Participant in expert panels. • Participant in workshops. • Collection of data (e.g., demand, consumer profiles, current practice). • Internships for Master thesis students.	• Acting as 4C by coordinating and handling websales of companies Neckermann, WE, M&S and others. • Input will be delivered by logistics manager and the logistics management assistant.
Centraal Boekhuis	• Case in activity 6 (see part B). • Participant in expert panels. • Participant in workshops. • Collection of data (e.g., demand, consumer profiles, current practice). • Internships for Master thesis students.	• Acting as 4C for various companies. • Takes care of order fulfillment for bol.com. • Input will be delivered by several people from within the company.
SIOB VOB	• Case in activity 4 (see part B). • Participant in expert panels. • Participant in workshops. • Collection of data (e.g., demand, consumer profiles, current practice). • Internships for Master thesis students.	• Has insights in all relevant knowledge with regard to libraries and its consumers. • In transition to a new way of organizing flows. • Input will be delivered from people working at several important. organizations within the Dutch library system.
Scanyours.com	• Validation of models and concepts designed in activities 1 and 3 by means of testing them at consumers using the internet for their sales. • Collection of data on consumers' wishes. • Participant in expert panels. • Participant in workshops.	• Company that focuses on designing tools to help companies to increase profits from web activities (e.g., presenting the target group, increasing visibility, online survey tools).

mYuice	• Participant in expert panels. • Participant in workshops. • Validation of promising methods to check if implementation is an option. • Providing interesting additional cases. • Selecting tools that are ready for implementation.	• Sales, implementation, and support of SAP software and development of additional tools for SME.

Project organization



At least one senior researcher will participate in each of the activities as formulated in part B. The post-doc will contribute to activity 3 and activity 6 under supervision of dr. K.J. Roodbergen. The Ph.D. candidate will participate in activity 1 and 4 under supervision of dr. K.J. Roodbergen and prof. dr. J. Boter. The Master students will be perform case studies at the companies as mentioned in activities 4, 5 and 6. All Master students will be supervised by at least one of the senior researchers. All companies and public organizations in the consortium have tasks as specified in the various activities mentioned in part B. Dr. K.J. Roodbergen will be project leader and will coordinate all activities and projects being performed. Budget decisions will be made by dr. K.J. Roodbergen in close cooperation with the other two senior researchers in the project.

Part D: Evaluation and monitoring

In part B we have specified for each activity the expected results and contributions of all consortium partners. The people involved in these activities will schedule meetings to discuss the outcomes and progress of the activities.

In general, we consider the following aspects of importance in evaluating and monitoring the progress and outcomes of this project:

- sharing information
- senior researchers' meetings
- expert panels
- individual meetings with partners in the consortium
- peer review assessment
- workshops with partners
- progress reports
- final report

We will discuss each of these aspects in more detail below.

Sharing information
Within the project, information will be shared via a website. There will be an open access as well as an intranet part. At the open access site, project results will be shared with the world at large, targeting both academics and professionals. The intranet pages will be used to share internal communications such as reports of meetings, special notes on case studies for a specific company, progress reports, unfinished papers, preliminary management reports and suggested project adjustments. Next to that, articles and papers will be published both in professional and scientific journals and results will be presented at practice-oriented and academic conferences. In this way, partners in the consortium as well as outside parties can decide which approaches are appealing to them to implement.

Senior researchers' meetings
The senior researchers will meet at least once every three months to evaluate the results and the status of the project. At these meetings, new expert panel sessions, meetings with individual partners or workshops with partners will be scheduled.

Expert panels
Quite regularly the researchers in the consortium will meet with representatives of the companies and public organizations participating in this project. The overall goal of these meetings is to (1) discuss new insights and methods resulting from the research being performed; (2) out-of-the-box discussions to come up with innovative ideas; (3) discuss actual themes and new technological innovations that were initially not covered in the project plan, but that might be of interest for this project.

Individual meetings with partners in consortium
At the start of the project, individual meetings with partners in the consortium and the project leader dr. K.J. Roodbergen will be scheduled to discuss expectations and contributions in more detail. Direct result of each of these meetings is a report summarizing the aspects discussed. In the remaining years, at least once a year a meeting will be scheduled to discuss the involvement of each of the partners in the project, the results obtained, expectations and so on.

Peer review assessment
Academic output will be reviewed by colleagues in the field when papers or theses are submitted for publication. These review reports will be used to improve the methods proposed. Next to that, the models will be discussed with the partners in the consortium to discuss the feasibility of implementation in practice. Finally, assessment of the case studies will be discussed in the consortium and on professional and academic conferences to receive feedback on the methods and outcomes. All feedback will be used to improve the results.

Workshops with partners
Once a year, a workshop will be scheduled for all partners in the consortium where research results, case studies and implementation options will be presented. Small break-out sessions will be part of these workshops to allow for extensive discussions.

Progress reports
Each year the senior researchers will use the input of the workshops, individual meetings, peer review assessment and expert meetings together with the academic outputs to evaluate the status of the project. Progress will be monitored by using the milestones as described in part B of this proposal. A short report will be composed in which a detailed summary of the results so far is described. Next to that, it will be specified which project adjustments will be made based on new developments in technology, modeling and so on. This report will be submitted to Dinalog and all partners in the consortium for feedback.

Final report
September 2015, the senior researchers in consultation with the companies in the consortium will write a final report in which they summarize the results of the project in terms of academic publications, white papers, case studies, implementation plans and actual implementations. This report will be submitted to Dinalog, all partners in the consortium, and other interested parties.

Part E: Valorization and implementation strategy

Valorization and knowledge dissemination

Organization
As shown in part B, we have defined 7 activities to structure our research project. Each activity contains a work package consisting of specific research questions. The steps performed for each research question are in general organized as follows: (1) formulation of the problem definition; (2) formulation of the conceptual model; (3) data analysis; (4) formulation of the model; (5) formulation of the solution approach; (6) validation and verification of the approach by means of simulation studies; (7) validation of the practical usefulness of the method by means of a case study; (8) writing an academic paper; (9) judgment whether the new tools would a valuable contribution to and can be interfaced with ERP software and web systems; (10) drafting an implementation scheme.

Tangible research results for each activity related to these steps are (see part B for more details on, for example, exact planning of milestones and deliverables):

- A series of high-quality academic papers and Ph.D. theses;
- White papers;
- Magazine and newspaper articles;
- Conference presentations;
- Feasibility check in companies of the consortium;
- Estimates of profitability of the concepts;
- Implementation schemes in commonly used software formats;
- Selection of tools to be implemented.

Clear insights can be obtained in the potential applicability of the developed concepts due to the breath of the consortium. Three different types of 4C (i.e., Neckermann.com, Centraal Boekhuis, and public libraries) participate in the consortium and create the perfect opportunity to validate the designed methods. mYuice and Scanyours.com contribute to respectively judging whether new tools can be implemented and judging the interface and opinion of the consumers on the designed policies and options offered during the ordering on the web.

Making knowledge and results available
Within the project, information will be shared via an open-access area at our web site (see part D). At the open access site, project results and knowledge will be shared with colleagues both in the academic and professional world. Next to that, articles and white papers will be published both in professional and scientific journals and results will be presented at practice-oriented and academic conferences. We will regularly write Dutch papers to be submitted for publication to, for example, www.logistiek.nl in which we describe the problem under study, the solution method, case studies with results and ways to implement the approach in general. The senior researchers will use the outcomes of the project and the knowledge obtained directly in their educational activities. Both at the Rotterdam School of Management and the VU University of Amsterdam, knowledge can directly be transferred to students in Bachelor and Master courses, to Ph.D. students in Ph.D. courses at the research institutes ERIM and ABRI, and to students in part-time programs.

Transfer beyond the consortium
Ideas, methods and concepts generated in this project will need to be communicated broadly and need to be implemented in a software environment if they are to be used by a larger audience. Communication strategies have been described above. Consortium partner mYuice has the capabilities to judge whether the new tools would a valuable contribution to and can

be interfaced with ERP software. Partner Scanyours.com has the capacities on the web interface with the consumers.

We intend to validate all models and solution approaches by means of performing a case study. If the designed methods are valuable, but not suitable for the 4C partners in the consortium, we will actively search for other partners. For example, mYuice may be able to find a suitable application site from its large client base.

We expect that the outcomes of this project (i.e., design procedures, control concepts and efficiency estimators for Cross Chain Control Centers) can be extended to other sectors. This especially holds for companies starting a new internet sales channel. Costs to initiate a web shop can be considered to be low. However, sales volumes of such a startup company are too small to afford a logistics network of its own. Only outsourcing or cooperation with other companies are viable options. As a result, we expect that our methods can contribute to the success of start-ups in the field of internet sales. By making all knowledge available and by designing tools that are ready to be implemented in ERP software, we offer new businesses to design an efficient logistics process to deliver items to their consumers. At the same time, we offer existing web shops the opportunity to increase performance and decrease costs.

To implement the innovative concepts introduced in this research proposal, side effects in creating businesses are expected to occur. For example, the concept of having fast deliveries from decentralized coordination points to consumers' homes coordinated by an 4C (see Theme 3 in part A, can result in the creation of a pool of employees to handle the actual distribution. As a result, additional activities for temporary employment agencies arise in selecting and hiring, for example, students with mobile phones.

More on the expected impact of this project can be found in the section "expected results" in part A.

Implementation

We intend to pay significant attention to the options to implement results directly from the start (see also the section "goals and objective in part A, as well as the descriptions in part B). In each of the described work packages, researchers will have direct contacts with the companies to explore new fields and to discuss possible implementation of the newly developed design and control tools. After finalizing a model and validating the solution approach by means of a case study at one of the companies in the consortium, an implementation scheme will be designed. All involved companies can play a vital role in the feasibility check from their own perspective, as an active 4C, from an ERP implementation point of view, or from the consumers' interface perspective.

Concepts that are considered feasible for implementation in practice, can be taken up by the consortium partners. Some of the concepts that will be investigated in this project are likely to be appealing to other companies as well. Consortium partners will have the first mover advantage, but other companies can be expected to follow, especially if the concepts can be made available in a commonly used software formats. More specifics for the companies in the consortium and the world at large can be found under "expected results" in part A.

Curricula Vitae of the Scientific Researchers

K.J. Roodbergen

Dr. Kees Jan Roodbergen is an Associate Professor at Rotterdam School of Management, Erasmus University, The Netherlands. In his academic research, Roodbergen has a diverse interest, ranging from supply chain management, logistics of temperature-controlled (food) products, human factors in logistics, facility logistics, and traveling salesman problems. He has published in international journals such as Operations Research, IIE Transactions and the European Journal of Operational Research and has been a visiting researcher at the Georgia Institute of Technology.
Roodbergen serves on the Scientific Advisory Council of the World Food Logistics Organization, an organization that represents 3500 companies specialized in handling cooled and frozen food products. Next to that he is a member of the College-Industry Council on Material Handling Education in the USA. This council is affiliated with the Material Handling Industry of America (800 companies) and facilitates the information interchange between industry and academia. His solution approaches have been successfully applied at a number of companies, and have been included in a SAP add-on.
His teaching activities span the whole spectrum of Operations Management and Supply Chain Management at all levels, ranging from first-year Bachelor courses to post-experience programs.

Five selected publications for Kees Jan Roodbergen:
Roodbergen, K.J. and Vis, I.F.A. (2009), A survey of literature on automated storage and retrieval systems. European Journal of Operational Research 194(2), 343-362.
Vis, I.F.A., and Roodbergen, K.J. (2009), Scheduling of container storage and retrieval, Operations Research 57(2), 456-467.
Roodbergen, K.J., Sharp, G.P., and Vis, I.F.A. (2008), Designing the layout structure of manual order-picking areas in warehouses. IIE Transactions 40(11), 1032-1045.
De Koster, R., Le-Duc, T., Roodbergen, K.J. (2007) Design and control of warehouse order picking: a literature review. European Journal of Operational Research 182(2), 481-501.
Dekker, R., De Koster, M.B.M., Roodbergen, K.J., and Van Kalleveen, H. (2004), Improving order-picking response time at Ankor′s warehouse, Interfaces 34(4), 303-313.

I.F.A. Vis

Dr. Iris F.A. Vis is an Associate professor of Logistics at the VU University Amsterdam. She holds an M.Sc. in Mathematics (specialization Operations Research) from the University of Leiden, and a Ph.D. from the Erasmus University Rotterdam. Iris Vis has been a Visiting Professor at the Virginia Polytechnic Institute and State University.
Vis is a fellow of the research institute Tinbergen. The research interests of Vis are in the design and optimization of container terminals, vehicle routing, supply chain management and inventory management. The common goal in her projects is to develop new planning and control concepts to improve logistics operations by means of techniques from Operations Research. Empirical testing is performed in close relation with companies like Amsterdam Container Terminals and warehouses of DHL. Her articles have been published in or accepted by scientific journals as Operations Research, European Journal of Operational Research, IIE Transactions and Transportation Science. She received several awards for her scientific work, such as the INFORMS Transportation Science Section Dissertation Award 2002.

Five selected publications for Iris Vis:

- Vis, I.F.A., Carlo, H.J. Sequencing two cooperating automated stacking cranes in a container terminal, forthcoming in Transportation Science.
- Bijvank, M., Koole, G., Vis, I.F.A. (2010), Optimizing a general repair kit problem with a service constraint, European Journal of Operational Research, 204(1), 76-85.
- Vis, I.F.A., Roodbergen, K.J. (2009), Scheduling of container storage and retrieval, Operations Research, 57, 456-467.
- Vis, I.F.A. (2006), Survey of Research in the Design and Control of Automated Guided Vehicle Systems, European Journal of Operational Research 170(3), 677-709.
- Vis, I.F.A., De Koster, R., Savelsbergh, M.W.P. (2005), Minimum vehicle fleet size under time window constraints at a container terminal, Transportation Science 39(2), 249-260.

J. Boter

Prof. dr. Jaap Boter studied Musicology (MA) at Utrecht University. Having worked for a number of years as a consultant and lecturer of Arts Marketing at Utrecht University, he switched to the Marketing Department of the VU University Amsterdam in 2001 as assistant professor, to complete his PhD research into analyzing transaction data of cultural organizations, such as theater box office data, museum visiting behavior of Dutch Museum Card holders, and borrowing data of public library patrons. While GIS originally was simply included to map the customers in the data, his enthusiasm for the potential of GIS techniques grew rapidly and became an important foundation of his research. He set up a course on GeoMarketing for the M.Sc. Marketing program and is one of the founding partners of the Geomarketing Knowledge Center, in which the departments of Marketing, Logistics and Spatial Economics join several partners from industry to carry out research on the interface of customer service, distribution & warehousing, and spatial/geographical data. Next to his current work within the Marketing Department of the VU University Amsterdam, Jaap Boter also holds the Royal Booksellers Association chair on book trade at the University of Amsterdam; a field in which, again, his interest in culture, business economics, retail and logistics, and location, all come together.

Five selected publications for Jaap Boter:

- Vis, I.F.A., Boter, J., and Van der Voort, K. (working paper), “Designing Library Storage Facilities”.
- Bijvank, M., Vis, I.F.A., and Boter, J. (working paper), “Network assortment planning with customer choice modeling”.
- Verhagen, T., Boter, J., and Adelaar, T. (forthcoming), “The Effect Of Product Type On Consumer Preferences For Website Content Elements: An Empirical Study”, Journal of Computer-Mediated Communication.
- De Graaff, T., Boter, J., and Rouwendal, J. (2009), "On Spatial Differences in the Attractiveness of Dutch Museums", Environment & Planning A, 41 (11), 2778-97.
- Rouwendal, J., and Boter, J. (2009), "Assessing the Value of Museums with a Combined Discrete Choice/Count Data Model", Applied Economics, 41 (11), 1417-1436.