The improvement of inflight catering equipment distribution using a redesigned control model

A case study at KLM Royal Dutch Airlines

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Challenge the future

THE IMPROVEMENT OF INFLIGHT CATERING EQUIPMENT DISTRIBUTION USING A REDESIGNED CONTROL MODEL

A CASE STUDY AT KLM ROYAL DUTCH AIRLINES

by

J.J. Stolk

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PREFACE

This thesis describes my applied research focusing on the improvement of inflight catering equipment distribution within the global network of an airline. I conducted my research programme within the Inflight Services department at KLM, Royal Dutch Airlines. The research programme was supervised by the Transport Engineering Logistics chair of the Faculty of Mechanical, Maritime and Materials Engineering atDelft University of Technology. The thesis is part of the Master's degree in Transport, Infrastructure and Logistics of the Faculty of Civil Engineering and Geosciences at TU Delft.

My motivation for this thesis lies in my background in Supply Chain Management. After internships in the beer industry, I was looking for an assignment in the air transport industry. During the MSc programme TIL, this complex but dynamic environment inspired me. The case study within KLM turned out to be exactly the challenging project I was looking for. During the project, my focus was on both the technical design of the control model and on the actors involved. From the beginning, I had a strong focus increasing collaboration and commitment for a new control model; an instructive experience I consider very valuable for an engineer.

The readers to whom I would like to address this thesis are found in various organizations. The first group exists of students and researchers interested in logistic challenges. This thesis provides an academic approach for certain subjects. The second group consists of logistics operators within airlines, looking for ways of increasing efficiency. Given the current field of competitors, a cost efficient operation is vital for an airline's future. This thesis provides insights into how to improve the efficiency of the specific logistics operations involved in inflight equipment distribution. The third group consists of people in industrial environments working with rotating equipment and/or the theory of Closed Loop Supply Chains. This thesis provides a model that increases control and optimizes the use of the rotating equipment.

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J.J. Stolk
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Summary

The commercial aviation industry is currently characterized by fierce competition between airlines. In order to compete in the contemporary airline industry, airlines need to focus on cost reductions and efficient operations. Within the airline industry, KLM is one of the main competitors. With a history of over 95 years, KLM is one of the main European providers of passenger air transportation. KLM operates with a focus on costs, safety and service. KLM provides the possibility for transportation via aircrafts in a network of destinations. From Amsterdam, KLM operates with flights towards Europe (EUR) and flights towards Intercontinental (ICA) destinations. KLM operates their network according to the hub-and-spoke network configuration. This means that they organize the configuration of their flights from the hub in Amsterdam. On a yearly base, KLM transports more than 26 million passengers. Since 2004, KLM is merged with Air-France and they operate a dual hub system with hubs in Amsterdam (KLM) and Paris (Air-France).

The main process criteria's at KLM focus on safety, costs and service. These process criteria focus on the aim of KLM to provide a service oriented and efficient product against optimized costs. Service for KLM means a broad network, convenient departure times, ground operations and services. The on-board service is organized by Cabin Inflight Management (CIM). CIM is responsible for all the different elements that are required to organize the on-board experience for the passengers. This concerns the cabin crew, inflight sales, catering and on-board entertainment. For the management of catering, the subject of research, different departments are required. The product department is responsible for the design of new products, meals and serving equipment for the different classes. The Inflight sales department manages in-flight sales and the Crew Products and operations department manages flight support, crew reporting desk and crew products. The Network and Supply Management (NSM) department is responsible for the planning and logistics of the CIM products.

A comprehensive distribution network, existing of different nodes, is used to distribute the articles and equipment towards the catering production nodes in the network nodes of KLM. An important network operator is KLM Catering Services (KCS). This is the subsidiary of KLM that is responsible for production of catering in the hub (KCS Production). The warehouse facility of KCS stores the products for the network in their warehouse (KCS-Warehouse). This warehouse is used to provide KCS-Production and the outstations with articles. KLM operates with 58 outstations in ICA destinations. These outstations produce catering in a production facility and use warehouses to store surpluses in equipment and replenishment from products. The replenishment of the OS-Production facilities is either managed via sea-freight from Amsterdam or via local suppliers that meet the KLM required quality standards. NSM-Planning is responsible to ensure, aside from the availability of the articles, the availability of the catering equipment. The responsibilities within NSM-Planning are distributed between area- and central planning. The area-planners are responsible to monitor the consumption of articles in the outstations. Based on the consumption, replenishment with articles is organized from Amsterdam. The other objective for the area-planners is to monitor the equipment inventories in the outstation warehouses. The responsibilities within central planning are to ensure availability of articles for KCS-Production in KCS-Warehouse.

The focus in this research is on the distribution of catering equipment. The catering equipment concerns standardized equipment to improve storage possibilities and to increase the efficiency of the transfer operations. The catering equipment can be categorized in serving equipment and loading equipment. The serving equipment concerns the items used to support the transfer between the galleys and the passenger (plates, dishes, cutlery). The loading equipment concerns the equipment to support transfers and the storage of equipment (trolleys, containers, oven racks) in either the aircraft or storage facilities. The reason for research is found in the shortages at the network production facilities that occurred in June 2014. The NSM-Planning department indicates that their current equipment distribution control model is insufficient to manage the distribution. Aside from the occurring shortages, the current control model lacks a complete overview of the network and there are few forecasting possibilities.

Analysis is applied to reflect on the current state of the equipment distribution within the network of KLM. The equipment distribution is identified as being subservient to the main production of KLM; the provision of the possibility for transportation between origins and destinations. The flow sizes of equipment depend on the timetable (amount of flights between origins and destinations), the allotment (loading profile per flight) and loading scenario. Each outstation is allowed to have the allotment of the biggest aircraft type in their station. The current regulation is that no spare equipment is allowed in the OS-Warehouse. Although this is regulated, the outstations show low compliance with this regulation. Analysis shows the low equipment efficiency in the distribution network. This is concluded based on the low inventory in KCS-Warehouse and the high inventories of spare stock in the OS-Warehouses. The effectiveness of the control operations is also lacking. There are unobserved subtractions and additions to the loop, the fleet size is unknown and the area planners lack insights in OS-Production inventory levels. Moreover, the boundaries for network inventories are not defined and a there is currently no central strategy to control the equipment distribution. Moreover, the collaboration between NSM-Planning and KCS shows signs for improvement. The analysis shows that the current control model is not supporting the KLM requirements to optimize the distribution on service, costs and safety. This leads to the conclusion that redesign of the control model is required.

The redesign of the new control model starts with the identification of the constrol structure. The identified structure is centralized for KCS and decentralized for the outstations. The boundaries for network operations are based on the strategy of NSM-Planning. To ensure service, the identification of a service level is required. The identified service level is 98% for the total loop and 99,9% for the active loop. Based on this service level, the efficiency ratios are identifeid. These efficiency ratios are input for the control model that calculates the boundary thresholds for the network nodes. These boundaries, minimum levels in KCS-Warehouse and maximum levels in OS-Production and OS-Warehouse, are input for the NSM Planners. The area-Planners manage these levels in the outstations while the central-planners manage these levels in KCS-Production. In addition to the thresholds, the monthly-expected equipment losses (based on the return rate) are allocated from KCS-Warehouse towards KCS-Produciton. NSM-Planning organises replenishment from suppliers based on the sais improved through targets that step by step increase efficiency, effectiveness and reduce costs.

The new control model is based on the implementation of barcode + RFID to measure the supply chain data. The data focuses on inventory level in outstations, return rate and inventory balance. The implementation of the technology increases the ability to collect reliable data in the network. In addition to the control model, different tools are designed to support the optimization of catering equipment distribution. The first tool concerns the maintenance plan to overcome the shrinkage of the fleet. Based on the measured return rate, the monthly-required equipment replenishment is calculated. The second tool concerns a forecasting tool that is able to forecast the expected inventory level in KCS-Production. Increased insights in this inventory will increase the control of NSM-Planning and reduce ad hoc required replenishment.

A quantitative case study is used to reflect on the quantitative impact of the control model on the current equipment distribution. The total control costs after 5 years are compared within this study: 1) Continue with the current scenario, 2) Implement the control model using the identified timeline. The total control costs for NSM-Planning for a period of 5 years are 2.989.597 euro if no further action is undertaken and the state of the distribution is not improved. The implementation of scenario 2 results in a total control costs of 2.399.060 euro after five years. The reduced costs are related to the increasing productivity of the equipment, increased automation and increased forecasting. Although additional research on the quantitive effects is required, the potential cost reductions are shown. These results are without the influence of the return rate. If the return rate is incorporated and improved, the total cost reductions increase even more. The implementation proposes the different required actions for implementation. The implementation is divided into a preparation phase, an implementation phase and a commitment phase. Per phase, different required actions are identified that focus on increasing the required commitment level for that specific phase. Bottlenecks for implementation focus on failing commitment by KCS, failing commitment by NSM-Planning, failing technology or insufficient planning.

Samenvatting

De hedendaagse commerciële luchtvaart industrie wordt gekenmerkt door hevige concurrentie tussen luchtvaartmaatschappijen. Om hun concurrentie positie te verbeteren, richten luchtvaartmaatschappijen zich steeds meer op kostenreductie en efficiënte bedrijfsvoering. Binnen de huidige luchtvaart is KLM een van de belangrijkste Europese aanbieders van wereldwijd passagiersvervoer. KLM biedt vluchten naar Europese (EUR) en Intercontinentale (ICA) bestemmingen. De vluchten worden aangeboden, op basis van de "hub-en-spoke" netwerk configuratie, vanuit hub Amsterdam. Op jaarbasis vervoert KLM meer dan 26 miljoen passagiers. Sinds 2004 is KLM gefuseerd met Air France en exploiteren zij samen een duaal-hub systeem met hubs in Amsterdam (KLM) en Parijs (Air France).

De proces criteria bij KLM richten zich op het doel van KLM om een service gericht, veilig en efficiënt product te leveren tegen optimale kosten. Service voor KLM betekent een breed aanbod van bestemmingen, comfortabele vertrektijden, betrouwbare grond operaties en beschikbaarheid van catering en artikelen aan boord. De service aan boord wordt georganiseerd door Cabin Inflight Management (CIM). CIM is verantwoordelijk voor alle verschillende elementen die nodig zijn om de ervaring aan boord voor de passagiers te organiseren. Dit betreft het cabinepersoneel, taxfree artikelen, entertainment en catering. Voor het beheer van de catering, het onderzoeksonderwerp, zijn verschillende afdelingen binnen CIM betrokken. De afdeling "Product" is verantwoordelijk voor het ontwerpen van nieuwe producten, maaltijden en benodigd equipment voor de verschillende klassen. De afdeling "Inflight Sales" beheert in-flight verkoop. De afdeling "Crew Products and operations" is verantwoordelijk voor de vlucht ondersteuning, het crew meldpunt en producten voor de bemanning. De afdeling "Network Supply Management" (NSM) is verantwoordelijk voor de planning van beschikbaarheid van CIM producten voor de productie locaties in het netwerk.

Een distributienetwerk, bestaande uit verschillende knooppunten, wordt gebruikt om de voorwerpen en equipment naar de catering productie knooppunten in het netwerk te transporteren. De belangrijkste netwerk knooppunt vallen onder KLM Catering Services (KCS). Dit is de dochteronderneming van KLM dat verantwoordelijk is voor de productie van catering in de hub (KCS-Productie). KCS slaat de producten voor het netwerk op in hun magazijn (KCS-Magazijn) en vanaf hier wordt het getransporteerd naar KCS-productie en de buitenstations. KLM werkt met 58 buitenstations in de ICA bestemmingen. Deze buitenstations produceren catering in een productielocatie en gebruiken magazijnen voor de opslag van productie artikelen en catering equipment. Het aanvullen van de productie faciliteiten wordt zowel via zeevracht vanuit Amsterdam of via lokale leveranciers die voldoen aan de vereiste KLM kwaliteitsnormen. NSM-Planning is verantwoordelijk voor de beschikbaarheid van de artikelen de beschikbaarheid van het catering equipment. De verantwoordelijkheden binnen NSM-Planning zijn verdeeld tussen centrale- en netwerk planning. De netwerk planners zijn verantwoordelijk voor het monitoren van het verbruik van artikelen in de buitenstations. Op basis van het verbruik wordt de belevering van nieuwe artikelen georganiseerd vanuit Amsterdam. De andere doelstelling voor de netwerk-planners is om de equipment voorraden in de buitenstation magazijnen controleren. De verantwoordelijkheden binnen de centrale planning zijn om de beschikbaarheid van artikelen voor KCS-Productie in KCS-Magazijn te garanderen.

De focus in dit onderzoek ligt op de verdeling van het catering equipment in het distributienetwerk van KLM. De catering equipment betreft gestandaardiseerde apparatuur om opslagmogelijkheden te verbeteren en de efficiëntie van het transport te vergroten. De catering equipment kan worden gecategoriseerd in service equipment en transport equipment. De "service" equipment betreft de items die worden gebruikt om de overdracht tussen de keukens in het vliegtuig en de passagier (borden, schalen, bestek) te faciliteren. Het "transport" equipment betreft het equipment (karretjes, containers, ovens) om het transport tussen vliegtuig keukens en netwerk locaties (productie en magazijn locaties) te ondersteunen. De reden voor het onderzoek is te vinden in de tekorten in de productie locaties die zich voordeden in juni 2014. De NSM-Planning afdeling geeft aan dat hun huidige besturingsmodel onvoldoende is om de distributie te beheren. Afgezien van de optredende tekorten, mist een compleet overzicht van het netwerk en is wordt niet gewerkt met een lange termijn planning.

De equipment stromen in het netwerk zijn afhankelijk van het tijdschema (hoeveelheid vluchten tussen herkomst en bestemming), het beladingsprogramma (per vlucht) en het beladingen scenario. Elk buitenstation is toegestaan om het beladingsprogramma van het grootste vliegtuigtype in hun station te hebben. De huidige regel is dat er geen reserve capaciteit is toegestaan in de magazijnen van het buitenstation. Echter tonen de buitenstations lage naleving van deze verordening. Ook is er momenteel geen prestatiemeting van de verdeling van equipment in het netwerk. Op basis van de KLM eisen service, veiligheid en kosten is een nieuw bedieningspaneel geconstrueerd. De geïdentificeerde parameters ondersteunen een efficiënte en effectieve verdeling in het netwerk. Hierbij wordt zowel de prestaties als de kosten gemeten. De analyse van de huidige verdeling laat zien dat de efficiëntie presentatie in het distributienetwerk laag is. Dit komt tot uiting in de lage voorraadniveaus in het KCS-Magazijn en de hoge voorraden in de magazijnen van de buitenstations. De doeltreffendheid van de controle ontbreekt tevens. Er zijn toevoegen en onttrekkingen aan de equipment stroom die niet geregistreerd worden, de omvang van de vloot is onbekend en de netwerk planners ontbreekt inzicht in de voorraadniveaus in de buitenstations. Bovendien zijn de maximale niveaus voor de equipment voorraden niet gedefinieerd en is er geen centrale strategie voor de verdeling van equipment. Daarnaast vereist de samenwerking tussen NSM-Planning en KCS verbetering. De conclusie is getrokken dat het huidige besturingsmodel niet de KLM-eisen van een distributie op service, kosten en veiligheid ondersteund. Dit bevestigt dat herontwerp van het controlemodel vereist is.

Het herontwerp van het besturingsmodel begint met de identificatie van de controle structuur. De geïdentificeerde structuur is gecentraliseerd voor KCS en decentrale controle voor de buitenstations. De begrenzing van de voorraad voor netwerk punten zijn gebaseerd op de service level strategie van de NSM-Planning. Het geïdentificeerde service level is 98% voor het KCS-Magazijn en 99,9 % voor de magazijnen in de buitenstations. Op basis van deze service niveau, zijn de efficiency ratio's berekend. Deze efficiency ratio's zijn input voor het sturingsmodel dat de bandbreedtes berekent voor de bestemmingen in het netwerk. Deze grenzen, minimale niveaus in het KCS-Magazijn en maximale niveaus in de buitenstations, zijn input voor de NSM planners. De netwerk planners beheren deze niveaus in de buitenstations en de centrale planners beheren deze niveaus in het KCS-Magazijn. In aanvulling op deze grenswaardes wordt het maandelijkse verwachte equipment verlies (op basis van het return percentage) aan de voorraad van KCS productie toegevoegd. NSM-Planning organiseert de levering van equipment door haar leveranciers op basis van hetzelfde return percentage. Met behulp van het controle model kan de efficiënte en effectieve verdeling van het equipment verbeterd worden en kunnen kosten naar beneden worden gebracht.

Het nieuwe controle model is gebaseerd op de invoering van barcode + RFID om de vereiste data in het distributie netwerk te meten. De gegevens richten zich op de voorraadniveau in de buitenstations, het return percentage en de balans van het equipment tussen KCS productie en het KCS-Magazijn. De implementatie van de technologie vergroot de mogelijkheid om betrouwbare gegevens in het netwerk te verzamelen. Naast het besturingsmodel zijn verschillende instrumenten ontworpen om de equipment verdeling en aansturing in het netwerk te ondersteunen. Dit betreft een onderhoudsplan om vlootkrimp te kunnen berekenen en een voorspellingsmodel voor de stroom door de productie van KCS. De verhoogde inzichten in deze aspecten zullen de controle van NSM-planning verbeteren en het aantal ad hoc acties naar beneden brengen.

Een kwantitatieve case studie laat de impact van het besturingsmodel op de totale beheerskosten na 5 jaar zien. De totale controle kosten na 5 jaar worden voor 2 scenario's met elkaar vergeleken: 1) 5 jaar equipment distributie volgends de huidige staat van de operatie 2) De invoering van het besturingsmodel een geïdentificeerde tijdlijn. De totale beheerskosten voor NSM-planning voor een periode van 5 jaar zijn €2.989.597 als er geen verdere actie wordt ondernomen en de toestand van de besturing niet verbeterd is. De invoering van scenario 2 resulteert in totale beheerskosten van €2.399.060 na vijf jaar. De lagere kosten hebben betrekking op het verhogen van de productiviteit van het equipment, automatisering, verhoogde lange termijn planning en vermindering van adhoc (en kostbare) acties. Hoewel er meer onderzoek naar de kwantitatieve effecten nodig is, worden de potentiële kostenbesparingen getoond. Als het return percentage wordt meegenomen en verbeterd, groeien de beoogde besparingen substantieel. Het implementatie plan stelt de verschillende benodigde acties voor de implementatie voor. Per fase zijn verschillende vereiste acties geïdentificeerd die zich richten op het verhogen van de benodigde draagvlak en de daarvoor benodigde activiteiten. Knelpunten voor de implementatie zijn een falend draagvlak in KCS en CIM, falende technologie en onvoldoende of onvolledige planning van de verschillende activiteiten.

Récapitulation

L’industrie contemporaine de l’aviation commerciale est caractérisée par une concurrence féroce entre les différentes entreprises aériennes. Afin de faire face à cette concurrence, les compagnies aériennes doivent se concentrer sur la réduction des coûts et l’amélioration de l’efficacité des opérations. Dans le secteur du transport aérien, KLM constitue un concurrent de taille . Elle représente un des principaux fournisseurs de transport aérien depuis plus de 95 ans. KLM opère en mettant l’accent sur trois axes, à savoir, les coûts, la sécurité et la qualité de service. KLM offre la possibilité de se déplacer par avions dans un réseau qui compte une panoplie de destinations. Depuis Amsterdam, KLM offre des vols vers l’Europe (EUR) mais aussi des vols vers des destinations intercontinentalles (ICA). KLM opère dans le réseau selon la configuration du réseau hub-and-spoke, ce qui signifie qu’elle planifie ses vols dans la platforme centrale en Amsterdam. Sur une base annuelle, KLM transporte plus de 26 millions de passagers. Depuis 2004, KLM a fusionné avec Air-France et depuis elle dispose donc de deux platformes , une à Amsterdam (KLM) et l’autre à Paris (Air France). KLM fait partie de l’alliance de Sky-Team.

L’objectif de KLM à travers leurs critères operationelles, c’est de fournir un produit, répondant aux normes de sécurité, orienté client tout en occasionnant un minimum de coût. Par sécurité ,KLM cherche à assurer des voyages sécurisés avec zéro accidents. Par bon service, KLM entend mettre à disposition des passagers un bon personnel sol ainsi qu’à bord de l’avion , des départs à l’heure et pleins de services aditionnels. Le service à bord est organisée par le personnel cabine Inflight Management (CIM) . Ce dernier assure tous les éléments nécessaires pour le bon déroulement du vol pour les passagers: Il s’agit de l’équipage de cabine, des ventes à bord des avions, de la restauration et du divertissement à bord. Pour assurer le management de la restauration, ce qui constitue un objet de recherches, on passe par différents départements: Le département “Product” qui est destiné à la conception de nouveaux produits, des repas et de couverts adaptés à chaque classe. Le département “Inflight Sales” offre des produits à vendre pendant le vol . Pour le département des opérations, il a un rôle de support de l’équipage et finalement le département de gestion des approvisionnement dans le réseau est responsable de la planification et de la logistique des produits de l’CIM.

Un réseau de distribution clair, composé de différents noeuds. La distribution des articles et des équipements se fait via ces noeuds dans le réseau de KLM. Ce réseau de noeuds est représenté par KLM Catering Services (KCS). C’est la branche de KLM qui assure la production de catering dans la centrale. Les produits sont stockés dans l’entropôt de KCS. Cet entrepôt founira les articles en cas de besoin KCS production ainsi que toutes les stations. KLM opère avec 58 stations appartenant aux destinations ICA. Ces stations produisent la restauration (catering) dans un lieu destiné à la production et utilise les entrepôts pour y mettre les suplus de production. La reconstitution des installations US-production est soit gérée par fret maritime d’Amsterdam ou par l’intermédiaire de fournisseurs locaux qui répondent aux normes de qualité nécéssaires pour KLM. NSM-planification est responsable de s’assurer de la disponibilité des produits ainsi que la disponibilité du matériel de restauration. Les planificateurs zones sont responsables de surveiller la consommation d’articles dans les stations figurant dans le réseau . Basé sur la consommation, le réapprovisionnement des articles est organisé en Amsterdam. L’autre objectif des planificateurs zones est de surveiller les stocks de matériel dans les entrepôts de chaque zone. Alors que la planification centrale est responsable d’assurer la disponibilité des articles produits par KCS-production et mis en KCS-Entrepôt de chaque zone.

L’accent dans cette recherche est mis sur la distribution du matériel de la restauration. Le but c’est d’améliorer la disponabilite et a reduire les couts des operations. Le matériel de restauration peut être classé en équipement de service ou en matériel de chargement. L’équipement de service est utilisé pour assurer le ravitaillement du passager (assiettes, plats, couverts). L’équipement de chargement est tout ce qui permet de transférer et stocker les matériaux (chariots, les conteneurs, les grilles du four) que ce soit dans les avions ou dans les entrepôts. La raison essentielle pour cette recherche est les pénuries des installations de production qui ont eu lieu en Juin 2014 dans le réseau . Ca siginife que le modèle de contrôle de la distribution du matériel actuel est insuffisant pour gérer la distribution. En plus des pénuries de matériel, le modèle de commande actuel manque de visibilité complète du réseau, ce qui induit la difficulté à faire des prévisions.

L'analyse va nous amener à réfléchir sur l'état actuel de la distribution de matériel au sein du réseau de KLM. L'importance des flux dépend du planning (nombre de vols entre origines et destinations), le matériel attribué (profil de chargement par vol) et le scénario de chargement. Chaque station peut avoir une attribution de matériel suffisante pour le plus grand type d'avion dans la station en question. La réglementation actuelle stipule qu'aucun équipement de réserve n'est autorisé dans l'entrepôt OS. Bien que celà est réglementé, les fourniseurs ne respectent pas tous cette régle. Il n'existe actuellement aucune moyen de mesure de la performance de la distribution. En se basant sur les exigences de KLM, la sécurité et les coûts, un nouveau panneau de commande est construit. Les paramètres identifiés jouent le rôle de support pour les opérations afin de les rendre plus efficaces et plus efficientes. Ce panneau permet de mesurer , à la fois la performance et les coûts. L'analyse de la distribution actuelle montre que l'efficacité de l'équipement est faible dans le réseau de distribution. Les opérations de contrôle ne sont pas efficaces. Il y a soustractions non observées et des ajouts arbitraires, la taille de la flotte est inconnue et les planificateurs zones n'ont pas un aperçu des niveaux des stocks dans les entrepôts OS. De plus, les limites pour faire les inventaires des équipements dans le réseau ne sont pas définies et il n'existe pas actuellement de stratégie centrale pour contrôler la distribution de l'équipement. Cependant, la collaboration entre NSM planification et KCS montre des signes d'amélioration. Le modèle de contrôle actuel ne soutient pas les exigences KLM pour optimiser la distribution en terme de services, de coûts et de sécurité donc c'est nécéssaire de reconcevoir le modèle de commande.

La conception d'un nouveau modèle de contrôle commence par l'identification de la structure de commande. La structure identifiée est centralisée pour KCS et décentralisée pour les stations. La limite pour les opérations du réseau est essentiellement la stratégie du NSM-Planning. Pour assurer la disponibilite des materiaux, l'identification du niveau de service est obligatoire. Le niveau de service identifié est 98% pour les entrepots dans le reseau et 99,9% pour KCS-Warehouse. Sur la base du niveau de service, les ratios d'efficacité sont calculés. Ces ratios de rendement sont des entrées pour le modèle de commande qui calcule les limites des noeuds existants dans le réseau. Ces limites, les niveaux minimum des entrepôts KCS et les niveaux maximum pour l'entrepôt OS et la production OS, sont communiqués à la NSM-Planning. Les planneurs des zones gèrent les niveaux des stations, alors que les planneurs dans la centrale gèrent au niveau de KCS-Production. En utilisant ce modèle de contrôle, le processus de distribution de l'équipement peut être optimisé par rapport à l'objectif, petit à petit il y aura augmentation de l'efficacité. Le nouveau modèle de contrôle est basé sur la mise en œuvre d'un code à barres + RFID pour mesurer les données de la chaîne d'approvisionnement. Les données sont essentiellement des données sur les stocks dans les escales, sur le taux de retour et le solde des stocks. L'utilisation de la technologie augmente la capacité de collecter des données fiables dans le réseau. En plus du modèle de contrôle, il y a différents outils qui ont été conçus comme support pour l'optimisation de la distribution du matériel de restauration. Le premier outil est le plan de maintenance qui sert à garder la flotte intacte. En se basant sur le taux de retour calculé, la reconstitution de l'équipement mensuel requis est définie. Le deuxième outil constitut un outil de prévision qui permet de prévoir le niveau des stocks attendu en KCS-Production. Des connaissances accrues relative au état de stock permettra d'augmenter le contrôle de NSM planification et donc de réduire l'approvisionnement ponctuel arbitraire.

Une étude de cas quantitative permet de réfléchir sur l'impact quantitatif du modèle de contrôle sur la distribution de l'équipement actuel. On compare les coûts totaux de contrôle après cinq années dans cette étude selons deux scéarios possibles: 1) Continuer avec le scénario actuel, 2) Mettre en œuvre le modèle de contrôle en utilisant un calendrier bien déterminé. Les coûts totaux de contrôle pour NSM-planification pour une période de cinq années s'élèvent €2.989.597 si aucune action n'est entreprise et la qualité de la distribution ne s'améliore pas. La mise en œuvre du scénario 2 aura un coût total de contrôle de €2.399.060 après cinq ans. La réduction de coûts est liée à l'augmentation de la productivité de l'équipement, à plus d'automatisation et une meilleure visibilité vu qu'on a des prévisions. Bien que des recherches supplémentaires sur l'impact quantitatifs sont nécessaires, les possibilités de réductions de coûts potentielles ont été démontrées. Ces résultats ne tiennent pas compte du taux de retour. Si en plus il est amélioré, les coûts augmenteront encore plus. Différents plans d'action nécessaires pour la mise en œuvre du scénario. La mise en oeuvre est divisé en une phase de préparation, une phase de mise en oeuvre et une phase d'engagement. Par phase, différentes actions identifiées sont nécessaires et qui souligne l'importance de l'augmentation du niveau d'engagement requis pour cette phase spécifique. Les points d'amélioration pour la mise en œuvre sont l'amlélioration des faiblesses en terme d'engagement de KCS, des faiblesses d'engagement de NSM et CIM, utiliser plus la technologie et instaurer un système de splanification .

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Introduction to the research

This chapter provides the introduction to the research environment. The first section reflects the introduction to KLM. This introduction provides a brief reflection on KLM together with its mission and vision. The second section reflects the introduction to the topic: the Inflight equipment distribution within the network of KLM. The last section introduces the structure of the report.

1.1. Introduction to KLM

Introduction to KLM

The "Koninklijke Luchtvaart Maatschappij" (KLM) is the flag carrier airline of the Netherlands. KLM is founded in 1919 and is the oldest, still operating airline in the world. It serves over 130 destinations worldwide using the KLM fleet. These destinations are either European (EUR) or Intercontinental (ICA) destinations. KLM operates their network using a hub-and-spoke network configuration with a hub at Amsterdam Schiphol Airport. Through code-share agreements with other airlines, it is possible to reach over 662 destinations via KLM. KLM transports annualy over 26.6 million passengers, whereby 75% are transfer passengers. The average passenger load factor of the operation is 85,3 percent and the passenger business transport revenues are €6,869 billion [6].

In 2004, KLM merged with Air France. Both airlines retain their own brands and operate from two hubs; KLM at Schiphol Amsterdam Airport and Air-France from Paris-Charles de Gaulle Airport. With the creation of the Air France - KLM holding, the world's lagest airline group was created. Both KLM and Air France are part of the SkyTeam Alliance. The KLM group operates with several subsidiairs and associated airlines. Subsidiaries focus on portfolio brands (KLM Cityhopper, KLM Cityhopper UK, Martinair, Transavia.com, KLM Asia, Kenya Airways), other transport modes (High speed Alliance), support departments (KLM Catering Servies, KLM Equipment services, KLM financial services, KLM Health services, KLM UK egineering) [7].

Mission

With Air France, KLM is at the forefront of the European airline industry. Offering reliability and a healthy dose of Dutch pragmatism, 32,000 KLM employees work to provide innovative products for our customers and a safe, efficient, service-oriented operation with a proactive focus on sustainability. KLM strives to achieve profitable growth that contributes to both its own corporate aims and to economic and social development. KLM works to create sustainable growth at Schiphol, to gain access to any market that will increase the quality its network and to maintain a level playing field for all industry players. It also works to ensure a balance between the company's interests and those of the people living and working close to the airport [8].

Vision

KLM wants to be at the front of the industry by being smarter than the rest. By merging with Air France KLM has come to occupy a leading position in the international airline industry. KLM wants to be the customers' first choice, to be an attractive employer for its staff and, a company that grows profitably for its shareholders. With smart partnerships and pioneering new destinations, KLM offers global access through its extensive network. By responding to market opportunities and technological developments, KLM offers customers a contemporary produc [8].

1.2. CONTEXT OF THE RESEARCH

The mision and vision of KLM shape the context of the research. It is important to add additional remarks on the current context at KLM. KLM operates within a very competitive field. This current field of competitors is characterized by a strong competition on price. Both for the European (EUR) flight as for the flights towards Intercontinental (ICA) destinations, there are many competitors. The competition in Europe exists of low-cost carriers like EasyJet and Ryan Air (operating with point to point flights) and traditional flag carrier competitors like Lufthansa and British Airways. For the ICA destinations, there is a strong competition with "Gulf-carriers" like Etihad, Qatar Air, Emirates [9]. In order to participate in this field of competitors, KLM needs to reduce costs to be able to provide low fare prices with sufficient margins. To reduce costs, KLM implemented the perform 2015 cost program and realized a cost reduction of over €700 million. In february 2015, perform 2020 is started with a foreseen total cost reduction of another €700 million. The current financial results (€535 million loss in 2014) and a debt of €5,4 billion shows the urgence of structural improvements [8].

This research focuses on the optimization of the current catering equipment distribution in the network of KLM. The distribution of inflight articles is applied through the use of catering equipment. The catering equipment is categorized between service and loading equipment. The control model aims to optimze the performance on the three operational KLM performance categories cost, safety and service [8]. The optimized distribution of the catering equipment is foreseen to increase the service and to result in reduced costs. The reduced cost contribute to the Perform 2020 program targets, increase the financial health of KLM and increase its competitiveness in the current airline industry.

1.3. STRUCTURE OF THE REPORT

The thesis exists of 8 chapters. This first chapter introduces the main introduction and structure of the report. The second chapter provides an introduction to the environment of KLM, inflight articles, catering equipment and the distribution network. The third chapter provides analysis on the current equipment distribution, the current control model and identifies the problem statement. The fourth chapter introduces the solutions to the identified problems. The fifth chapter provides the design of the new control model. This design concurns both the system structure, the different tasks and tools for the specific departments as well the governance of the system. The sixth chapter reflects the cost savings, calculated by the quantitative case study, through the implementation of the new control model. The seventh chapter provides the implementation program. This implementation program, based on the commitment model [5] proposes different tasks in different phases of the implementation. The eight chapter provides the conclusions of the research and recommendations for further studies.

Figure 1.1: The loading of catering equipment by KCS operators (Source:klm.com)

2

The Inflight catering equipment at KLM

This chapter provides an introduction to the research environment: the Inflight catering equipment distribution at KLM. The first chapter discusses the different drivers and categorizations for equipment. The second chapter elaborates on the distribution network. The third chapter discusses the current parties and stakeholder involved for equipment management within KLM. The fourth paragraph discusses the foreseen introduction of new equipment because of the implementation of the new Boeing 787 Dreamliner aircrafts. The descriptions are based on industry standards, different sources (literature, interviews) and observations on the current equipment distribution at KLM.

2.1. The introduction to inflight equipment

The explanation of the use of Inflight equipment starts with the distribution and use of inflight articles on board of commercial aircrafts of KLM. The use of inflight articles is based on the service programs provided on board of the flight. At KLM, there are different service programs based on destination and class. Each level has its specific program involving seats, check in program, additional products, meal programs and choice of drinks. The different service levels are based on the following segments:

- European destinations, Economy Class (EUR-M)
- European destinations, Business Class (EBC)
- Intercontinental destinations, Economy Class (ICA-M)
- Intercontinental destinations, Business Class (WBC)

The mealprograms, the drink choices and on-board articles are part of the inflight articles. The inflight articles concern all the articles loaded on-board to use during the flight. The articles used are either for consumption (food, drinks, snacks, icecubes), entertainment (headphones, newspapers), shopping (Tax-free articles), convenience (information on the airline, aircraft, escape instructions), Customs (VISA), health information (ebola formulas) or comfort (towels, pillows). Within the supply chain concerned to supply articles towards and away from the plane, there are many transfers and intermediate storages involved. Standardized equipment is used to smoothen the distribution and to enable an easy and cost-effective application of equipment. The standardization of catering equipment started, according to Flight-International (1989) with the introduction of the first Boeing 747-200. The first major clients for this commercial aircraft decided to collaborate on an industry standard for inflight equipment. The first standard (KSSU) is developed through KLM, SAS, Swiss Air and UTA Airlines. In 1974, the alliance between Air France, Alitalia, Lufthansa/Condor, Sabena and Iberia (ATLAS) was founded as an alternative for KSSU. Since airframers aim to increase standards in layouts, the contemporary airline industry offers only ATLAS standard galleys (the prevalent galley standard utilized on over 80% of the world's commercial aircraft fleet) on the Airbus 350 and Boeing 787. The influence of this decision is discussed in chapter 2.4. The next chapter discusses the application of the inflight equipment.

The categories of Inflight equipment At KLM, the current type of equipment is based on the KSSU standard. This means that the trolley used are according to the KSSU definition, certification and measurements and that the additional equipment (placed on- or inside the trolleys) is also based on these required measurements. The categorization in catering equipment is made between "loading" equipment and "serving" equipment. The loading equipment is used for the transportation, storage and preparation of articles on board. The loading equipment exists of trolleys (in different sizes), ovens, ovenskits, containers, trays and inserts used for different purposed and types of content. Serving equipment is used to provide a transfer tool from the loading equipment to the passenger and/or to consume the articles. The serving equipment exists of bekers, cans, trays, cutlery and dishes. Often, the serving equipment is customized in the themes of the airline. Airlines hire famous designers to design the serving equipment. In the case of KLM, designer Marcel Wanders designed both the look of the serving- and the loading equipment for WBC. This is done to increase the on-board experience of the customer.

Different types of applications of Inflight equipment The different types of catering equipment are used for specific purposes. The categorization is already made between serving- and loading equipment. However, it is possible to make another categorization based on the functional application; for the distribution of articles and for the preparation of food.

The first application is for the distribution of articles. The distribution of articles is either between the passengers and the galley or between the galley and the different network nodes outside the commercial aircraft. The article distribution on larger distances (for example between aircraft and catering production facility) is organized with trolleys and containers. The trolley types in the current operation are halfsize and fullsize trolleys for M-Class and WBC. The containers currently operated are square and standard containers. Often, the "complete" transport unit is an assembly of a trolley, a drawer, trays and additional serving equipment. The second application is for the preparation of food. For the food preparation, there are different types of loading equipment (ovensracks and oven inserts). The galley has a specific oven unit that takes care of the heating of the food. The galley itself provides functional compartments to place equipment, storage for items and space to prepare food. Based on the aircraft type, there is either a central galley or decentralised galleys. The galleys in the KLM aircrafts of the current ICA-fleet are constructed with the measurements of the KSSU standard.

The current equipment types used at KLM is categorized in a matrix with the categories and the application of equipment; The loading equipment for article distribution concerns the (Halfsize and Fullsize) trolleys, the containers drawers and glassracks. The average value of the loading equipment in this category is €116,50 per item. The average value of the serving equipment is €1,64 per item. The most specific designed equipment is the serving equipment used for article distribution for the WBC. Most of the equipment used for M-Class is not rotable and therefore thrown away after each flight. In the M-class, only the trays are rotable. Most of the equipment is used for article distribution; only a small part of the equipment is used specifically for food preparation. The most critical items are the oven racks and skids. According to NSM-Planning manager Doze (2014), there is alternative equipment for all of the serving equipment items and for most of the loading equipment. However, there is no alternative for the ovenracks and skids. Therefore, oven racks and skids are obliged to be loaded on each ICA flight.

2.2. THE INTRODUCTION TO THE CATERING DISTRIBUTION NETWORK

This section introduces the catering distribution network at KLM. The representation of the current network is provided in figure 2.1. The catering equipment distribution network discusses the catering distribution between the ICA destinations, the facilities of KCS, the reparation facility and the supplier. The different distribution modes are either an aircraft, sea-cargo or trucks.

Within the distribution network, two sub-distributions are identified; the total equipment loop and the active equipment loop. The total equipment loop describes the equipment flows between nodes that have equipment either used or available to be used. This described the distribution between the warehouses and the production facilities (both for KCS and the outstations). The active loop described the flows and the network nodes with equipment within the total equipment loop but outside KCS-Warehouse. This distribution is made since KCS-Warehouse stores the spare equipment capacity for the whole network. This distribution enables further analysis of the equipment effectiveness and efficiency in chapter 3. The paragraph below elaborate the features outside the network ndoes: outstation logistics and the nodes for reparation and suppliers. The following sections (2.2.2 and 2.2.1) elaborate the descriptions of the specific network nodes.

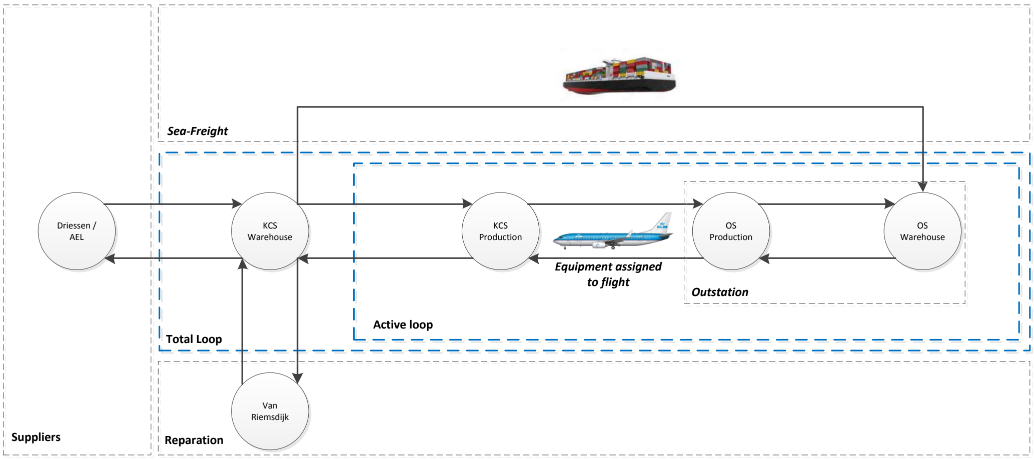


Figure 2.1: The equipment distribution network at KLM (Source: Own Production based on analysis)

OUTSTATION LOGISTICS

Outstation logistics are required to provide the outstations with catering articles and equipment. This is required during steady state operations (only catering articles) or when a new station is opened (both catering articles and equipment). These logistics towards the outstations are operated using sea-freight. KLM uses of a third party logistics (3pl) provider and a fourth party logistics provides (4pl). A 3pl operator is a firm that provides services to its customers focusing on the outsourcing of the logistic services for part or all of their supply chain management functions. Third party logistics providers typically specialize in integrated operation; warehousing and transportation services scaled and customized to customers' needs based on market conditions and the demand and delivery service requirements for their products and materials. The current 3pl operator at KLM is "Kuhne and Nagel". Kuhne and Nagel have integrated the supply chain from KCS-Production towards the outstations. Since October 2014, KLM has assigned the company SkyLogistiX as a 4pl company [3]. A fourth party logistics provider has no own transport assets or warehouse capacity. They have an allocative and integration function within a supply chain with the aim of increasing the efficiency. SkyLogistiX is a joint venture between Kuhne and Nagel and catering operator LSG Skychefs. KLM hired SkyLogistiX to improve the management of the supply chain around the distribution of catering equipment. SkylogistiX is currently working on a business case for the implementation of Radio Frequency Identificaiton (RFID) tracking for catering equipment. An introduction of this case is provided in chapter 2.4.

REPARATION AND SUPPLIERS

The additional nodes reflect on the suppliers of equipment and the reparation facility. The suppliers of equipment provide replenishment for equipment. There are two suppliers for equipment: Driessen and AEL. The replenished equipment is either bought or leased. The reparation facility (called van Riemsdijk or abbreviated VRR), is the company that takes care of the reparation of the equipment. The equipment (either broken on board or at KCS-Production) is labeled by the crew or KCS operators and transported to the KCS-Warehouse. From the KCS-Warehouse, there is a transport twice a week to VRR. At VRR, the equipment is either repaired or a decision is made that the equipment is scrapped. The scrap-decision means that the equipment is demolished. The stocks at van Riemsdijk are administrated in the ERP system SAP.

2.2.1. THE TOTAL EQUIPMENT LOOP

The total loop exists of all the nodes where equipment is either used (production nodes/aircraft) or ready to be used (in the warehouses). Within the total loop, the distribution is made between KCS-Warehouse and the active loop. This distribution enables to reflect on the required capacity (active loop) and the spare equipment capacity for the whole active distribution network.

THE NETWORK WAREHOUSE IN AMSTERDAM

The function of the KCS-Warehouse is to store the spare equipment of for the network. The warehouse is operated by KCS (KCS-Warehouse) is responsible for the storage of food, drinks, equipment and additional articles for KLM. The KCS-Warehouse receives their articles from a selection of suppliers. KCS-Warehouse stores the products and sends them, if required, to the KCS-Production facility. They also send products to the outstations using sea-cargo. The ground of KCS warehouse has a specific customs status and is declared international ground. Therefore, comprehensive documentation is required but the operation is exempted from import- and export taxes. The warehouse operators run the KCS-Warehouse. However, the organization of the storage, the forecasting and the ordering of replenishment is organized by NSM-Planning. Section 2.3 elaborates on NSM-Planning. Figure 2.2 shows the flow diagram of a warehouse. The input of the warehouse is a combination of the surplus of the inventory in KCS-Production and the deliveries from suppliers. The output is the flow towards KCS-Warehouse and the outstations.

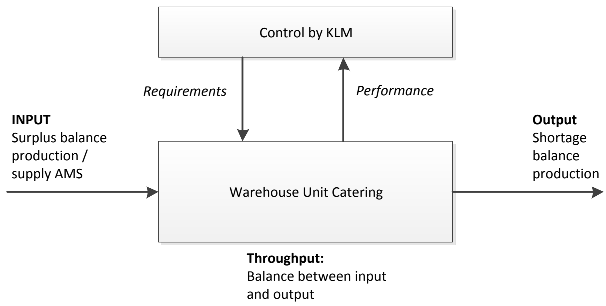


Figure 2.2: Flowchart warehouse node (Source: Own production)

2.2.2. THE ACTIVE EQUIPMENT LOOP

The active loop exists of the flows and inventories within the network nodes within the total loop but outside KCS-Warehouse. It represents the equipment distribution between KCS-Production and the outstations via the aircrafts. This active loop exists of the network nodes KCS-Production, the Outstation-Production facility and the Outstation-storage facility. The different nodes are discussed below.

THE AIRCRAFT

The aircraft is the transport mode between the origin and destination airports. The equipment is brought on-board directly from KCS-Production and stored in the galleys. During the flight, based on a standardized scheme, the equipment is used to distribute the catering and articles. When the aircraft lands, all the serving equipment and articles are stored in the loading equipment and taken off-board. The outstation catering facility prepares a new set of articles (according to the allotment) and replenishes the aircraft during the turn-around time (the time at the destination between arrival and departure). There are also catering articles replenished on board by the catering facility. Given this replenishment protocol, it is required to have a complete allotment set in the outstation-production facility already preperaed. The used set of the arriving flight is pushed into the production location. This set is used to prepare the next arriving flight. In this way, the "sets" (with the allotment configuration) rotate in the network between Amsterdam and the destinations. At the ICA destinations without caterer, only passengers exit and enter the aircraft.

KLM CATERING SERVICES PRODUCTION

The production facility of KCS (defined as KCS-Production) is the central node in the catering distribution network at KLM because it produces all the meals for the KLM-hub in Amsterdam (350.000 meals on a weekly base for all the outbound flights of KLM). The operations for the production are seperated between the EUR-destinations and the ICA-destinations. KCS-Production is directly located at the Schiphol platform and receives equipment straight from inbound flights. KCS-Production is supplied with articles/food from the KCS-Warehouse. Once production is finished, there is direct replenishment from KCS-Production towards the outbound flight. In terms of monitoring, KCS-Production is the hub that covers all the active logistics flows of loading equipment within the loop with the outstations. Therefore, it is the ideal location to monitor the characteristics of the flow [1]. However, there is currently no tracking or active management/forecasting of equipment in KCS-Production. Figure 2.3 shows the flow diagram of a production facility. The input is based on the timetable and the allotment per flight. The same accounts for the output. The throughput is based on the balance between input and output. There are days with more input than output, this results in an increasing inventory level. The KCS-Production facility is a subsidairy of KLM but operates independently.

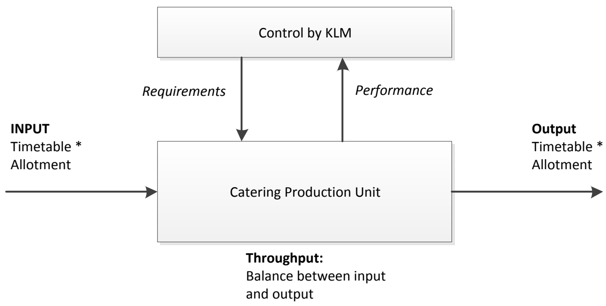


Figure 2.3: Flowchart production node (Source: Own production)

THE OUTSTATIONS

KLM operates currently a network with 68 ICA destinations. Depending on the configuration of the route, it is decided whether or not the destination is required to have a production facility for catering. There are three types of routing configuration; directly, round flight (2 destinations; each once visited) or subloop (2 destinations, 1 destinations is twice visited). An example is the choice for a catering in Colombia. The flight is configurated from Amsterdam to Bogota, Cali and back to Amsterdam (AMS-BOG-CLO-AMS). The catering is provided in Bogota. From the 68 ICA destinations, replenishment is provided in 58 destinations. In all of these 58 destination, a catering providing company operates a production facility (OS-Production) and a warehouse facility (OS-Warehouse). The following subsections discuss the two types of facilities.

OS-Production The outstation production facility produces catering for the homebound KLM flights. To ensure a short turn around time, the equipment of the arriving flight is replaced by a complete set prepared in the production facility. The equipment they use is for production is from the previous arriving flight. This set is used to prepare the next flight. The products used for production are either replenished from Amsterdam (by either air-cargo/sea-transport or delivered by cocal suppliers that meet the required quality standards of KLM. The operations at the outstation-catering operator are comparable with the KCS-Production operations. The catering supplier is either a local player or global brand (like Gate Gourmet or LSG Skyschef). The inventory in the OS-Production facility is referred to as "working" stock. The inventory is not monitored in the ERP system SAP.

OS-Warehouse The warehouse of the outstation catering supplier is used to store additional equipment and stock. The function is a decoupling of the logistics stream between KCS-Warehouse and the OS-Production facility. The equipment stocks in the catering warehouse are called ‘store stock’ and are tracked in the ERP system. The catering operator is obliged to mangage the distribution between working and storestock and to book the overcapacity in working stock towards the ’store’ stock in SAP. The inventory in the OS-warehouse facility is referred to as "working" stock. The inventory is monitored in the ERP system SAP.

2.3. THE MANAGEMENT AND MONITORING OF EQUIPMENT AT KLM

This section reflects on the different aspects of the management of equipment at KLM. Within KLM, KLM Inflight Services (KIS) is responsible for all the activities concerned for the inflight articles. The main strategy at KLM Inflight Services is to focus on maximum consumer experience for the passengers of KLM. This focuses on the configuration of the different products and services, the quality and the availability on board. KIS exists of the following two departments: KLM Catering Service (KCS) and Cabin Inflight Management (CIM). KCS is responsible for the storage and assembly of the cabin load for KLM flights as introduced in the previous sections. Cabin Inflight Management (CIM) is responsible for the management and organization of the cabin articles and catering.

CIM, as part of KIS, is responsible for the management, design, replenishment and planning of Inflight articles and crew. It exists of the following four department: 1) Product management is responsible for the design of new products, meals and serving equipment for the different classes. 2) Inflight sales is responsible for the management and planning of producs for in-flight sales and sales through the website delivered on board. 3) Crew Products and operations is responsible for flight support, crew reporting desk and crew products. 4) Network and Supply Management (NSM) is responsible for planning and logistics for CIM products. NSM exists of the following 6 departments; 1) Project management is responsible for multi-disciplinairy supply chain projects 2) Supply Chain specialists are responsible for (small) supply chain improvement projects 3) Loading and ordering is responsible for the design of loading profiles (an example is provided in figure 2.4). 4) Customs and distribution is responsible for customs clearance of products and sending of products to outstations 5) Contract management is responsible for the monitoring of the performance of the catering at the outstations 6) Planning is responsible for the planning and organization of replenishment to the network nodes (warehouses).

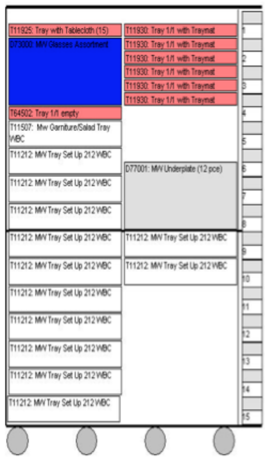


Figure 2.4: Example of a trolley configurations (Source: KLM Loading and Ordering)

NSM Planning Planning, as part of NSM, exists of two departments: 1) area-planning and central-planning. Area-planning is responsible for the planning, replenishment and ordering of products for the outstation catering production facilities. The area planners are also responsible for the planning of shipments for short-term replenishment with products to outstations. The central-planning is responsible for the planning, replenishment and ordering of products delivered to the KCS-Warehouse. They are also responsible for the planning, replenishment and forecasting of catering equipment and they have the final responsibility for the availability of spare equipment. The two collaborate with eachother on the management of the availability of equipment. For equipment management, the area planner should observe the stock levels in the warehouses in the outstations. The central planner is required to maintain a (minimum) stocklevel in KCS-Warehouse to provide sufficient capacity for KCS to issue. Area- and central-planning are required to balance the equipment through active allocation from the nodes with excess stocks to the nodes with demand.

The monitoring and ICT infrastructure Different monitoring and ICT systems are used to manage the operations in the different locations. Specific departments at CIM use these systems. NSM manager Joosten (2014) indicates that the current ICT structure is very complex. This is something that makes the current CIM organization slow moving. The system "SAP SE" (to be referred to as SAP) is used as the common ERP-system within CIM and KCS warehouse and is used by the NSM-Planning department. NSM planning uses SAP for the planning, replenishment and automatic ordering of products. SAP contains information about food, drinks and equipment (measurements, weight, value). SAP stores information about stock, safety stock, consumption rate, characteristics about equipment, weight and suppliers. As described, there is only partly registration of inventories in the network nodes. The oustations use a web-based portal to communicate with SAP. The outstation operators are required to registrate through the portal what they take out of the warehouses. Based on this consumption pattern, the area-planners forecast replenishment.

The program "Space" is used by loading and ordering department to create the PSU loading profile of equipment based on the decisions made by de CIM product department. The program creates a loading profile per aircraft type to ensure the weight is equally distributed. This loading profile is input for the program "BAAN". Baan is the ERP-system used at KCS-Production. BAAN is comparable to SAP and they are partly connected. BAAN generates the specific loading profiles for the different flights. Based on these 'tickets' the different departments within KCS-Production prepare the loading of the equipment. 24 hours before departure, BAAN generates the loading profile based on a forecast on the expected amount of passengers. The program "Samos" is currently used as a database to provide the data to KCS-Production on the passenger numbers. Based on the passenger numbers, KCS-Production is increasingly testing with projects to adjust loading profiles based on updates on passenger numbers rather than PSU. However, this is currently only focussing on drinks and meals and not on equipment.

2.4. THE INTRODUCTION OF NEW CATERING EQUIPMENT

Within KLM, different aspects of the catering equipment environment are changing. Starting from October 2015, the current "KSSU" standard equipment is replaced by "ATLAS" equipment. KLM has decided, in order to improve the efficiency and to increase the fleetsize, to implement 25 new Boeing 787 Dreamliner aircrafts. The new Dreamliners are equiped with galleys designed for equipment built according to the ATLAS standard. The ATLAS equipment is standard for the Airline industry. In the contemporary airline industry, only KLM and a couple of other airlines still use equipment with the KSSU standard. Therefore, together with the implementation of the Boeing 787 Dreamliner, CIS has decided to switch the current catering equipment towards ATLAS. Therefore, all the galleys in the ICA aircrafts (Airbus 330-200, Airbus 330-300, Boeing 777-200, Boeing 777-300, Boeing 747) are reconstructed to the new ATLAS measurements.

SkyLogistiX is currently working on the development of a business case for the implementation of a system that can monitor the movements of catering equipment through the logistics chain using RFID. If KLM makes its choice to use RFID for their new equipment, it is according to the system design of SkyLogistiX. Their proposal is to equip all the ATLAS trolleys with a barcode and a RFID tag [3]. These two measures ensure the probability for the scanning of the equipment (also if either one of the two systems is not working correctly). The scenario elaborates that KCS-Production facility is equiped with antennas to track in- and outgoing streams of trolleys. As soon as the equipment exits the hub, it is assigned to the outstation. As soon as it enters the hub again, the equipment is booked back from the outstation back to the KCS catering station. According to Joosten (2014), there is currently no user-scenario or system design identified for the use of RFID. The benefits are still unknown and no financial businesscase has been made.

2.5. OBSERVED CHALLENGES WITHIN THE EQUIPMENT DISTRIBUTION

This chapter elaborates on the different problems observed within the current distribution of loading equipment by NSM-planning manager Doze (2014), KCS-planning manager Buijs (2014), central-planner Stroobach (2014) and area-planner Tempels (2014). The following observations for the current problems for equipment distribution are made:

- Strategy for equipment management - Currently, there is no strategy defined for equipment management. There are no measurements recorded on efficiency or effectiveness parameters in the network. Moreover, there is no short- or long-term strategy concerning the equipment. Because of this lacking strategy, it is hard to define the right boundaries for the network nodes to operate in. NSM-Planning manager Doze (2014) indicates that this reduces the ability for tailored management and focus on cost reduction.

- Inventory management - In the current set-up of the equipment control, the visiblity of equipment is not sufficient since only the warehouses are tracked with the ERP-system SAP, the production locations are not visibile for the area-planners. The area-planners have no insight in the inventory levels in the OS-Production facilities. Area-planners Tempels (2014), Roos (2014) and Bakema (2014) confirm that with lacking information on inventories, it is hard to apply sufficient control of the inventories.

- Outstation compliance - The outstations have low compliance with the regulations proposed by the NSM Area-planners and NSM Contract management. Contract manager Schoenmakers (2014) indicates that it is difficult to increase the reliability. The NSM departments applies control from a big distance to outstations in different time zones, cultures and languages. NSM-Planning manager Doze (2014) indicates that most of the outstations currently have excess stocks of equipment.

- Unclear operational boundaries - In the current inventory control model, there are little standard levels defined for the equipment in the network nodes. The lack of standard levels and standardized regulations for the control of equipment in the network nodes results in shortages in KCS-Production and KCS-Warehouse. Moreover, area planner Tempels (2014) indicates that part of the outstation-warehouses have big inventories of equipment. The unclear boundaries concern also the functional boundaries within the distribution network. There are different unclear boundaries between KCS- and NSM-planning. This results in confusion between the departments.

The next chapter focuses on the actual analysis of the equipment distribution. The analysis, according to the DSA principles, focuses on the different states of the operations, both on the flow sizes as the different control operation within NSM-Planning and the network nodes. The next chapter concludes with the problem statement.

3
System analysis and problem statement

This chapter elaborates the analysis of the current equipment distribution system and concludes with the problem statement. The first section elaborates on the methodolgy used for analysis. The second section reflects on the main operations at KLM. Hereby is the focus on the realization of the product (the possibility for transportation between origin and destination combinations). Section two reflects also on the subservient role of equipment. Section three reflects on the current control in the network. Section four performs analysis on the current state of the distribution. The conclusion focuses on the current problems statement for equipment distribution control in the current KLM network.

3.1. Methodology used for Analysis

The current environment at KLM is observed to be a system, therefore system analysis is required to describe the current environment at KLM and measure its performance. Different approaches are proposed to perform the system analysis. Firstly, a SWOT analysis proposes an analysis approach. This method is often used to perform an analysis to identify the strengths and weaknesses of a company. However, the focus is mostly on the strengths and weaknesses of the company compared to its competitor. Another system analysis approach is the Delft Systems Approach (DSA). With the DSA, is possible to analyze different elements of the (industrial) system. The DSA proposes an approach for the analysis of industrial systems whereby the focus is to cover all disciplines concerned [2]. Another supply chain analysis method is value stream mapping whereby the focus is on the identification of the different flows and their behaviour. This model is focusing on the specific flow in a node with the aim to reduce (several forms of) waste [10]. The DSA is identified as the suitable analysis method since it prososes the required analysis approaches to analyze industrial systems using the analysis of different system layers and the proposition of the aspect- and sub-systems. These tools can be used to seperate the different procedures for equipment control in the different nodes. Value stream mapping could have been usefull for specific flow analysis in for example KCS-Production. Moreover, it proposes to be a valuable tool for future process improvements and waste reduction.

The current subject of research, the loading equipment flow, is observed to be supportive to the main function of the system. Since loading equipment is supporting the steady state system for production, the PROPER model is used. The PROPER model, as part of the DSA, is used to identify different hierargical steady state systems within the same production environment. Within the PROPER model the influence of different mutual relations are observed. This reflects on the role of the equipment for the total production at KLM. Once the equipment is defined, the control parameter are identified to measure the performance of the current equipment control. The characteristics of the equipment loop show similiraties with the theory of closed loop logistics (source). The purpose of the third layer of the PROPER model (resource) is to control the loop of loading equipment. The characteristics of the flow show similar characteristics as the theory on returnable packaging materials management [1]. The control procedures in the network nodes are analysed based on the distribution analysis model. This model represents different control procedures in the network nodes and is constructed using the DSA principles. The last section provides analysis on the current distribution. Since there are currently no performance parameters identfied, a new control panel is required. This control panel is based on performance measurement of systems [11] and the performance measurement of RPM management [1]. The problem statement focuses on the current performance of the control distribution model. The input for analysis is based on interviews with planners, management, outstations- and warehouse operators and external actors. Moreover, data analysis and literature review is used. The conclusion of the analysis focuses on the problem statement for the current catering distribution management. The main focus in the problem statement discusses the gap between the system requirements and the actual performance of distribution control.

3.2. SYSTEM REQUIREMENTS FOR THE KLM OPERATIONS

The function of this chapter is to analyze the current operations of KLM. The operations at KLM are translated into a black box. This first step is proposed by the DSA to identify input, output and the requirements to the operation. The transformation is identified as the a transportation possibility of a seat in an aircraft between an origin and destination. Figure 3.1 shows the identified black box at KLM. KLM strives for a safe

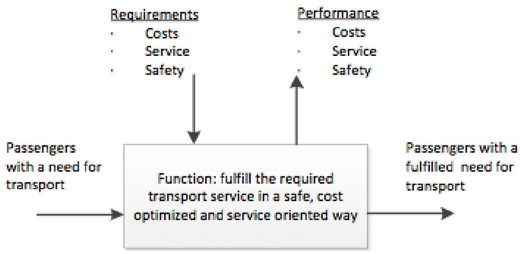


Figure 3.1: Black Box KLM passenger operations (Source: Own production)

environment to transport their passengers wherby safety is regarded as zero-accidents. Accidents result in inconvenience by the passengers and inconvenience in the operation at KLM. Regarding laoding equipment, safety is regarded as zero accidents with equipment during all different procedures where the loading equipment is handeled. The service KLM wants to provide is based on service level. The general target is to deliver a premium experience to the passengers. Service is a broad aspect and observed in many ways. Service for the passenger can discuss a broad network, quality food and personal attention. For the equipment distribution, according to NSM Planning manager Doze (2014) and NSM manager Joosten (2014), it is observed as the availability of equipment in the network nodes to ensure production. The third requirement at KLM is costs. The aim is to perform the operation with optimized costs. This means the performance to provide service is required to be organized in an efficient way. The input of the black box is a seat between an origin and a destination. It is also possible to identify a passenger with a need for transport as input. However, the equipment is fully loaded in the aircraft (regardless the passenger load factor). Hence, the input is the seat at the origin and the output is the seat at the destination. The function is defined as: “KLM fulfills the required transport of a seat in a safe, efficient and service oriented way”. Hereby, the requirements are based on the costs, the service and the safety of the transformation. The performance of the Black box is assessed on these same parameters.

3.3. THE CURRENT LOADING EQUIPMENT DISTRIBUTION AT KLM

This section reflects on the position of the loading equipment in the distribution network of catering. The first section describes the function of the loading equipment using the PROPER model. Hereby the focus is to investigate how equipment is used. The second section discusses the application of the loading equipment in the network and the drivers for the flow sizes.

3.3.1. THE POSITION OF LOADING EQUIPMENT IN THE KLM OPERATION

In order to to analyze different aspects and dynamics of the passengers business at KLM, it is required to zoom into different system layers. As introduced in the methodology in chapter 3.1, the analysis is performed using the PROPER model. The proper model representation of KLM, provided by figure 3.2 exists of 4 different layers. Different subsystems are discussed below. The control layer controls the operations in different steady state systems. The requirements going in are the black box requirements of the KLM passenger operation.

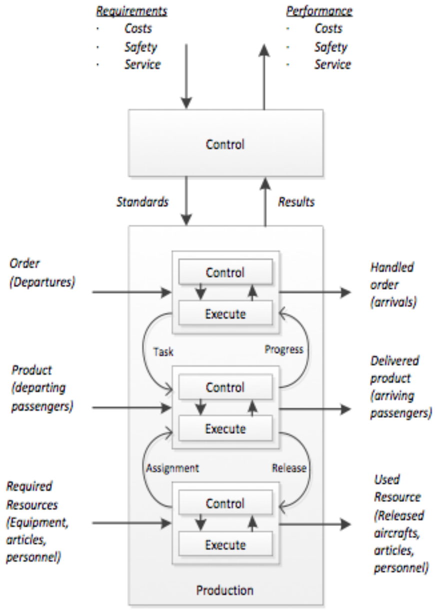


Figure 3.2: PROPER Model representation of the KLM Passenger Service (source: Own production)

Based on these requirements, standards are proposed for the production environment. The standards are based on the strategy of the company in a combination with the requirements costs, safety and service. The monitoring of the results focuses on the following topics: Service (network coverage, time table, service levels, additional services, distribution channels, availability), costs (CAPEX, OPEX) and Safety (zero accidents). The standards for production levels are based on the values at KLM and cover (among others) service levels, network model, timetable and procedures for ticket sales, check-in and additional operations for baggage handling and ancillary products. The production exists of an order layer, a product layer and a resource layer. The order layer shows the orders coming into the company for a product. In the case of KLM, it is the request for an available seat for a specific Origin-Destination (OD) combination. This request is made on a data forecast of the market demand by KLM. Based on the amount of tickets available, there is a tasks released towards the production steady state layer. Based on the numbers of orders available for different OD-combinations, the planning for required resources is made. The production layer is the steady state system where production takes place. At KLM, the production layer is the system where the available seat for the OD combination is provided. All the resources are supplied and assembled for the full seat capacity on the flight. The production reflects the aircraft where the transformation takes place. The resource layer assigns and assembles the resources towards production. Once used for production, it is released in the destination. The non-rotable equipment is taken of board and demolished. The rotable equipment is clearned and and available for of a new flight. The resources involve everything required to fulfill the flight organized by KLM. This resource layer involves materials (aircraft, Inflight articles and materials) and personnel (ground personnel, cabin crew, pilots). There are also resources required to realize the flight outside the scope of KLM Inflight Services (airport operations, navigation etc). These resources are left out of scope.

3.3.2. THE DESCRIPTION OF THE EQUIPMENT DISTRIBUTION LAYER

This subsection describes the production flow of loading equipment. The production flow discusses the flows of equipment between KCS-Producton and the OS-production. The description of the equipment flows is provided through the introduction of different elements. The first paragraph introduces the timetable at KLM; the schedule with flights between origins and destinations. The second paragraph introduces the allotment, the loading profile per flight. The third paragraph introduced the destinations and the routing. The last paragraph introduced the loading scenarios. These aspects are discussed in the following paragraphs.

Timetable The timetable provides the flight schedule of KLM. It provides the exact information on the amount of flight between origins and destinations and the aircraft type used for the specific flight. The aircraft type dictates the available seats in the classes WBC and M-Class for ICA and M- and C-Class for EUR

Flights. The timetable of KLM provides flights to 668 destinations. This big number of destinations is thanks to the code-share agreements with partners from the Sky-team alliance (Skyteam, 2015). A code-share agreement means that KLM can sell tickets for destinations operated by other airlines within the alliance. This is a mutual agreement between the alliance members. Only 142 destinations are operated by KLM. KLM configurates these flights according to the hub-and-spoke network configuration. Hereby, the focus is to bring people from all over Europe to Amsterdam (Schiphol Airport). Within Amsterdam, the passengers can tranfer to ICA flights. Almost 75% of the passengers at KLM is transfer passenger (KLM, 2014). The timetable has two profiles: the summer schedule and the winter schedule. For the summer schedule, more destinations are added to the schedule or the frequency to destinations is increased. The summer schedule starts the last weekend of March. The winter schedule starts the last weekend of October.

Allotment Each aircraft is loaded with a complete set of equipment (allotment) during the flight. The allotment is defined on the service schemes on board (this is different per destination); the distribution between C- and M-Class and whether it is a day or night flight. The allotment is different per aircraft type. It is observed that the allotment of the Airbus 330-200 and 330-300 don't have a big difference. However, there is a big difference between the A330 and the Boeing 747-400. Moreover, there are typical ratios between equipment. For example the ratio between oven racks and oven inserts (1:7). The loading scenario within the aircraft is called the Pre-Setup (PSU). The PSU discusses the positions within the aircraft where the equipment is loaded.

Destinations and routing KLM operates a network with 142 destinations (KLM, 2015). The destinations are categorized between EUR destination (74 in total) and ICA destination (68 in total). For the European destinations, the flights are loaded and offloaded with Inflight articles by KCS-Production. Given the short turn-around time and the low volume of inflight articles, there is no replenishment in the EUR destinations with new articles. The only two exceptions are the flights with destinations Barcelona and Lisbon since KLM has night stopovers there and has enough time for replenishment. The ICA destinations (68 in total) make use of 58 catering stations. This imbalance between destinations and catering facilities is because of the network configuration. KLM makes use of three different routing profiles: 1) Direct connection between origin and destination. An example is the combination of flight KL427 AMS-DXB and KL428 DXB-AMS. 2) A round-trip with two destinations. One of the destinations contains the catering station that provides replenishment. An example is the combination of flights with number KL531 (AMS-JRO, JRO-KIG, KIG-AMS). This is a round flight from Amsterdam Schiphol Airport to Kilimanjaro International Airport (Tanzania) and Kigali (Rwanda). 3) a combination of 2 round flights (long haul and short-haul). An example for this configuration is flight KL807 (AMS-MNL, MNL-TPE) and KL808 (TPE-MNL, MNL-AMS). For this research, the flights on the ICA-destinations are in scope.

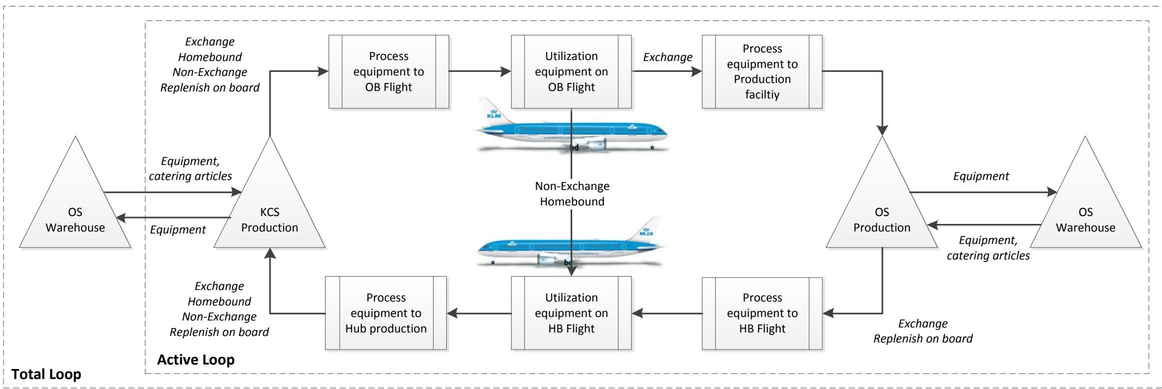


Figure 3.3: The loading scenarios at KLM (Source: Own production)

Loading scenario The flow sizes within the active flow depend on the loading scenarios for Inflight equipment. According to Loading and Ordering manager Brethouwers (2014), there are four loading scenarios: 1) Non-exchange: The non-exchange equipment is put on board for both the outbound as the inbound flight towards Amsterdam. 2) Exchange: equipment is put on board for the outbound flight and offloaded at the destination. At the destination, the equipment is replenished. The equipment taken off board is prepared for the next flight; loading equipment is put on board on exchange positions. 3) On board replenishment: this concerns items replenished on board by the outstation-catering operator. For example wine replenished on board. The wine trolleys remain on board, only the bottles are replenished. Per route and per outstations, it differs which products are replenished on board. 4) Homebound: the articles solely for the purpose to be used on the homebound flights. For example, Customs documents for non EU-residents that want to enter Europe on ICA flights. These documents have no purpose on ICA flights going out of Europe but are already loaded on board for the return flight.

The introduction of Closed Loop Supply Chains The flow of equipment between the outstation and the production facility of KCS shows many similarities with the Closed Loop Supply Chains (CLSC) theory. This is concluded based on the closed character of the loop, combined with the returing flow of reusable equipment. Within CLSC, different types of products are identified. The first category identified is focusing on returnable transport items (RTI)[12]. Examples of RTIs include pallets, maritime containers ([13], railcars [14] standardized vessels for the transportation of fluid, crates, totes, collapsible plastic boxes, trays [15], roll cages [1], barrels, trolleys, pallet collars, racks, lids, etc. Most RTI are used in business to business settings, although its use also appears in B2C contexts with elements such as supermarket trolleys, baggage trolleys in airports and train stations and wheeled bins arranged by local councils [16]. Returnable packaging materials (RPM) identified [17] for primary packaging materials designed to directly protect and hold the product that the end consumer really wants. Examples of RPM are reusable glass bottles for beverages ([18]; [19], gas cylinders [20][21], kegs [22], containers for chemicals, toner cartridges [23], single-use cameras [24], medical equipment protection, windmill parts equipment protection or steel coils packaging [25]. Reusable products (RP) is term a term is a term identified by [1] for products used multiple times. For instance, sterilized surgery instruments, wheel chairs or other types of medical equipment lent by National Health Services to patients [26], systems for borrowing of books, video tapes or sport equipment [27] or the service tools [28]. Based on the description of the identified categories, the equipment at KLM is identified as RTI. The identification of the KLM equipment as RTI means that the analysis methods for CLSC is used. The identified analysis method is the RPM management model [1]. This model proposes valuable analysis methods for rotating equipment in industrial systems.

The distribution of RTI is organized through 2 types of network configurations; Star systems and Multi-depot networks (see picture 3.4). In star systems, the central facility supplies the end customers or use intermediate distributors to serve the end customers in a given region. RTI always returns to the same central production facility, regardless sub-routes. Given the hub-and-spoke network configuration, the current RIT flow is organized according to the star network. There is a possibility that the RTI fleet of KLM is integrated with Air France. If this is integrated, a mutli-depot network configuration is required to be adopted because it becomes possible to work with the dual-hub strategy of the Air France-KLM group.

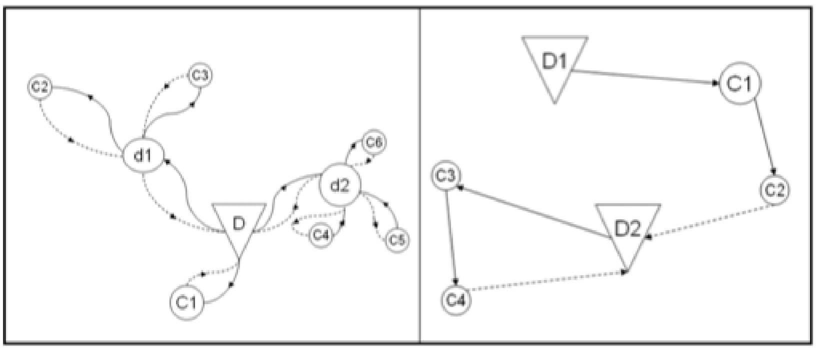


Figure 3.4: RTI network configurations: Star system (left) and Multi-depot network (right) [1]

3.4. ANALYSIS OF THE CURRENT EQUIPMENT DISTRIBUTION CONTROL PROCEDURES

This section provides the analysis of the current control methods distribution network. The analysis of the procedures is applied based on the subsystem control model. This model reflects the required control aspect systems in different sub-systems. This model is constructed based on the principles of the DSA method. The subsequent sections elaborate the current control procedures in NSM-Planning, KCS and the outstations.

3.4.1. THE INTRODUCTION OF THE SUBSYSTEM CONTROL MODEL

The DSA method, used to analyse to current state of the equipment distribution, proposes principles to structure a system. Based on these principles, the analysis model, provided in figure 3.5 is constructed. The model exists of two layers; the network control layer (NSM-Planning) and the network nodes. These systems are identified as the sub-systems of the distribution control model. The activities within the sub-systems are the aspect-systems. The aspect systems within NSM-Planning are systems that control the safety, service and costs because NSM-Planning is required to control the distribution according to the main criteria for the operations at KLM (see chapter Chapter 3.2). The aspect systems within NSM-Planning are required to propose boundaries for the operations in the network. This is input for the aspect-system "Compare" in the network nodes. The aspect-systems in the sub-systems focus on measure, compare, decide and act. Measure focuses on the measurements of required values in the sub-system. The compare aspect-system focuses on the comparisment of the measured value with the required value. The decision aspect-systems focus on the decision-making. The act aspect-systems focuses on the way the decisions are currently applied in the operation (see chapter 3.4.4 and chapter 3.4.3). The analysis in this section described the activities in each aspect-system shown in figure 3.5.

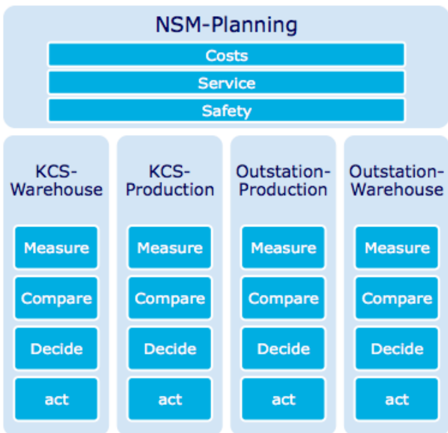


Figure 3.5: The distribution control model constructed using the DSA principles [2]

3.4.2. CONTROL OF THE NETWORK BY NSM-PLANNING

NSM-Planning is responsible for the planning and allocation of resources to ensure availability in different nodes. Hereby is the focus on availability in KCS-Warehouse and OS-Warehouse in case KCS-Production and OS-Production require additional equipment. It is for the production locations to decide if they have demand for editional equipment. However, complete insight in the stock levels is required to enable NSM-Planning to actively allocate equipment. The focus to have the backup of equipment stored in KCS-Warehouse. If any nodes in the network (OS-Production) has demand for equipment, it is pushed into the network through KCS-Production. The tasks within NSM-Planning are divided between area- and central planners. The NSM central planners are responsible for the availability of the stock in KCS centrum. In cooperation with the area planners (responsible for outstations stocks) they should organize replenishment flows of KCS-warehouse by the outstations and replenishment of KCS-Production by KCS-Warehouse. Therefore the tasks are for the planners to monitor stock levels and to balance them to have tailored safety stocks in the outstations and the entire surplus in stock in the KCS-warehouse. Hereby it is important to measure that NSM had the final responsibility for the availability in the nodes of the network. It is also important to measure that NSM is the only sub-system that has an overview on the activities in all different nodes of the network.

The control methods There is no active control of efficiency, nor are their tresholds or boundaries identified. There are no systems currently in place to track the efficiency. The lacking insights in Outstation-Production areas makes it impossible to verify the on-hand inventory. The return-rate is not measured and the inventory balance is not tracked. There is currently no monitoring of costs. According to NSM-Planning manager Doze (2014), none of the identified cost parameters is incorporated in the current distribution management at NSM-Planning. The decisions are made based on shortages observed by the KCS-Production shift leaders. Althoug the Controling department within KCS is responsible for the monitoring of cost, there is no collaboration on the costs of equipment distribution (not on the operational costs, nor on the investments). This indicates that budgets to replace equipment are not defined and improvement routes to reduce losses cannot be identified.

The observations above show that in the current control set-up, NSM-Planning is not (able) to monitor any of the performance parameters. Clear dashboards does not exist for the management of stock levels in different nodes. The available data in the ERP system SAP is not sufficient to cover the management since big parts of the active loop are not incorporated. Therefore, additional procedures (mostly with Excel) are put in place in different nodes. The ERP System SAP provides the ability to monitor some aspects but this is not very clear and not tailored to the specific needs of KLM/NSM planning.The current operations and structures for decision making have different time frames. However, clear structures for the monitoring and decision making for the topics of loading equipment are not clearly defined or not clearly communicated to different nodes. This results in inconvenience between the departments and frustration. The supply chain collaboration is lacking and KCS-Planning manager Buijs (2014) and NSM-Planning manager Doze (2014) indicate that it should improve.

3.4.3. Control in the network nodes: KLM Catering Services

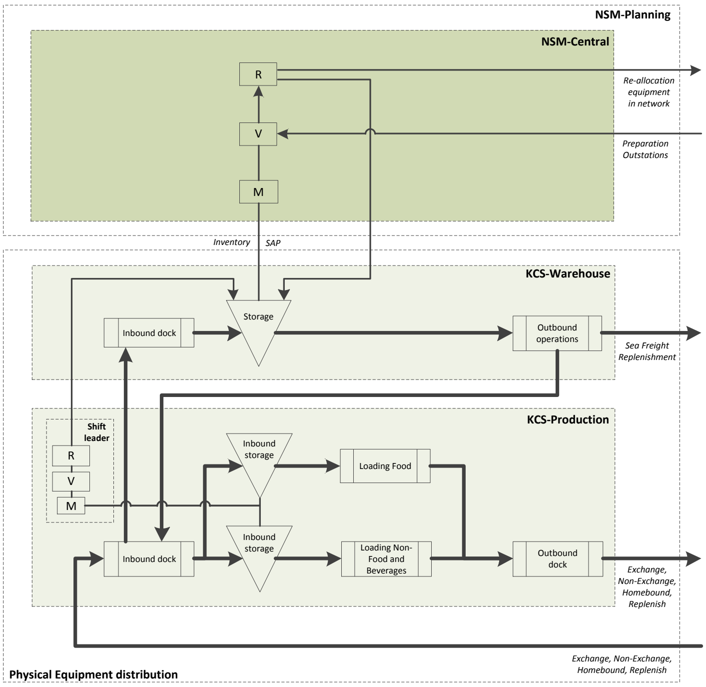


Figure 3.6: The current steady state distribution system in KCS (Source: Own production)

The control operations in KCS-Production

KCS-Production is the central node in the distribution network. The function of KCS-Production is to produce the catering and assemble the equipment with the inflight articles. KCS-Production is also responsible for the logistics towards the aircraft. The equipment used for production is pushed into the production facility from incoming flights. The differences between the out- and inbound flows results in fluctuations in the inventory level in KCS-Production. The location where the equipment is pushed into the facilty and pulled again into production, is called the "ROA" area. Based on the inventory level in the KCS inbound storage, the shift leader determines if additional replenishment is required.

The control methods The current measurements in KCS-Production are applied by the production shiftleader and the control center (besturingsbureau). The shiftleader observes the inventory levels in the KCS inbound storage. This is the location where the equipment (pushed into the KCS-Production facility) is stored. This is equipment coming from the arriving KLM ICA flights. KCS-Production produces based on the outbound flight scheduled by the timetable. The equipment for the departing flights is pulled into production out of the KCS inbound storage. Currently, there are no additional measurements. There is no realtime insight in the total equipment inventory level neither in KCS-Production nor on the weekly flow of equipment through the node. Also the RPM parameters are not measured although KCS-Production is the production location where these measurements should take place. The compare levels with bandwidths for the minimum and maximum level in the KCS inbound storage are not defined. Central planner Stroobach (2014) indicates that the compare levels are based on the tacit knowledge of the shift leader. The shiftleader compares the observations in the KCS inbound storage with his experience. Since there are several shiftleaders, there is a possiblity that the shiftleaders have different patterns of decision making. Some make conservative decisions, others may decide for excessive replenishment orders. The current guidelines for minimum or maximum rqeuired levels are not exactly defined. KCS Shift-leader Peters (2014) indicates that the shiftleaders prefer to have enough equipment at the end of the day to start the first production block the next morning. This first production block takes 75 minutes. Given the theoretic capacity of 3 trolleys per washing machines per 15 minutes, the total capacity for 1 production block with 6 washing machines is 90 trolleys. The act procedures start with the shift leader. His decision for replenishment is communicated to the control center. Here, there is a material planner (passively) managing the equipment flows. The material planner orders KCS-Warehouse to take action by either collecting the equipment or to bring equipment. The material planner is assigned with the forecasting task for materials but this doesn't involve equipment. The comprehensive system description of KCS-Production is provided in Annex A.

THE CONTROL OPERATIONS IN KCS-WAREHOUSE

The function of KCS-Warehouse is to store the surplus of equipment of KCS-Production. The inventory in KCS-Warehouse symbolises the spare capacity of the total distribution network. Since KCS-Production is the central node of the network, it means that KCS-Warehouse stores the back-up equipment to cover the balance between supply and demand in the total network. In case the total network has lower demand, more equipment is coming into KCS-Production (and vice versa). Below, different control operations are discussed.

The control methods The measurement methods within KCS-Production are done by the store operators on the working floor. They are required to administrate all the incoming and outgoing flows into SAP. SAP provides a real-time insight in the (theoretic) inventory levels. There are currently no tools operational that provide easy acces to these inventory levels in SAP. There are no compare levels or procedures for decision-making. KCS-Warehouse is only a warehouse and is required to be controlled by the Central Planner of NSM-Planning. However, NSM-Planning manager Doze (2014) and central-planner Stroobach (2014) indicate that there is currently no minimum level identified for the levels in KCS-warehouse (as figure 3.3 shows). The low inventory visibility and the lack of minimum inventory levels results in shortages in KCS-Warehouse. The current monitoring and decision making is done on a reactive base rather than pro-active. The acts currently applied for KCS-Warehouse focus on the phsycial balancing of inventories with KCS-Production. This is based on incoming orders. The current control of the inventory is the responsibility of the warehouse operators and the centraal planners at NSM-Planning. The operational control functions are the responsibility of the warehouse operators. They are required to control the in- and outbound flows and administrate it in SAP. The central planner has the final responsibility to guarantee the availability of equipment in KCS-Warehouse.

3.4.4. CONTROL IN THE NETWORK NODES: THE OUTSTATIONS

THE CONTROL OPERATIONS IN OS-PRODUCTION

KLM works with 58 different catering producers in the outstations. The facilities are operated trough different (global) caterers. Therefore they all have different states of maturity, compliance and current performance. It is possible to reflect on general observations on the outstations to provide an overview of their current

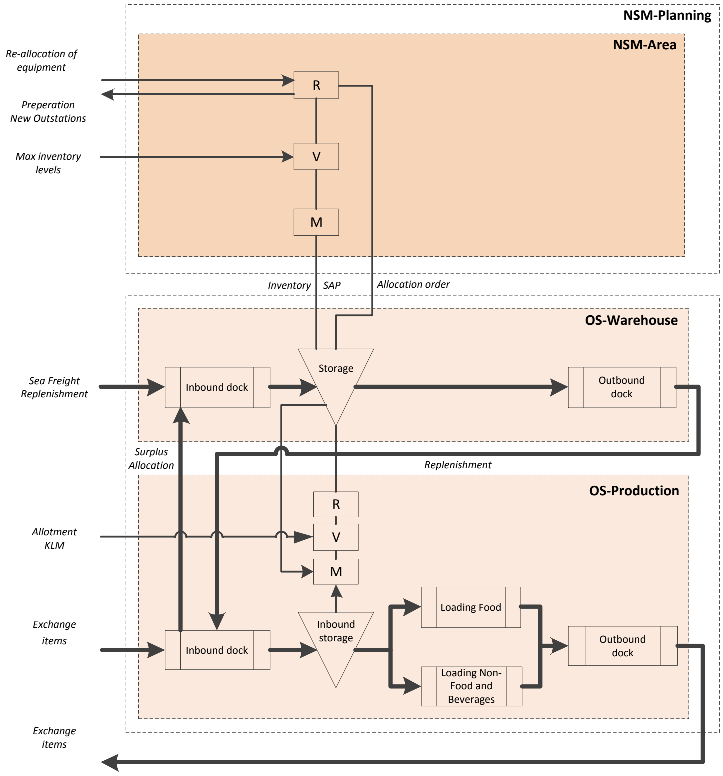


Figure 3.7: The current steady state distribution system in the outstations (Source: Own production)

practices. This reflection tries to propose a general and unified description of a generic outstation. The OS-production facility processes the catering for KLM in the outstations. Most of the locations only handle one KLM flight per day. They are required to keep one complete allotment in the production facility. This is stored in the facility and only brought to the production floor when KLM is produced. The moment the flight arrives, the arriving set is offloaded and the prepared flight is off-loaded. The production floor is not monitored in SAP. A comprehensive overview of the operations is provided in the Annex.

The control methods The measurement methods in the outstations depend on the outstation; some count every incoming piece (as observed by the researcher in the catering facility of Do&Co in Istanbul). The outstations count their production floor if required by the NSM Area-planners. The compare level in the outstation production location is different per location. The biggest aircraft type flying on the specific station determines the quanity stored in the outstation. These levels are calculated by the loading and ordering department. Normally, it is the allotment of the biggest type that flies on the specific destination. For example, in the destinations on the East coast of the USA (JFK, IAD, IAH), the biggest set is for the Boeing 747-400 while normally a Boeing 777-300 flies on these destinations. The shopfloor operators should make the decision to take action when the stock level exceeds the maximum allowed level (allotment). The compliance with the inventory policy is questionable per outstation. Contract managers Schoenmakers (2014), Reijndorp (2014) and Area-planner Roos (2014) indicate that many outstations have more equipment on the production floor than the maximum level. Moreover, they indicate that the maximum level is not clear to all the outstations. The act aspect system either focuses on questioning replenishment from AMS via the area-planners or to move the surplus in equipment towards the OS-Warehouse. The fact that NSM-Planning has no insight in the inventory levels of OS-Production makes it hard to control. The regulations are not very clear to the outstations and the verification of the application is not strict enough. This leads to lacking control and the possibility of increasing stocklevels in the outstations.

THE CONTROL OPERATIONS IN OS-WAREHOUSE

The Outstation warehouse is used to balance the inventory of the production location. The location is managed by the OS-operators and monitored by the NSM Area-Planners. The current maximum level is identified but according to NSM-Planning manager Doze (2014) not strictly managed. According to Area-Planner Tempels (2014), the maximum spare stock levels are only for the drawers because of the probability of broken pieces. For example the allotment is for a full pax 747 rather than the actual flying Boeing 777. Different aspect systems are discussed below. A comprehensive overview of the operations is provided in Annex A.

The control methods The inventory levels in the outstation warehouse are measured via the SAP-portal. Warehouse and/or Production operators are required to administrate every piece of equipment they take from or add towards the warehouse. However the compliance, according to the Medina (2014) audit shows that the compliance with this procedure is not 100% in every outstation. Therefore the theoretic inventory levels in SAP can vary from the real levels. According to Area-planners Tempels (2014) and Bakema (2014), the current spare-stock levels in the Outstation warehouse is zero spare-stock inventories for loading equipment. Only some spare stock inventory for drawers is allowed. However, the analysis in picture 3.10 shows that the compliance with this regulation is very low. The outstation operators are required to send equipment back to AMS if the inventory exceeds the maximum level. Moreover, the area-planners are required to monitor the levels to request inventory back to Amsterdam. However, the compliance with this regulation is low for the outstations and the area-planners are not actively monitoring these levels. According to contract-managers Schoenmakers (2014) and Reijndorp (2014), it is regulated in the contracts with the outstation that they are penalized if they hoard equipment. However, these penalities are rarely applied. The control of the inventory in the outstations is currently not sufficient. The inventory builds up easily since it is not strictly monitored by the outstation operators and barely monitored or actively managed by the area-planners.

3.5. THE ANALYSIS OF THE CURRENT EQUIPMENT DISTRIBUTION

This section reflects on the current performance of the equipment distribution. The first subsection reflects on the set of parameters to measure the performance of the distribution. Given the current lack at NSM-Planning of a sufficient set of parameters, a new control panel is identified. The identification of new performance parameters is based on literature. The new control panel measures the efficiency, effectiveness and the costs of the current distribution panel. The last subsections in this section provide the analysis of the current distribution of the current aspects.

3.5.1. THE PERFORMANCE MEASUREMENT SYSTEM

The identification of the relevant parameters is made based on the general performance of systems [11] and the performance measurement of RPM management [1]. The general performance of systems approach is used before in the same KLM environment [29][30]. A comprehensive reflection on different performance measurement elements and the identification of the final control parameters is discussed in Annex A. The relevant parameters are identified as ratios and parameters for efficiency, effectiveness and costs. These control aspects enable NSM-Planning to identify their strategy towards reduced costs while ensuring maximum service. The efficiency parameters reflect on the efficiency of the loop. The two efficiency ratios used are the total efficiency (3.3) and the active efficiency (3.4). These efficiency rates can also be used to calculate the equations for the inventory in KCS-Warehouse (equation 3.6) and the maximum in the outstations (equation 3.7 and 3.8). The efficiency ratios use the fleetsize with maximum productivity (equation 3.1) to calculate the total fleetsize (equation 3.2). The node efficiency is also measured but not part of the central control panel. The strategy decides on the total equipment efficiency and the active efficiency. The combination of the two results automatically in a (targeted) outstation efficiency.

The three effectiveness parameters identified are used to reflect on the effectivenss of the operation. The first effectiveness parameters discusses the number of outstations that have the allotment in their production facility and between 0 and the maximum allowed spare stock level for their warehouse. This is expressed as a ratio whereby the number of right performing network nodes is divided by the total number of network nodes. The second parameter shows the balance of equipment. This is used to balance the equipment with the outgoing (reparation) flow and the incoming (BBO) flow. The balance is shown per equipment type in scope for the dashboard. The third effectiveness parameter is the return rate. A theoretic perfect operation has a return rate of 100 %. For costs, it is important to monitor the development of different components.

$$n_{fleetsize} = (\sum n_{OS} * A_{OS}) + (\sum n_{aircraft} * A_{aircraft}) + n_{Reserved} + n_{KCS}) * f_{load} \tag{3.1}$$

$$\sum n_{equipment} = \sum n_{total} + \sum n_{reparation} \tag{3.2}$$

$$n_{total} = \frac{n_{active}}{\eta_{total}} = n_{active} + I_{KCSW} \tag{3.3}$$

$$n_{active} = \frac{n_{fleetsize}}{\eta_{active}} = n_{total} - \sum I_{OSW} \tag{3.4}$$

$$n_{reparation} = n_{fleetsize} * r_{reparation} \tag{3.5}$$

$$I_{KCSW} = n_{total} - n_{active} \tag{3.6}$$

$$\sum I_{OSW} = n_{active} - n_{fleetsize} \tag{3.7}$$

$$I_{OSW} = \frac{\sum I_{OSW}}{n_{OS}} \tag{3.8}$$

$n_{fleetsize}$	*Fleetsize with maximum productivity*	
n_{OS}	*Number of catering facilities in the network*	
A_{OS}	*Allotment for the catering facility*	
$n_{aircraft}$	*Sum of aircraft fleet at KLM*	
$A_{aircraft}$	*Allotment per aircraft type*	
$n_{Reserved}$	*Amount of sets reserved to equip facilities*	
n_{KCS}	*Amount of equipment in KCS-Production*	
f_{load}	*load factor of the flight*	%
n_{active}	*Fleetsize active distribution network*	
η_{total}	*Efficiency rate total loop*	
η_{active}	*Efficiency rate active loop*	
n_{total}	*Total required fleetsize distribution network*	
I_{OSW}	*Maximum inventory level OS-Warehouse*	
n_{OS}	*Number of catering production facilities*	
η_{OS}	*Efficiency catering production facility*	%
I_{OS}	*Inventory oustations (Production+Warehouse)*	

Table 3.1: The equipment control panel for NSM-Planning (Source: Own production)

Category	**Control aspect**	**Control parameter**
Efficiency	Efficiency total network	Total % equipment
	Efficiency active network	Total % equipment
Effectiveness	On-hand inventory	Total % per outstation
	Inventory balance	Total % per equipment type
	Return-rate	MA in % per equipment type
Costs	Total working capital	Total value in €
	Maintenace and replacement costs	Total value in €
	Transportation costs	Total value in €
	Warehousing costs	Total value in €
	Control costs	Total value in €

The efficiency is controled using the ratios for efficiency for different indicates loops (total and outstation). The effectiveness is controled by verifying the on-hand inventory in the nodes, the inventory balance and the return rate. The costs are monitored for the cost components working capital, maintenance and replacement, transportation, warehousing and control costs. In this way, NSM-Planning can monitor the biggest operational requirements (efficiency and effectiveness) as the effects it has on the cost components.

3.5.2. THE CURRENT EFFICIENCY OF THE EQUIPMENT DISTRIBUTION

This chapter reflects on the analysis of the current efficiency of the equipment distribution. The two efficiency rates, total- and active efficiency, are calculated using the trolley count (may 2014) and SAP data (January 2015) is used. To calculate the total equipment the active loop is deviated by the total fleetsize. Table **??** shows the results for the calculation of the current efficiency ratio for the total loop. The calculations show average efficiency between 96,5 and 99,53 % for different equipment items. The average efficiency of the active loop is between 79,9 % (oven racks) and 98,5% (FS Trolley 1/1 Business Class). The low efficiency of the oven racks confirms the observation of the low efficiency of the equipment. The total network efficiency is high; this is caused by the low inventories in KCS-Warehouse. The high total loop efficiency leads to stock-outs in both KCS-Warehouse and KCS-Production. The active network efficiency is low. This is caused by the stock build up in the OS-Warehouses. If the active efficiency rate of, for example, oven racks is increased from 79,9% to 95%, there are 640 oven racks released from the outstations. It is not possible to draw conclusions on an average number for the total equipment efficiency. Additional calculations were not possible since reliable information on the current fleetsize of the equipment is not available.

Benchmark with literature The identified parameter for efficiency is based on the performance theory [11]. Based on the theory, the efficiency using inventory ratios is calculated. The following factors that contribute to an decreasing efficiency [1] large stock quantities of used and reconditioned articles at depots, long reconditioning lead times (for filling, repair, sterilize, etc.), long transportation distances, infrequent deliveries and collections at distributors and/or customers, long supply chains with a high number of intermediaries, excessive customer holding time. For KLM, mainly the excessive holding time in the outstations and the collections at distributiors. KLM has long transportation distance but short transportation time, frequent deliveries and a short number of intermediaries.

It is possible to use the cycle time as replacement of the current used efficiency ratio[1]. The same variable has been referred to in literature with different names such as turnaround time or trip duration [18], return delay [24] sojourn time [31], time until return [32], lead time [33] or circulation time [17]. Based on these descriptions, the cycle time is identified as the full tour from KCS-Production towards the outstations and back. Using the calculations provided in Annex C, it is possible to calculate the theoretic shortest cycle time for the equipment distribution at KLM. In the current timetable (summer, 2015) the calculated yearly outflow (to outstations) is 594840 standard containers (60600). The calculated minimum fleetsize (for maximum productivity) is 5468. The reserved outstation equipment is subtracted since this represents the infinite cycle

Table 3.2: Calculations of equipment fleet efficiency ratios (Source: Own production based on SAP data)

SAP code	Equipment type	Fleet	KCS-W	OS-W	Eff. Total	Eff. Active
60506	FS Trolley 1/1 Business Class	1503	7	21	99,53%	98,5%
60507	HS Trolley 1/1 Business Class	661	12	25	98,1%	96,1%
60525	Universal Light Weight Trolley Diethelm	2100	73	282	96,5%	86,1%
60600	Standard Container	6191	96	385	98,5%	93,7%
60280	Oven Rack	4201	27	840	99,3%	79,9%

time (it is reserved untill further notice). If these sets are subtracted (resulting in fleetsize of 5084), the average circulation time is to 3,11 days. If the original fleetsize is used (5468), the cycle time is 3,37 days. Hence, the efficiency decreases when the fleetsize increases with the same amount of shipments. However, the focus is on inventory efficiency. Clear calculated inventory boundaries are easier for the area- and central-planners to steer upon. Therefore, the efficiency is calculated using the network inventory ratios.

3.5.3. THE EFFECTIVENESS OF THE CURRENT EQUIPMENT DISTRIBUTION

The analysis of the effectiveness provides the information on the current on-hand inventory, the inventory balance and the return rate of the flow. The conclusion provides conclusions on the current effectiveness performance of the distribution control.

ON-HAND INVENTORY

Low inventories in KCS-Warehouse Analysis and interviews with NSM-Planning manager Doze (2014), NSM manager Joosten (2014), KCS-Planning manager Buijs (2014) elaborate on the shortages that occur in the KCS-Warehouse. Picture 3.8 shows the inventory levels for specific loading equipment types in 2014. The picture shows a stock-out of oven racks and a near stock-out occured for square containers. Moreover, the inventory of oven skids is declining. The shortage of ovenracks resulted in a shortage of ovenracks in KCS-Production because spare equipment is not available in KCS-Warehouse. KCS flow director Jansen (2014) indicates that the required minimum level of ovenracks in the KCS-Warehouse is ninety pieces. This value is based on tacit experience rather than profound calculations or strategy. Central-planner Stroobach (2014) indicates that there is currently no minimum level defined in KCS-Warehouse for different equipment types.

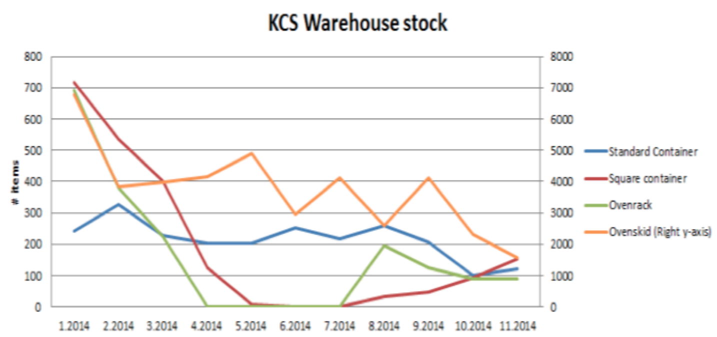


Figure 3.8: KCS-Warehouse inventory levels (Source:SAP)

High inventories in Outstation warehouses The analysis of the outstation inventories (figure 3.9). The y-axis shows different outstations-warehouses that currently operate within the KLM network. The x-axis shows the inventory height in the specific outstation-warehouse. Analysis shows up to spare inventories of 90 oven racks in the warehouses. This contrasts with the regulation indicated by Area-planner Tempels, (2014) that no spare-stock is allowed in the outstations. This is also confirmed in interviews with NSM-Planning manager Doze (2014) and Area-planners Bakema (2014) and Roos (2014). Figure 3.9 shows that almost all the 58 outstation warehouses have spare-stock inventory levels of oven racks that exceed the regulation. The total theoretic capacity of passive oven racks in the network, based on the analysis of SAP data, is around 850 oven racks. However, it is unknown if this result is reliable because the passive equipment on the working floor and the real amount of equipment in the warehouses is unknown.

The reason for the imbalances is found, among other reasons explained further in this chapter, in the extend of compliance with the PSU. If outstations make errors in production and therefore not comply to the regulation 100% outbound and 100% inbound flows, imbalances occur. According to NSM-Planning Doze (2014) and area-planners Roos (2014) and Tempels (2014), these imbalances can occur when in- and outbound flights have different meal programs. For example flight KL661 AMS - IAH. The outbound flight has a meal service 3 times and therefore uses 3 sets of ovensracks. The return flight, KL662 IAH to AMS has 2 meal services and uses therefore 2 sets of ovenracks. Although the 'empty' set has not been in production, it should be loaded on board. However, loading errors occur (in multiple stations) although loading is clearly indicated in loading profiles There is no data available on the occurence rate of loading errors.

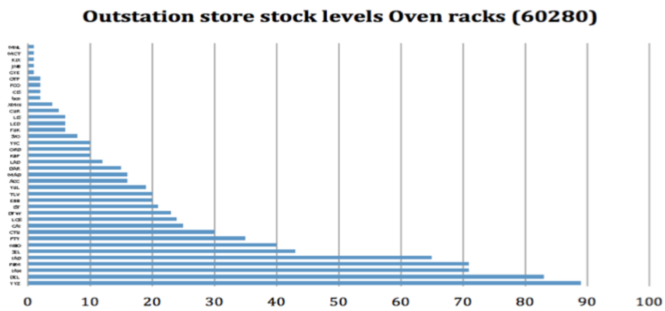


Figure 3.9: Outstation stocks for ovenracks (Source: SAP)

Reliability in Outstations The reliability of warehouse data is observed to be questionable. This is indicated in interviews by NSM-Planning manager Doze (2014), contract manager Schoenmakers (2014) and Medina (2014) audits. The audit reflects on the fact that 41 of the 58 outstations have a booking performance equal or below 50%. This indicates that the inventory level measured deviates more than 50 % from the inventory level calculated based on their indicated consumption via SAP. This measurement indicates the difficulties of the vendor managed inventory construction KLM currently applies. The consumption and administration of the outstation is not reliable. This makes it hard for KLM to forecast and plan replanishment. Also personal analysis of procedure compliance has found examples that outstation managers, for example in Delhi and Paramaribo, misunderstand the procedures. The managers in Delhi and Paramaribo book their working stocks as store stocks. Through this error, it appears that the Delhi warehouse storage is high (90) while their real capacity is low and not correctly administrated in SAP. In this way, KLM observes a high spare capacity while the actual capacity is rather low. Figure 3.10 shows the dynamics on the production floor in DEL. This is possible because of the error. It is observed that for all the equipment types, the inventory levels fluctuate. This shows the low reliability of PSU by the OS-production or by KCS-Production (or both). The station also has an increasing level of ovenracks. Therefore it is observed that this is one of the outstations collecting ovenracks.

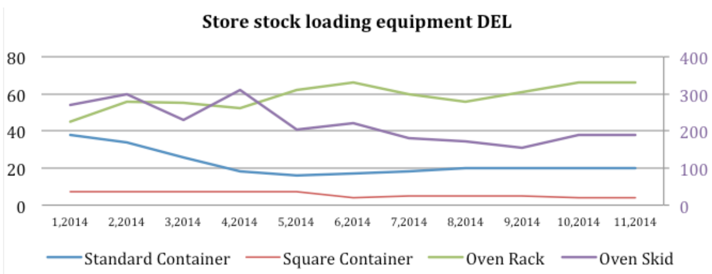


Figure 3.10: Production inventory fluctuations at DEL (Source: SAP)

INVENTORY BALANCE

Inventory fluctuations in KCS-Production The biggest influence on the amount of equipment flowing in the network of KLM is the timetable. Analysis of the timetable is provided in picture 3.12. The analysis of the fluctuations of the inventory level in KCS-Production inbound storage area is shown in table 3.11. The timetable shows the morning arrival peaks and the afternoon departure peaks. The biggest share in the arrivals and departure for the big aircraft is for the B 777-200 and for the smaller aircraft types for the B 333-200. The average amount of departures for the fleet is, for week 22 in 2015, 5,92 departures per week. This is almost 6 departures per week. The analysis of the inventory levels shows the low levels at the end of the day. Short after the start of the operation (6 AM), the equipment from the morning arrival peak arrives. The picture shows the shortage that occurs in the weekend. This analysis shows the imbalances between the incoming- and outgoing flights per day. As shown by picture 3.11, the inventory increases due to the morning arrival peak. Based on the departure peak in the afternoon, the equipment is taken out of the inventory. The low stocks on sunday is caused by the low number of arriving flights compared to the number of departures on monday afternoon. This pattern is also confirmed by KCS-Planning manager Buijs (2014) and KCS-Operations manager Zwager (2014).

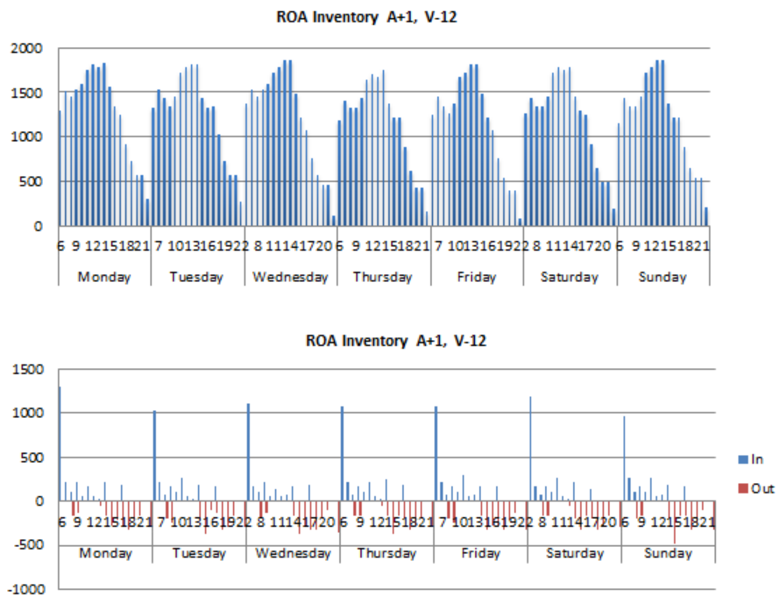


Figure 3.11: Stanard container stock fluctuations (both in-out flows as inventory development) (Source: KLM timetable S15, allotment L& O)

Unobserved additions There are different additional shipments loaded in the cabin aside from the PSU. These shipments are organized by NSM-Planning. The shipments are used to send items to the outstations in case of shortages. Normally, it is required to avoid these shipments since their cost is E 85 per shipment. Data analysis, provided by figure 3.13 shows that the number of shipments increase around timetable changes since timetable changes are often used to introduce new inflight products. If these products are not on time in the outstations by sea-freight, cabin shipments are used to reduce outstation lead times to 1 day from Amsterdam. There exist two types of additional shipments: The "Buitengewone Beladings Opdracht" (BBO) and the Pantry Shipment. The BBO is used to send equipment to the outstation. The equipment used for the BBO is taken out of the working stock in KCS-Production. Each BBO therefore influences the available equipment for production. The pantry shipment is the same as the BBO and used to send shipments to outstations. However, the shipment is prepared in KCS-Warehouse and uses equipment from the passive storage. Using interview with NSM Supply Chain manager Gerrits (2014), Area-Planners Roos (2014) and Tempels (2014), it is concluded that equipment is added to the loop and the total loop efficiency increases my means of pantry shipments. It is currently not verified if the equipment returns from the outstations. An active reversed loop to organize the pantry equipment reversed logistics towards KCS-Warehouse is also lacking. Therefore, it is concluded that the number of equipment items has increased, the efficiency has decreased and the number of spare stock decreases as well.

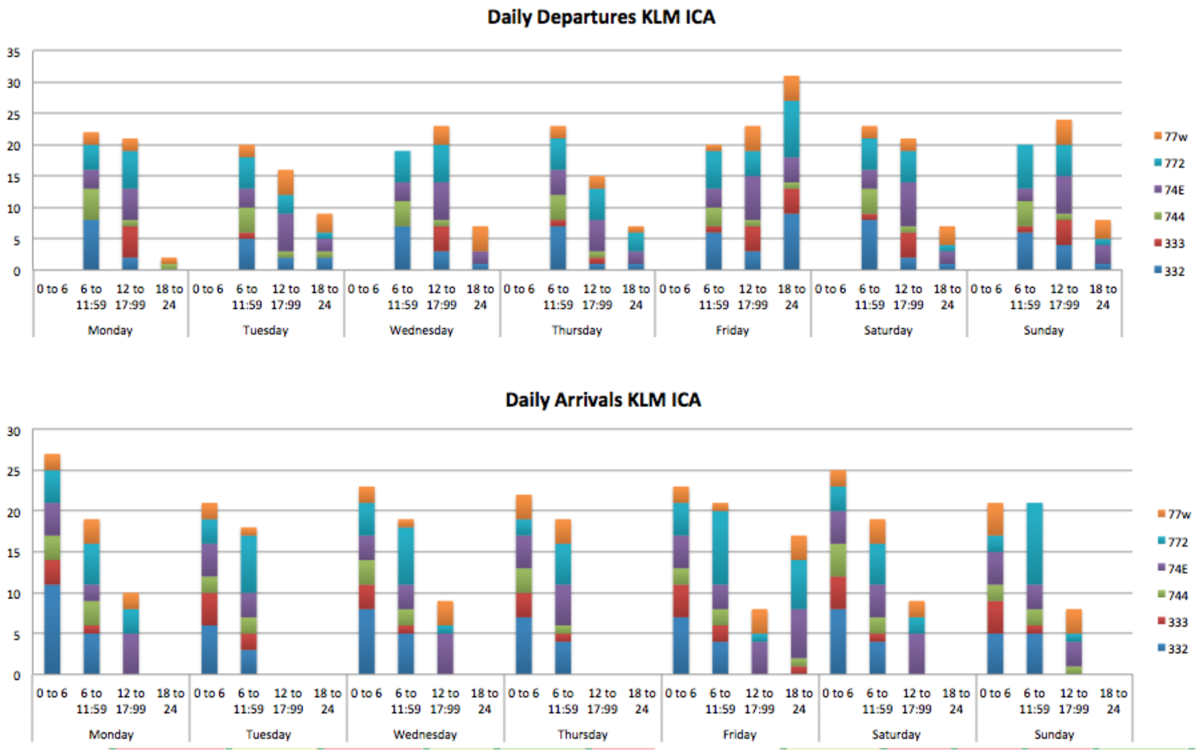


Figure 3.12: Daily number of the in- and outbound flights to AMS (Source: KLM Timetable 14/15

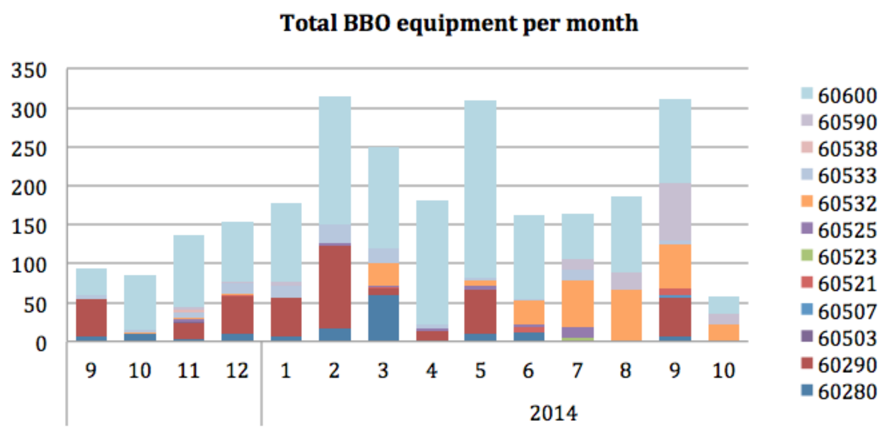


Figure 3.13: The number of cabin shipment per month (Source: NSM BBO sheet)

Table 3.3: The calculation of the average fleet reparation rate $r_{reparation}$

SAP	name	Average	Counted	Percentage	Relative Weight
60532	Trolley 1/2 Hybrite Driessen	33	4799	0,65%	0,20 %
60533	Trolley 1/2 Light Weight Diethelm	15	2480	0,62 %	0.10%
60538	Trolley 1/2 Light Weight Driessen	6	1188	0,49%	0,04 %
60507	HS Trolley 1/2 Business Class	5	750	0,64%	0,03%
60503	Trolley 1/1 Light Weight Diethelm	3	243	1.15%	0.02%
60521	Universal Trolley light weight diethelm	27	1199	2.29%	0.18%
60523	Dessert universal	2	208	0.11%	0.02%
60525	Universal trolley light weight driessen	41	2099	2.62%	0.27%
60506	FS Trolley 1/1 Business Class	5	1566	0.33%	0.03%
60534	Waste trolley light weight	12	588	1.97%	0.08%
60539	Waste trolley light weight Driessen	4	200	2.00%	0.03%
Average					0,99%

Unobserved subtractions The unobserved subtraction discuses the equipment pushed out of the active loop because of their state. The current procedure is that cabin crew labels the equipment in case they observe broken parts (during flight or in production). KCS-Production takes the labeled equipment out of the loop and the equipment is transferred towards KCS-Warehouse. KCS-Warehouse stores broken equipment and organizes, together with NSM Central Planners the reparation flows towards the reparation location VRR. The subtractions from the loop are also indicated by NSM Supply Chain specialist Gerrits (2014) and KCS-Planning manager Buijs (2014). Table **??** shows the analysis of the average inventory levels in the reparation facility. The average percentage of loading equipment in the reparation facility is 1% of the total fleet. The highest individual percentages in the reparation facility are for the Universal Trolley lightweight Diethelm (2,29%), the Univeral trolley light weight Driessen (2.62 %) and the Waste trolley light weight Driessen (2,00 %). Currently there is no active method to balance these subtractions per fixed period time frame (as indicated by KCS-Planning manager Buijs(2014), central-planning Stroobach (2014) and NSM-Planning managers Doze (2014). This balance control is required to maintain the total number of items in the active loop. In this way, a shortage is created and can increase in due course if anyone undertakes action. Moreover, the same is concluded for ovenracks because broken ovenracks are not repaired but directly demolished the moment they arrive in the repair location. In this way, a shortage is created anyway. This is observed as one of the reasons for the occuring shortages of ovenracks.

RETURN RATE

The return rate is the percentage of the outgoing flow that returns to the production location [1]. Currently, the return rate is not calculated. This is mainly because the exact incoming flows in KCS-Production are not monitored. Although the flow sizes are unknown, it is theoretically possible to approach the loss rates. This is possible using the formulas provided by Annex C. These formulas enable to calculate the outgoing flow based on the allotment per flight, the timetable and the amount of flight per week. Table **??** shows the input values used to make the calculation on the return rate. The "send to network" input shows the amount of equipment send to the network from KCS-Production. The "replenished" value shows the amount of equipment replenished from KCS-Warehouse to KCS-Production. The return rate is calculated by substracting the replenished from the send to network. This product is deviated again by the "send to network" value. The average return rate for loading equipment is 99,6%. The average return rate for serving equipment is calculated to be 95 % for the items calculated in table **??**. However, there are certain values identified as biased. For example the 89,31% loss rate for knifes, the 94,59% for Water glasses and 93,32 % for MW Liquer glasses. The low return rate shows that serving equipment is more prone to get lost. If the average return rate for serving equipment would be 94%, the average monthly replacement value (theoretic) would be €110.000. NSM-Planning manager Doze (2014) confirms that this is too high. Therefore, it is stated by the researcher that the current return rate for serving equipment is around 98%. An important remark is that there is currently no fleet replacement plan. The fleet replacement plan is required to maintain the fleetsize and overcome the impact of the return rate. The current fleet replacement is applied when a shortage is observed. The fleet size replacement is a shared responsibility of the supply chain specalists (to calculate required replenishment) and the central

Table 3.4: The calculations of the return rate (Source: SAP)

SAP	Description	L/S	Send to network	replenished	Return rate
60290	Ovenrack	L	404612	1483	99,63%
60506	FS Trolley 1/1 Business Class	L	97483	824	99,15%
60507	HS Trolley 1/2 Business Class	L	56084	232	99,59%
60525	Trolley Light Weight Driessen	L	191376	578	99,70%
60533	Trolley 1/2 Light Weight Diethelm	L	567716	1047	99,82%
60590	Square ContainerL	L	116131	566	99,51%
60600	Standard Container	L	575703	1733	99,70%
60787	Glass Rack 14cm	L	188756	729	99,61%
60795	Mug Rack 8 cm	L	76521	429	99,44%
62001	MW Knife Stainless steel	S	2066744	221000	89,31%
62502	MW China Casserole round	S	648487	14000	97,84%
62506	MW Side plate round	S	1394026	59000	95,77%
63800	MW Water glass	S	2110617	118000	94,41%
63801	MW Wine glass	S	2286109	56000	97,55%
63802	MW Liquor glass	S	267955	18500	93,10%
64505	Display tray	S	1467148	35000	97,61%

planners (to observe declining spare inventories in KCS-Warehouse).

Benchmark with literature In order to reflect on the state of the return rate, a benchmark with literature is applied. A very high return rate (close to 100%) makes Closed Loop Supply Chains (CLSC) particularly interesting for reuse compared to CLSC with lower return rates [1]. The high return rate at KLM indicates that this loop is sufficient for reuse. The leaking of CLSC (deviation from 100% return rate) is widely recognized in academic and practitioners-oriented literature ([20];[21];[34];[16];[35])

An overview of 10 different case studies is used to reflect on the return rates of similar subjects [1]. These case studies have different returnable subjects (crates, shoppig carts, service tools) but all indicate a return rate above 90%. This would confirm to leave the return rate of the knifes (as calculated in the previous chapter) out of scope. This return rate is indicates in a case on the global pool size of wooden pallets [36]. Another case description [37] shows the application of a 3pl party to increase the return rate.[1] indicate that the overall return rate (including the three types of losses origins: quality, incidental and structural) is not straightforward. The losses due to damage are controlled (since they fall under the observable part of the supply chain) while losses due to misplacement or alternative use of rotable artcles by other supply chain agents (other airlines that use the same caterer) are not controlled (these losses take place in the unobservable part of the supply chain)[38]. The conclusion is drawn that the return rate is high compared to other case studies that make use of CLSC. However, it is important to identify a different return rate for service- and for loading equipment given their different character.

3.5.4. THE CURRENT CONTROL OF THE DISTRIBUTION COSTS

Currently, none of the cost components, identified by the control panel, are monitored. However, it is possible to reflect on different components of the current state of the costs if certain assumptions on the efficiency ratios are used. The calculation of the fleetsizes is provided in Annex C. The working capital discusses the total financial value currently invested in the equipment fleet at KLM. The total working capital for the current equipment fleet is estimated at €5.331.925,34. The loading equipment represents 96% of the working capital. The serving equipment represents the 4% of the working capital. The maintenance costs at VRR are known and are €300.000 for the year 2014. This is indicated by Project-buyer Meinen (2015). As reflected, the current return rates of the loading- and serving equipment are unknown. However, if the return rates for loading equipment and service equipment are identified as 99,6% and 98%, the annual replacement costs are calculated to be €2.490.216,11. 82% of this value is to replace the lost service equipment. The costs per ride for the driver, fuel and depreciation are calculated to be €60,61 (this calculation is provided in Annex C). The current average amount of rides is identified as 1 per day based on a discussion with KCS-Planning manager Buijs (2014). The control costs represent the amount of FTE concerned for the control of the equipment. The current amount of FTE is identified as 2; in total 1 for the area planners and 1 for the central planners. This is decided in a discussion with NSM-Planning manager Doze (2014). As stated, there is currently no insight in the costs nor does NSM-Planning make a strategy using clear calculations.

3.6. PROBLEM STATEMENT FOR THE CURRENT CONTROL SYSTEM

The sections below discuss the problem statement and the conclusions after analysis of the current equipment distribution. The system requirements paragraph focuses on the general requirements of KLM and what these requirements mean for the equipment distribution. The performance paragraph reflects on the conclusions and observations on the current equipment distribution.

System requirement and the current Control of distribution The system requirements identified in chapter 2 relate to two items; service and costs. NSM-Planning is responsible for the management of equipment, they should monitor the network and request allocation if required. However, there is no central strategy and no overview of the network. The data reliability provided by the outstations is low and there is currently no improvement project to increase this reliability. The relation between NSM-Planning and KCS-Production requires improvement and is currently based on mutual incomprehension. The on-hand inventory in KCS-Production is not forecasted or used by the shift-leader in KCS-Production. They decide on replenishment based on tacit knowledge and experience. There is no procedure to monitor the unobserved additions and the unobserved subtractions to the loop.

The performance of the distribution The analysis of the equipment distribution shows the bad performance of the current equipment distribution. The efficiency of the equipment distribution is too high for the total loop and too low for the active loop. This results in low inventory levels in KCS-Warehouse and too high levels in the Outstation-warehouses. Because of the low inventory levels in KCS-Warehouse, KCS-Production cannot issue. This can lead to problems in production. The high inventory levels in the outstation-Warehouses result in a high working capital compared with what is possible. The effectiveness shows lacking insights in on hand inventory, no insights in the return rate (and no additional fleet maintenace plan) and no balance of the unobserved subtractions and additions. There are no costs monitored or involved in the contemporary management of equipment. The low control of the performance results in shortages and frustration between departments at KLM. It is concluded, based on observations on the system requirements, that the control in the distribution network and the overall performance of the distribution is insufficient. Therefore, the re-design of the control model is required. The next chapter proposes different solutions to the identified problems.

4

Solutions to identified problems

The current control model at NSM-Planning is insufficient. Hence, a new control model is required. This chapter reflects on the different solutions to the identified problems (as stated in the problem statement). The first section introduces the general research question and the sub research question that have their focus on the design of the control model. The third section discusses the required control mechanisms for the new control model.

4.1. Research questions

The problem statement in chapter 3 shows that sufficient control of the different procedures is lacking. Therefore, it is required to design a new control model to improve the management of the fleet according to the requirements of KLM. Based on the applied method of the DSA, in combination with the RPM management model and the aspect systems of the Systems and Control theory, the research question is defined as follows:

"How to improve the catering equipment distribution with a redesigned control model at KLM to ensure availability and reduce total control costs?"

Given the research question and the requirements of KLM based on safety, service and costs, different sub research questions are identified. Hereby, the focus is on costs and service (given the assumption that loading equipment is always applied in a safe way). The following sub questions are identified:

- What are the required equipment levels in the network to ensure availability?
- How to measure and control the relevant parameters for performance in the individual nodes?
- What are the additions and modifications to the existing distribution control model?
- what are foreseen cost reductions when the model is implemented and the equipment distribution improved?
- How to implement the model at the responsible departments within KLM and the network nodes?

The questions above use the current environment with KSSU equipment. However, the possibility to implement new technologies to automatically track data in the network is within the scope of the project. The questions are used to come up with relevant recommendations for the structure of the theoretic framework for equipment control. The first four questions focus on the different components for the system (strategy, targets and procedures). The last question focuses on the implementation of the system in the environment at KLM. Relevant literature, industry report and interviews are used to answer the sub research questions. The focus within KLM is to design the new control model and to design additional tools that increase the capability of NSM-Planning to control the network.

4.2. THE MEASUREMENT AND CONTROL OF RELEVANT PARAMETERS

The measurement and control of relevant parameters is essential to improve the equipment distribution. This section reflects on the measurement and control of the relevant parameters by both NSM-Planning as the network nodes. NSM-Planning is required to identify the strategy and to control its application. The network nodes are required to operate within these boundaries. The identified new control procedures are discussed below per sub-system.

4.2.1. THE MEASUREMENT AND CONTROL OF RELEVANT PARAMETERS IN THE NETWORK

Below, the new procedures to measure and control the relevant parameters in the network are proposed. The first subsection discusses the measurement of relevant parameters. The second subsection discusses the modified control procedures in NSM-Planning. The third subsection discusses the modified control procedures in the network.

THE REQUIRED EQUIPMENT LEVELS IN THE NETWORK

The first required action is to identify the required equipment levels in the network to ensure availability. Currently, there are no safety stocks identified for KCS-Warehouse and the network warehouses. Without these safety inventories, it is possible that stockouts occur both in the network as in KCS-Warehouse. Moreover, it is unknown what the required safety stock is based on the return rate. The identification of the required equipment levels is based on the required service level. The service level is decided by NSM-Planning. If service level is increased, the probabilty of an equipment shortage is reduced but more spare equipment is required. The study focuses on a comparison of the different service levels. An overview of the impact of an identified service level enables NSM-Planning to decide on the service level that suits their requirements. The required spare stock inventories in KCS-Warehouse and the network warehouses are calculated based upon this service level. The calculated inventories are used to identify the preferred efficiency ratios that are targets for NSM-Planning to monitor and maintain.

THE MEASUREMENT OF RELEVANT PARAMETERS

The control panel, shown by table 4.1, shows the overview of the control parameters that measure the performance of the distribution. The first subject in parameter control is to identify the best means of measurement to collect the required data. The current observations in the network nodes are done using two methods. The first method is the manual observation of the inventory levels in the production nodes. These observations are required by the NSM-Planning department to have up-to-date insights on the production floor stock levels in the network. The reliability is questionable and the method is time consuming both for NSM-Planning as the shop floor operators. The second method of measurement is the registrations of stock levels in the warehouses via SAP. Although this data is accessible via the portal, the reliability is questionable. The introduction of a new form of data collection on the relevant parameters increases insight of NSM-Planning in the network. Moreover it can reduce the operational costs through the increase of automation. The focus is to identify the best means of measurements based on relevant requirements. The requirements are identified using the opinion of the relevant actors concerned for the control of the equipment distribution (NSM-Planning, contract managers NSM, operators KCS). The best alternative is identified using a multi-criteria analysis [39]. The identification of the right data collection method increases the reliability of the data and should make it easier for NSM-Planning to have a (real-time) overview of the state of the distribution network.

THE CONTROL PROCEDURES IN NSM-PLANNING

The control procedures in NSM-Planning focus on the overall control of the distribution network. The past chapter identified the control parameters (see table 4.1). It is the objective of NSM-Planning to use the control parameters to steer on maximum service and reduced costs. The control procedures focus on the monitoring of network boundaries, the allocation of equipment, the application of the fleet replacement program and a focus on cost reduction. The different aspects are discussed in the next paragraphs.

Inventory management by NSM The first control procedure is inventory management by NSM. Based on the service level, the inventory boundaries are calculated. These boundary lavels are translated towards the network nodes and the area-planners monitor if these maximum levels are respected. New design of the penalty structure is required to clear the current indistinctness on this part. Moreover, the contract manager is used to increase commitment of the outstations. The NSM-planners order allocation of equipment if they monitor exceeding levels in the network. The urgency of the return is determined by the central planner

Table 4.1: The equipment control panel for NSM-Planning (Source: Own production)

Category	Control aspect	Control parameter
Efficiency	Efficiency total network	Total % equipment
	Efficiency active network	Total % equipment
Effectiveness	On-hand inventory	Total % per outstation
	Inventory balance	Total % per equipment type
	Return-rate	MA in % per equipment type
Costs	Total working capital	Total value in €
	Maintenance and replacement costs	Total value in €
	Transportation costs	Total value in €
	Warehousing costs	Total value in €
	Control costs	Total value in €

(based on the availability of equipment in KCS-Warehouse). Analysis shows that there is currently no control by NSM-Planning on the inventory in KCS-Warehouse. Increased control on the control leads to improved efficiency parameters (inventory balance and availability of on hand inventory). Moreover, central planning can focus on forecasting and tailored planning of replenishment. If the forecasting capability is improved, the amount of logistics costs for replenishment is reduced.

The application of the fleet replacement program The second new control procedure focused on the application of the fleet replacement program. Currently there is no replacement program and additions to the network are organized on ad-hoc base. The new procedure focuses on a calculation of the required volume based on the return rate. The fleet replacement is organized by NSM-Planning and pushed into the inventory of the hub caterer KCS-Production. It this way, the replacement of catering equipment is organized proactively rather than passively.

4.2.2. THE MEASUREMENT AND CONTROL OF RELEVANT PARAMETERS IN THE NETWORK NODES

This section describes the new control procedures and structures required in the new control model. The network nodes operate based on the boundaries proposed by NSM-Planning. The new control procedures are discussed for KCS and the outstations.

THE REQUIRED CONTROL PROCEDURES FOR KCS

The required control procedures in KCS focus on two aspects: the performance of data collection and the increased collaboration of KCS with NSM-Planning. The first required control procedure at KCS is the focus on data collection. This is mainly identified for KCS-Production. Since KCS-Production is the central node of the distribution network, it is the best point to measure effectiveness rates for inventory balance, on-hand inventory and return rate. As discussed, a new method for data collection is identified in the next chapter. This method for data collection is used to measure all the incoming and outgoing flows. This method is proposed by the RPM management model [1]. Regardless the identified data collection method, implementation is required in the operation of KCS-Production. Moreover, compliance with the required collection method is essential for the feasibility of the data collection method. There is currently no control over the inventory in KCS-Production by NSM-Planning. Different possible new control procedure can increase the control by central-planning and improve the service (availability) of the equipment while reducing the costs. Therefore, the focus is to increase the reliability of inventory forecasting. Moreover, it is required to increase decision making on replenishment compared to the current situation. The collaboration is also focused on increased standardization. Currently, definitions about certain procedures (emergy scenarios) and mutual agreements on requirements lack. To increase collaboration, mutual agreements are required on standard procedures (replenishment, scanning, spare inventories).

THE REQUIRED CONTROL PROCEDURES FOR THE OUTSTATIONS

The required control procedures in the outstations focus on two aspects: the administration of inventory movements and the increased collaboration of KCS with NSM-Planning. The data reliability within the outstations shows signs that improvement is required. The control procedure is focused on the improvement of the data administration within the outstation. Moreover, active control and feedback by NSM-Planning on the data reliability and administration in SAP is required. Analysis showed also that the current inventory compliance is low. The new control model is required to warn the outstations with (automated) messengers that provide direct feedback on the compliance of the outstations with the regulations. This concerns both good as negative behavior. The outstations should improve their procedures to keep the inventory in production within the boundaries of the allotment. The inventory in the warehouse should be kept below the maximum level as proposed by the area-planners (based on NSM strategy).

4.3. ADDITIONAL ELEMENTS

The research question focuses on two additional elements of the solution. First of all, a quantitative case study is required to show the potential impact of the new control model. The current impact of the equipment distribution on the total control costs is unknown. Insights in the possible financial benefits of a new control model can increase the commitment for change. Moreover, it shows the impact of the different elements of the new control model. Examples of sub-elements discuss the impact of improving return rate, the impact of reducing working capital and the impact of reduced transportation costs between KCS-Warehouse and KCS-Production. The focus is to make the financial case study based on input parameters. NSM-Planning can use the dashboard to simulate the impact of foreseen strategic decisions on the total control costs.

The second additional solution to the problem discusses the implementation plan. As discussed in the past chapter (4.2.1 and 4.2.2) many new control procedures are proposed. Moreover, it is foreseen that a new data collection method is implemented in KCS-Production. Analysis showed that many actors are concerned with the current distribution network; several management departments and operators in Amsterdam and 58 worldwide locations. To ensure smooth implementation, a comprehensive implementation planning is required. Literature shows that implementation is improved if an implementation program is designed based on commitment. The structure for implementation [5] is identified to design the implementation of the new control model. This model proposes the required state of commitment per implementation phase and indicates projects per phase. Moreover, the implementation should provide information on the potential bottlenecks for implementation.

4.4. CONCLUSIONS

This new control model enables the NSM-Planning to decide on the strategy for the equipment control, to apply this strategy in the network and to measure the performance and impact of the strategy. Using this control model, NSM-Planning improves their operations on costs and service. This leads to increased efficiency and reduced costs. This enforces a shift from an uncontrolled situation with shortages and low visibility towards a controlled situation with shortage prevention and increased visibility. Moreover, the collaboration between the different parties within the network improves and it is easier to identify possibilities for CAPEX and OPEX reduction.

5

THE DESIGN OF THE NETWORK CONTROL MODEL

This chapter elaborates the design of the new network control model. This first section identifies the network control structure that NSM-Planning applies to the network. The second section reflects on the design of the aspect systems (measure, compare, decide and act). These individual components are used for the construction of the new control model in section three. This section introduces the new steady state system design and the new control procedures in NSM-Planning, KCS and the Outstations. The fourth section describes the improved state of the equipment distribution.

5.1. THE DESIGN OF THE NSM NETWORK CONTROL

This section elaborates on the design of the NSM network control model. The first section elaborates the identifciation of the control policy; this reflects on the approach how NSM controls the distribution network and how it decides on strategy. The second section of this chapter discusses how NSM-Planning translates and applies the strategy to the network nodes.

5.1.1. THE IDENTIFICATION OF THE CONTROL POLICY

NSM-Planning is required to control the network. The current control is decentralized for KCS-Production, OS-Production and OS-Warehouse. Only the control on KCS-Warehouse is (partly) centralized. To increase control on the network, it is important to reflect on the control policy applied by NSM-Planning. The theory on Vendor Managed Inventory is used to identify the possibilities for increased control of inventory in a network. The desired network inventory control by NSM-Planning is comparable with the theory on Vendor Managed Inventory (VMI) [40]. VMI is a supply-chain initiative where the supplier is authorized to manage the inventories of products at the retailers warehouses and stores. Within VMI, the customer's warehouse is the most important information source. The application of VMI can lead to reduced costs and improved service [40]. In VMI, the vendor assumes responsibility for managing inventories at retailers using advanced online messaging and data-retrieval systems ([41], [42], [43]). Reviewing the retailer's inventory levels, the supplier makes decisions regarding the quantity and timing of resupply. Decentralization should be applied where quick decision making due to changing technologies and environment is necessary and the flow of new information is upward through the hierarchy [44] [45]. On the other hand, centralization can have beneficial coordination effects [46] [47]. For KCS-Production, the centralized control method is identified as the suitable control policy. NSM-Planning actively controls the inventory levels and provides replenishment when required. NSM-Planning can do the monitoring if automatic measurement of inventory levels and/or incoming and outgoing flows is implemented. This to standardize the way KCS-Production is balanced. Moreover, NSM-Planning can control the replenishment and logistics costs. KCS-Warehouse requires centralized control since it has no control body in the warehouse. The warehouse operators only operate based on assignments by NSM-Planning. The decentralized control is proposed for the outstations [45]. This because the decision-making focuses on the outstation operations. These decisions are required to be made within the boundaries stated by NSM-Planning. NSM-Planning is required to monitor the outstation dynamics and they should undertake action if required. The overview of the decisions is shown in table 5.1.

Table 5.1: The identified control approach for the network

Network node	Control approach	Comments
KCS-Production	Centralized	Collaboration on the decision for replenishment
KCS-Warehouse	Centralized	Inventory management by NSM to ensure availability
OS-Production	Decentralized	Monitoring by NSM to view if regulations are being followed
OS-Warehouse	Decentralized	Monitoring by NSM to view if regulations are being followed

5.1.2. THE TRANSLATION OF NSM-STRATEGY TO THE NETWORK NODES

The main purpose of the control model, aside from the prevention of shortages, is to improve the distribution of the catering equipment. These improvements are using the relevant parameters identified in chapter 3. This chapter discusses how the strategy is translated into the network. First the strategy making is discussed, then the translation by NSM-Planning of the strategy towards operational boundaries. The last paragraph discussed the control required in het network nodes.

The decision on strategy The control panel is used to identify the boundary levels for the system. NSM-Planning managers are required to make a long-term vision (for example 5 years). This strategy is translated to yearly goals for efficiency, effectiveness and costs. These yearly targets are translated into boundaries for the operations per control parameters. The most important aspect is the decision on the required service level. If the service level is increased, the number of stock-out is reduced but more capital is required to invest in (spare) equipment to the network. The choice for a service level dictates the required spare stock inventories in the warehouses. These warehouse inventories are used to calculate the efficiency ratios for the network. This means that the choice for service levels is directly connected to the efficiency ratio for the active- and total loop. The first effectiveness aspect is the desired level of outstations with the right on-hand inventory levels. The closer the ratio gets, the better the outstations operate according to the KLM regulations. For the inventory balance, it is decided on the maximum bandwith (positive or negative). For the return rate, it is decided to operate towards a theoretic best return rate of 100%. For the costs, the strategy definition is based on different cost levels and the aim for reduction. Examples are targets on 10% cost reductions for transportation costs or control costs.

The application in NSM-Planning NSM-Planning is responsible for the translation of the NSM strategy towards the boundaries for the network. Input for NSM-Planning is the target for the equipment performance. The planners translate this target into inventory boundaries or maximum budgets. These boundaries are communicated to the network (both KCS as the outstations). NSM-Planning monitors the new strategy in the network and orders the allocation of equipment if the boundaries are exceeded or if required minimum levels are not obtained due to shortages. At the same time, NSM-Planning starts the replacement program based on the return rate. This replacement program replaces the broken or lost equipment. Moreover, NSM-Planning can start specific target projects to improve the state of specific parameters. Examples are the focus on effective inventory balancing in KCS-Centrum by designing a new balancing tool, the reduction of transport between KCS-Noord and KCS-Warehouse through increased forcasting and centralized control of the replenshment. Many projects are possible to improve the equipment distribution aside from active equipment allocation [1]. The network nodes are monitored if they keep their flows and inventories of equipment within the required boundaries. According to the decentralized control approach, they operate autonomous and NSM-Planning monitors their behaviour. The monitoring occurs either through the analysis of inventory data or through observations on the field by Contract management.

5.2. NETWORK NODE CONTROL MECHANISMS

The past chapter reflects on the control panel with the approach to identify the strategy and to structure to to translate this strategy towards the network. This chapter continues by designing how NSM-Planning monitors the strategy in the network. Therefore it is, as mentioned in the introduction, required to design the aspect systems for measure, compare, decide and act. The measure aspect system design discusses what is required to be measured with what frequency. The compare systems discussion elaborates on the inventory-

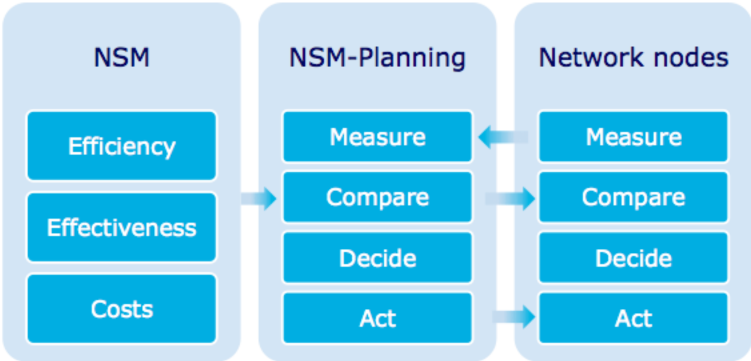


Figure 5.1: The identified network control structures at NSM-Planning (Source: Own production)

and review policies and the regulations how to compare the measured data. The decision- making aspect systems elaborate the decisions NSM-Planning is required to make. The act-system discusses different actions that NSM-Planning can apply to control and improve the network.

5.2.1. THE DESIGN OF THE ASPECT SYSTEM MEASURE

This section elaborates on the aspect systems for measurement. The first section elaborates on the identification on the means of measurement. A multi-criteria analysis using different means (both manual and mechanical) and requirements identifies the best measurement method for the required data in the network. The selected measurement method is used for system design in the network nodes. The second subsection discusses the collection of different cost aspects.

THE DATA COLLECTION METHOD IDENTIFICATION

This subsection discusses the choice for a methodology that measures the required supply chain data (inventory levels, return rate) in the network. A Multi-Criteria-Analysis [39] is used to define the best alternative based on the relative weights of the requirements for the relevant actors concerned. Annex B provides a comprehensive description of the alternatives and the identification of the best alternative. This section provides a summary of the requirements, the alternatives, the scoring and the reflection on the result of the MCA method. The comprehensive elaboration on the identification of the method is found in Annex B.

Requirements Based on the interviews with NSM-Planning manager Doze (2014), NSM-Operations manager ten Veen (2015), KCS-Planning manager Buijs (2014) and review of literature, different requirements are identified. The identified requirements are operational costs, implementation time, completeness and reliability, investments and scalability. The operational expenditure of the measurement systems discusses the costs to run the system in steady state. The costs are related to the manual costs (amount of FTE required), ICT costs (maintenance and costs of running the system) and general operation costs. Manual operations have high manual costs since it is operated completely by humans. Active RFID has low manual labour costs since no manual scanning is required and the scanning can be applied during the transporation within the production facility. The ICT-costs are low for manual operated systems and high for the active RFID system. The capital investments discuss the total investments concerned for the initial set-up of the setup. The required investments for manual measurements are low since no big investments are required except for the design of (Excel) tools and training of the people. The investments grow if additional features (barcodes, RFID tags, antennas, readers) or additional (ICT) infrastructure is required. Open-source software can reduce the capital investments. The requirement implementation time discusses the duration of the total implementation procedure. The data reliability depends on both the type of observation, the structure for data administration, the governance and whether the system is prone to errors. Manually observations are sensitive to error making and there are many steps between the field observation and the final tracking of the observations in the system. People can misread the trolleys, make errors in observations or have lack of compliance with the designed procedure. Barcode scanning shows good reliability if the scanning procedure is rightly applied. However, if people apply the scanning, misalignment with the procedure can occur.

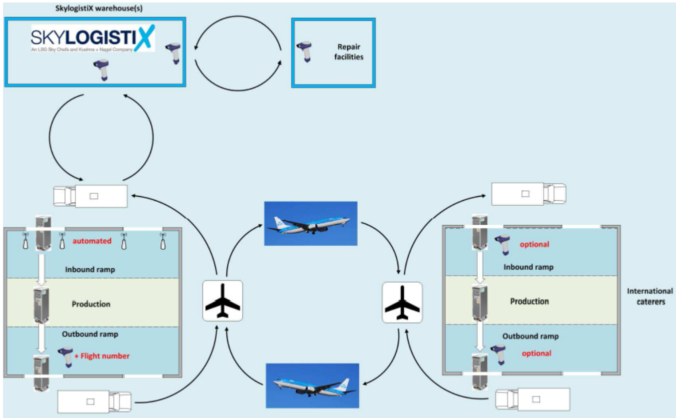


Figure 5.2: The barcode + RFID scanning scenario as proposed by SkyLogistiX [3]

Means of measurement This section discusses different means of measurement used for the MCA. The measurement methods discussed (in the Annex) are manual counting, barcode, passive RFId, active RFID, Barcode+RFID, Wifi and GPS. The Annex provides the elaboration on the identification process of the final input measurement methods for the MCA. The main focus hereby was the feasibility of the method and implementation. This excluded Wifi (low readability, GPS) and Active RFID (too expensive). The final list of technologies exists of RFID, Barcode, RFID+Barcode and two types of manual counting: Manual counting 1 (current setup) and manual counting 2 (first phase of the possible implementation of the new control model). A Passive RFID systems consist of a reader, a tag, and a computer and the system provides a snapshot of a nearby asset in a given time [48]. An advantage of passive RFID technology for managing containers is that is doesn't require the reader or scanner to see or contact the tag; a path of a reader is sufficient. Given the minimum manual activity, RFID is a very reliable method (if the tag is not damaged). Barcode technology, companies can more effectively track, control, recover, and secure returnable shipping assets during their entire lifecycle (Vertigo, 2009). Barcode systems offer relatively accurate identification rates and have a low misread ratio [49]. On the other hand, disadvantages also exist with a barcode system because each individual asset must be manually scanned and the barcode must be visible. This reduces the reliability of the method since manual labour is required. The Barcode + RFID scenario is a scenario that combines the RFID and barcode system to track both loading equipment and serving equipment [3]. Figure 5.2 shows the set-up of this data collection scenario.

Scoring of the MCA: the identification of the weights of the requirements The first task within the AHP procedure is to identify the general hierarchy of the requirements. The results of the scoring are provided by table **??**. The scoring of NSM-Operations shows the focus on Reliability and operational expenses. The scoring of NSM-Planning manager shows that she focuses on reliability and scalability. This is the exact same viewpoint as the planners (both area and central). The scoring of KCS-Operational shows their preference for scoring on operational costs. As indicated before by KCS-planning manager Buijs (2014) and KCS-operations manager Zwager (2014) they have a strong focus on (operational) cost reduction. Their low preference for data reliability and scalability can indicate that they are not concerning forecasting or additional administrative activities. The scoring of KCS-Planning shows their preference for the attribute scalability. This was expected since they suffer from shortages for serving equipment. The scoring of Central- and Area-Planning shows the same pattern. The scoring of the Researcher shows the importance of the reliability and scalability. The (relatively) least important aspect is the implementation. In general, it is concluded it is important that the collected data is reliable. All the actors indicate reliability as the most important aspect (except NSM-Operations management but she indicated it as the second most important aspect). Almost all the actors give relatively low importance to the attribute implementation time.

The assessment of the methods on the requirements Table 5.3 discusses the final result of the calculation whereby the scoring input is balanced using the preferences for the individual requirements/attributes. In general, it is stated that all the actors have the relative preference for the implementation of the Barcode + RFID scenario. The sole exception is KCS-OPS. They have the preference for only the RFID scenario. Given

Table 5.2: Relative requirement preference per actor (Source: Saaty Scoring NSM)

Function	NSM-O	NSM-P	KCS-O	KCS-P	Central	Area	Research
Reliability	0,32	0,47	0,16	0,28	0,41	0,45	0,442
Scalability	0,10	0,33	0,09	0,47	0,26	0,25	0,26
Implementation	0,13	0,12	0,02	0,06	0,05	0,05	0,06
CAPEX	0,14	0,04	0,23	0,05	0,17	0,09	0,10
OPEX	0,28	0,05	0,48	0,14	0,11	0,15	0,16

Table 5.3: Relative preference per actor for the data collection methods (Source: Saaty Scoring NSM)

Method	NSM-OPS	NSM-P	KCS-O	KCS-P	Central	Area	Researcher	Share
Barcode	0,17	0,32	0,09	0,16	0,16	0,17	0,17	17,50%
RFID	0,27	0,25	0,43	0,20	0,25	0,16	0,15	24,35%
Barcode+RFID	0,45	0,35	0,10	0,32	0,47	0,59	0,34	37,34%
Manual 1	0,05	0,03	0,25	0,19	0,05	0,04	0,18	11,41
Manual 2	0,05	0,05	0,12	0,14	0,08	0,05	0,17	9,40%

the interview with KCS-operations manager Zwager (2015), this was expected. She indicated the doubts for the feasibility of the implementation of the barcode scanning in production (also indicated by the scoring for the barcode scanning scenario by KCS-OPS). Moreover, KCS-operations manager Zwager (2014) indicates that she prefers to remain with the current manual scenario. Mainly every measurement method that involves change on the production floor is low scored (manual 2: 0,12; Barcode: 0,09 and Passive+Barcode: 0,10). The KCS actors indicate the fact that manual counting 1 is preferred above manual counting 2. The results also indicate that NSM is in favour of avoiding the manual counting scenarios. This is strongly correlated with the preference for the attribute reliability.

Scoring using relative weights for actors Analysis of the system and the observation of the results shows that it is possible to make different scenarios to weigh the results per actor. In total, 7 different scenarios are identified and shown in Annex B. The equal weights scenario assigns a weight factor of 1 to all different actors. The "NSM Only" scenario is used to identify the result if only the actors within NSM-Planning are involved. The "operational focus" scenario is to investigate the result with increased weigh to the operational functions within KCS and Area- and Central planning. Since Area- and Central planning are concerned for the planning of equipment distribution, their weight is higher than the KCS weight (4 vs. 2). The "NSM Hierargy" scenario incorporates the hierarchy of different functional levels within KLM. The "filter on consistancy ratio" scenario filters the results out of the final result that are too high. The "Bias filter" scenario focuses on the two actors (Actor and KCS-P) whose results don't show the biased attitude towards Barcode+RFID shown by the other actors. The "researcher only" scenario observes the objective scoring since the research has no functional preference for a collection method. Table 5.4 shows the results of the scoring with different scenarios. Hereby the final scoring per scenario with the weights for the actors are provided. The first observations for all the scenarios, is that barcode+RFID is the preferred method; the preference varies between 32,72% (for the "not exceeding CR" scenario and "Bias filter" scenario) 44,33% (the NSM hierarchy scenario). The preference for

Table 5.4: Scenario study results (Source: Saaty Scoring NSM)

Scenario	1	2	3	4	5	6	7	Average
Barcode	17,50	19,60	16,37	21,73	15,95	15,95	16,37	17,64%
RFID	24,35	21,43	24,23	24,07	17,39	17,39	14,87	20,53%
Barcode+RFID	37,34	43,91	41,88	44,33	32,72	32,72	33,75	38,09%
Manual 1	11,41	7,13	9,52	4,37	18,42	18,42	18,01	12,47%
Manual 2	9,40	7,94	8,01	5,50	15,52	15,52	16,99	11,27%

Barcode and RFID increases if the relative weight for NSM is increased. Within NSM, this is mainly through the influene of the management (observed through the comparison between scenario 2 and 4). The scenario with the exclution of the exceeding CR values shows a slightly different result than the other scenarios. The scoring of scenario 5 and 6 is the same since the actors observed to be neutral (not biased) also have scores with the right CR value. The results of scenarios 5 and 6 show the lower preference for Barcode-RFID than the other, However, the barcode + RFID scenario remains the preferred collection method. The scenario scores Manual 1 as the second-highest scenario. However, given the scoring of the other actors, the scoring deviates too much from the observations of the other scenarios for manual counting. The results of the researcher show the preference of the manual counting compared to the technologies. This is mainly because of the relatively high value for scalability (this results in a low value for RFID only), a high value for OPEX (this results in a relatively low value for RFID, Barcode and RFID+Barcode). The manual counting methods score relatively good since they score good on scalability, CAPEX and OPEX. The conclusion is drawn that barcode + RFID is the preferred method given the preferences and the scoring on the attributes by the actors involved. Even different scenarios, whereby the weight of the actors is varied show the preference for Barcode + RFID.

The physical/operational application of scanning The MCA identifies the barcode+RFID scenario as the preferred data collection method. Although the method is scalable to almost all the equipment types, there are practical constraints. The physical handling to perform scanning for the service equipment can result in delays in the process. This probability for delay could be one of the reasons for the preference for the current data collection method by KCS-Operational in the MCA. This observation indicates that the application for the barcode and RFID scenario is questionable. This observation is reinforced by the fact that the working capital of service equipment is small (5% of the total) compared to the total invested value in equipment. Therfore the decision is made to perform scanning on the loading equipment. Annex B provides the background information on the identification of the specific equipment types. The choice is made to focus on the loading equipment types with a value above €25 per equipment type combined with decentralized scanning. With this decision, 95% financial share of the working capital is scanned and tracked in the network.

This decision means that the trolleys (and loading equipment with wheels) are equipped with RFID according to the RFID+Barcode scanning scenario. The drawers, containers and other loading equipment types are equipment with barcodes. The moment the equipment enters the inbound storage equipment; the warehouse operators perform the scanning. Observations in KCS-Production show sufficient capacity for the warehouse operators to perform the scanning during the unloading of the inbound trucks. The moment the equipment is pulled in production, the barcodes are scanned again. No additional procedures are required for the RFID scanning since physical thresholds with antennas perform the scanning.

The choice for the equipment types as mentioned above means that 61% of the annual replacement value is traceble within the network. The additional 39% is not traceble (this inclued knifes, forkes and other types of serving equipment). It is recommended to start with the current boundaries and to focus on its cost reduction. Increased control on the outstations on the types of equipment in scope of scanning may also result in improved behavior on the types that aren't in scope. Additional research can be performed how to increase the tracability of the equipment types that are currently out of scope. Given the current maturity level of the organization, the choice is made to focus on the equipment types with this minimum value.

CALCULATING DATA FOR EFFECTIVENESS AND EFFICIENCY

The RFID and Barcode system measures the in- and outgoing flows in KCS-Production. It assigns the outgoing-flows to the indicated destination in KCS-Production. These destinations are either outstation-production nodes, KCS-Warehouse or VRR. The efficiency ratios make use of the inventory levels in specific locations. The inventory in outstation production is calculated using equation 5.1. This is calculated using the outflow to the outstation minus the return flow from the outstation minus the allotment. The result of this calculation is merged with the inventory level at To. The calculations assume that every piece of equipment that exceeds the allotment is transferred to the warehouse. The aligment of the procedure is verified through the comparison of the inventory level in the warehouse (in SAP) with the theoretic value.

An example is provided for the outstation in New York. In one week, 7 flights with KLM trolleys have flow to New York (JFK). Each day, one aircraft with 10 trolleys left for New York (70 in total). After 7 days, 7 aircrafts have returned with 6 times 10 trolleys and 1 time 8 trolleys. Via SAP, it is read that the inventory is 1 trolley.

$$I_P = I_{OS} - I_{SAP} - n_{flight} \tag{5.1}$$

$$I_{OS} = F_{OS} - F_{AMS} + I_{OSO} \tag{5.2}$$

$$r_{return} = \frac{F_{OS} - F_{AMS}}{F_{OS}} \tag{5.3}$$

$$b_P = F_{OUT} - F_{IN} \tag{5.4}$$

I_{OS}	Inventory Outstation
$F_{OS\alpha}$	Flow towards Outstation α
$F_{AMS\alpha}$	Returnflow to Amsterdam from Outstationα
I_{OSO}	Inventory outstation at t_0
I_P	Inventory production
I_{SAP}	Inventory registrated in SAP
r_{return}	Return rate
b_P	Balance in Production
n_{flight}	Flight on route

The identified allotment is 1 trolley. The inventory on the production floor is calculated to be 2 trolleys.

LOGISTICS COSTS MEASUREMENT

Besides the operational parameters measured in the network, also different cost components are measured for the network. Below, different aspects are discussed. Per cost component, first different aspects are discussed then it is decided which cost components is part of the final monitoring for the control panel. For NSM-Planning, the total working equipment is defined as the total inventory times their value. The costs for BBO and Pantry shipments are calculated using the amount of shipments times their costs. Further analysis of these costs can result in a deployment with the costs allocated per department. The transporation involve all the costs for the transportation of the equipment in between the network nodes. For the dashboard it is decided to measure only the costs between KCS-Warehouse and KCS-Production. These costs are for the account of KLM and are reduced when equipment is actively managed. The warehousing costs represent the costs for the storage of the passive equipment. It is calculated using the inventory per location times per warehousing costs per time frame. The costs involved for the control of the fleet in both KCS, NMS as the outstations. It is possible to calculate costs for the FTE concerned for planning (FTE at NSM-Planning, KCS, Outstations), measurement (FTE at KCS and Outstations) and ICT systems (costs for the operating system of Barcode, RFID). Collecting different financial values from the network, it is possible to calculate (roughtly) the majority of the total costs of ownership. The cost components above are input for the new control panel and is shown using graphs with moving averages. More on the actual design of the control panel is discussed in chapter 7.

5.2.2. THE DESIGN OF THE ASPECT SYSTEM COMPARE

This subsection elaborates on the different subjects for the compare aspect systems. Based on the inventory policy, there is either no spare stock (JIT-policy), minimum level (safety stock or re-order point), or a maximum/bandwidth (min-max policy). These policies are discussed in the first subsection. Based on the review policy, subjects in the network are either continously- or per fixed-time period reviewed. Both items are discussed in the second subsection. The conclusion discusses which items are applied in the system in which nodes.

INVENTORY- AND REVIEW POLICIES

This section discuses the identification of the inventory policies for the network nodes. Different inventory policies compared with eachother are Just In Time (JIT), safety stock, re-order point and the min-max inventory policy. JIT, as part of the lean management philosophy aims to minimize the costs of inventory [50]. In addition, the degree of time laps between materials arrivals, processing and assembly of the final product for consumers is minimized by the JIT technique [51]. The safety stock is the inventory level that, in case everything happends according to the forecast, is reached when the replenishment order arrives [52]. The safety stock is a suitable method to apply in the network nodes since there is a regular utilization pattern. The average utilization is calculated using the return rate [1]. The re-order point is the point where new replenishment

Table 5.5: The compare systems for the equipment distribution system (Source: Own production)

Location	Inventory policy	Review policy	Comments
KCS-Production	Min-Max policy with JIT loss replenishment	Continuous review	Possible implementation of a "bin" system
KCS-Warehouse	Re-order point with safety stock	Continuous review and Fixed period review	Review SAP stock level with fixed-period review inventory count
OS-Production	Min-Max Policy	Continuous review	Focus on active compliance with allotment
OS-Warehouse	Min-Max Policy with safety stock	Continuous review and Fixed period review	Review SAP stock level with fixed-period review inventory count

orders are made based on the size of the order and the leadtime vs. utlization per timeframe and proposes a solution for the network [52]. The min-max policy is seen as the opposite of the JIT policy [50]. The question how often the measurements are reviewed is based on the review policy for the specific node based on their function. The possible review policies are either continuous (continuous review) or once per given period (fixed-time period). Continuous review of the production locations is observed to be insufficient if manual measurement is required. Opposite to the continuous review, there is a fixed time period review model. The fixed-time period review is used to review the inventory at a standardised moment in time (for example once a week, month) [52]. In environments with low dynamics or low possibilities for tracking, it is recommended to review the inventory using a fixed period time review.

The identified inventory policy for KCS-Production is the min-max policy combined with a JIT approach for loss replenishment. The minimum inventory is identified by the shiftleader in KCS and is based on the minimum amount of equipment that is required in the inbound inventory to ensure production. According to KCS shiftleader Kelen (2014), this minimum is based on the production rate in the first 75 minutes in the morning. The JIT aspect that is applied within KCS-Production, is related to the required replacement program. The flow is identified as a stable process with a stable return rate (often a 12 month moving average is used[1]). Based on this return rate, repetitive replacement of lost equipment is required. It is decided, based on the JIT ideology, that monthly replenishment is applied from KCS-Warehouse to KCS-Production. More on the return rate and the applied replenishment is discussed in chapter 5.2. The KCS-Warehouse is the storage for spare equipment. The utilization of this spacestock is either for repetitive replacement based on the return rate and for additional demand for new stations, changing loading profiles. The OS-Production is very restricted in terms of inventory boundaries. As analysis shows, these restricted inventory levels are required to increase insights and increase control on outstation inventories. The maximum level for each equipment type is indicated by the allotment. The minimum level is also determined by the allotment. If the inventory is below the allotment, inventory is issued from the OS-Warehouse or from KCS-Warehouse/KCS-Production. If the inventory exceeds the allotment, the equipment is transferred to the OS-warehouse where it becomes visible for the NSM area planning. The OS-Warehouse is an entity where safety stock is combined with rotational stock (as shown in picture 5.3). The rotation stock is based on the expected losses (based on the return rate) and the safety stock based on these expected losses. The recommendation can be made that this safety stock is mainly applied for the service equipment. The measured return rate of loading equipment is small compared to the serving equipment and therefore NSM-Planning can decide to distribute only service equipment spare capacity. However, this is up to NSM-Planning to decide. This thesis continues with safety equipment for both the loading- and serving equipment.

THE REQUIRED EFFICIENCY BASED ON SERVICE LEVELS

The control panel reflects on the efficiency of the equipment distribution. Using the ratios for the efficiency of the active and total loop, it is possible to calculate the required inventory levels in the network nodes. However, it is also possible to calculate the minimum required inventory levels in the network nodes based on service level. This minimum required inventory level is calculated using the safety stock theory. The safety stock theory proposes a method to calculate safety stock inventory levels based on the dynamics of

Table 5.6: The input parameters for the safety stock calculations

$$I_{safety} = Z * \sqrt{(T_{leadtime} * SD^2_{demand}) + (I_{demand} * SD_{leadtime})^2} \quad (5.5)$$

I_{safety}	Safety stock inventory
Z	Z-value (represenation of service level)
$T_{leadtime}$	Leadtime in days
SD_{demand}	Standard deviation of demand in units
I_{demand}	Average demand per timeframe
$SD_{leadtime}$	Standard deviation leadtime in days

demand and leadtime (and their standard deviations). This chapter identifies the required service level for the equipment distribution and the influence on the required efficiency ratios for the active and total loop. This section introduces firstly theory on safety stock and continues with the required efficiency ratios based on the service levels and the indicated return rates.

Theoretical background on safety stock The method proposed by literature to compensate supply chain weakness, is safety stock. Safety stock is used as an essential element to cover external issues for delivery performances, improper scheduling, inadequate product capacity, poor maintenance [53][4]. When both demand variability and lead time variability are present, statistical calculations can combine to give a lower total safety stock than the sum of the two individual calculations. In cases where demand and lead time variability are independent, the combined safety stock equation is as shown by equation 5.5[4]. In other words, the safety stock is Z-score times the square root of the sum of the squares of the individual variabilities. The calculation of the safety stock, together with the allotment leads to the calculation of the minimum required inventory levels. The higher the service level gets, the lower the probability of stock-outs [52]. The service level is translated into the Z-value. The Z-value is used in standard statistics for calculating the confidence interval for a customer service level [54]. The cycle stock reflects on the inventory level in the network node used to process the normal procedure. Deciding on the right service level for a certain product is essentially through balancing the inventory costs versus the cost of a stock out. Often the associated cost functions are not only business, but product specific. Therefore it is recommended that KLM implements a product specific service level. A typical service level in retail is 95%, with very high priority items reaching 98% or even 99%. Often, rankings used to determine the priority include turnover, profitability, number of orders, COGS (cost of goods sold). For example 80% of the turnover: high service level, next 15% turnover: medium service level and last 5% turnover, loew service level. For the approach at KLM, the choice is made use equal importance of the equipment since there is no distribution of turnover. In collaboration with NSM-Planner Doze and NSM-Operations manager Veen, it is decided to focus on a maximum number of stock-outs per month.

An example of the safety stock application is the rotation of the inventories in the outstation production facilities or KCS-Production. The cycle time in the production facility is identified as 1 day. The cycle time in the warehouse facility of KCS-Production is identified as 31 days (one month). The service levels reflect on the probability that a cycle is prone for shortages. The combination of cycle time, cycle stock and service is shown in picture 5.3.

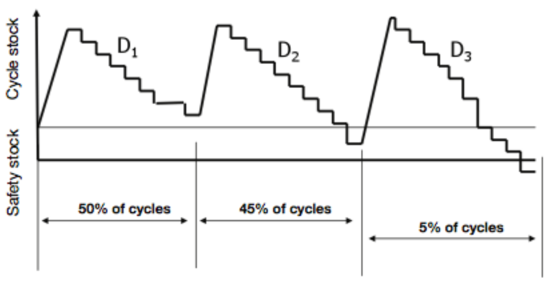


Figure 5.3: The influence of the service level on the inventory [4]

Table 5.7: The total expected number of stockouts for the equipment fleet at KLM

Service level	Monthly stockouts OS-W	Monthly stockouts KCS-W
84,00%	228,73	7,52
85,00%	214,44	7,05
90,00%	142,96	4,7
95,00%	71,48	2,35
97,00%	42,89	1,41
98,00%	28,59	0,94
99,00%	14,30	0,47
99,90%	1,43	0,047

The desired service levels The safety stock levels are calculated using the formula and the input parameters. The safety stocks are calculated separetely for KCS-Warehouse and the outstation warehouses. This seperate calculation enables NSM-Planning to calculate the efficiency for both the active- and total loop. The active loop has a quick rotation period (1 day). A high service level is required since otherwise a high number of stock outs occurs per year. The total loop makes use of the KCS-warehouse to store spare equipment. The cycle time for the KCS-Warehouse is identified as 31 days. In this way, the monthly fluctuations in KCS-Warehouse are used for both the replacement and the identification of the safety stock. The identification of the required service levels is based on the preference to have less than one stock-out per month with 47 different catering equipment types. Table 5.7 shows the influence of the service level on the probability of the stock-outs in KCS-Warehouse and OS-Warehouses. The table shows that for the service level in KCS-Warehouse, the desired service level is 98%. This results in 0,94 stock-outs per month. The desired service level for the OS-warehouses is identified as 99,9%. This results in 1,43 stock-outs per month. This is the lowest possible amount of stock-outs given the standard service levels. The total amount of stock-outs for the total equipment distribution is 3 per month. NSM-Planning manager Doze (2014) and NSM-Operations manager Veen (2014) confirm that this meets their desired level.

Required efficiency levels The inventory for outstations is grouped under "spare inventory outstations". The inventory in KCS-Warehouse is a combination of the safety stock and the average inventory level the cycle stock. The monthly cycle stock is the required replacement per month. For the service equipment, the required active loop efficiency is 97,85% and for the total loop efficiency 89,00%. The efficiency ratios for the loading equipment is 98,80% for the total loop and 99,70% for the active loop. These ratios are used for the further calculations as the reflection of the optimized distribution for service. More background information on the network thresholds is provided in annex A.

EFFECTIVESS AND COST COMPARISON

The on-hand inventory observes if different productions nodes have sufficient equipment inventories for production. The parameter is the amount of network nodes that have compliance with the regulation divided by the total nodes in the network (58 ICA destinations * 2 + KCS-Warehouse + KCS-Centrum)= 118 nodes. It is possible to start in the early phase with a target on-hand inventory parameter of 80% and to increase it later on up to a (theoretic) 100%. The fleet balance calculates per equipment type in scope (loading equipment) per fixed time period the balance. If the balance is zero, the balance procedure for the specific equipment type is sufficient. For each period, the cost component is compared with the historical data and the target cost levels. Based on the difference between the actual and target cost level, additional policies and strategy is made. Hereby the degree of insight is increased if a deployment per cost component is provided. [Provide the example of the BBO deployment].

5.2.3. THE DESIGN OF THE ASPECT SYSTEM DECIDE

Based on the control structure, for the majority of the network on decentralized control, it is important to define for NSM-Planning how to take decisions. Using the structure proposed by Miller (2002), it is possible to distribute the decisions in three categories: strategic decisions, tactical decisions and operational decisions. The three are discussed below for different network nodes.

DECISION MAKING IN NSM

The strategic decisions can involve long-term decision-making on the strategy and, regarding distribution management for equipment, involve the decision whether or not to outsource the equipment control. These decisions are not in the current scope of the project and therefore left out of scope. The tactical decisions can focus on the decision on NSM strategy for equipment distribution made once every year. The tactial decisions at NSM-Planning can focus on the choice for certain measurement means to implement (Barcode/RFID) or for the choice on targets for efficiency. The targets on efficiency have a big influence on the operations in the network nodes; therefore it is recommended to not change this strategy too often. Tactical decisions with smaller impact focus on the set-up of continuous improvement projects. If NSM-Planning wants to improve the effectiveness and cost levels of their operations, they can organize several (small) projects to improve the effectiveness and costs of the operation.

The decisions that have low risk, low costs and low impact are operational decisions. The operational decisions for NSM-Planning focus on the allocation of equipment. This is either between KCS-Production and KCS-Warehouse (by the Central-planners) or from the Outstation to Amsterdam (by the Area Planners). It is up to NSM-Planning to decide on the allocation strategy. If the efficiency ratios show the desired level, it is not required to demand ad-hoc equipment allocation from the outstation. But if inventory levels in KCS-Warehouse are low, short-term action is required. Hence, it is up to NSM-Planning to decide on the urgence of the allocation based on the inventory levels of KCS-Warehouse. It is recommended for NSM-Planning to re-design the current penalty structure for the outstations applied by Contract management. It is expected that clear communication about the penalty structure increase the alignment with the regulations.

DECISIONMAKING IN THE OUTSTATIONS

It is important that the outstation production operators are instructed with the right regulations on the maximum inventory levels. The decision making in the outstations is required to be monitored by Area-planning. The analysis showed that the current decision making in the outstations is not according to the regulations. It is important that the decision-making regulations are explained to the outstations. A recommendation is to change the current portal guide to make it more clear what the actual boundaries and definitions of the control are. Moreover, the analysis showed that the current penalty structure, applied by NSM contract management, it not clear and not applied. This is also something that influences decision-making. It is recommended to review the current penalty structure and communicate this structure clearly to the outstations. Although a clear penalty structure can increase commitment, a clear reward structure for good performing outstations should also be in place [55].

5.2.4. THE DESIGN OF THE ASPECT SYSTEM ACT

The aspect-system act translates the actions based on the decisions. The decisions are made based on the difference between the measured value in the network and the thresholds proposed by the system strategy. The actions focus on improvement of efficiency, the improvement of effectivenss and the reduction of costs. The four possible acts are discussed below.

Manage replenishment from suppliers The measured return-rate per equipment type demands the repetitive replacement from the KCS-Warehouse. NSM-Planning is required to organize the replenishment from suppliers based on this return rate. In this way, KCS-Warehouse provides sufficient capacity to provide replenishment to the network. At the same time, excess stock is reduced since the spare stock levels are based on the actual return rate.

Act with inventory allocation The majority of the activities at NSM-Planning will exist of the decisions and acts made for equipment allocation. These acts are focused to increase the efficiency and effectiveness to making sure that the right amount of equipment is in the right place. The network nodes are instructed with the new regulations how to handle the equipment flow. However, if NSM-Planning measures that it is not applied according to the regulation; action is required. If either efficiency is too low, or effectiveness is too low, it is required to be solved through organized equipment allocation. Moreover, allocation is required to solve the fleetbalance, overcome fleet shrinkage. The allocation is applied by the central planners (Between KCS-Centrum and KCS-warehouse) or by the area planners (between the outstations and KCS-Warehouse). For the equipment allocation, sufficient cooperation between the central- and area-planners is required.

Act with additional projects The act decisions are also focused on general improvement outside the focus on increased efficiency and effectiveness. Based on interviews with NSM-manager Joosten (2014), NSM-Planning manager Doze (2014), NSM-Operations manager Veen (2015) and KLM E& M Manager Kroes (2014), different improvements are listed. When the maturity level of equipment management increases, additional projects are undertaken. The additional project can focus on increase forecast capabilities, operational cost reduction or capital expense reduction. It is important that a cost/benefit analysis is applied per project. If the required investments, to start specific projects, are bigger than the cost savings, the projects are not feasible.

Automated acting by the control system The ICT system behind the barcode + RFID administrates the data in a database. It is possible to enable the system to send automated weekly updates towards the network nodes to reflect on their performance. Since the system calculates the return rate, the cycle time and the inventory in the outstation based on incoming- and outgoing flows, it is possible to share this with the outstation. It is possible to send these reports via email or to use a form of modern communication like Whatsapp to update outstation station managers if any mistakes on the loading are made. It can also be used if specific return rates per outstations are going down. Automated acting with performance updates is expected to increase the awareness of the outstation managers.

5.3. THE DESIGN OF THE CONTROL MODEL BASED ON BARCODE AND RFID

This chapter introduces the design of the new control model for the distribution control model based on the measurement/identification method Barcode and RFID. The first section introduces the new design of the steady state system. Hereby is the focus to introduce different adjustments compared to the old steady state system. The second subsection discusses the new control structure and tasks in NSM-Planning. The third subsection discusses the new control approach (structure and tasks) in KCS and the fourth subsection discusses the new control approach in the Outstations. The description of the new procedures for control in the system is described using the High Performance Organizations (HPO) model [56]. This model makes use of 6 model elements (tasks, tools, people, structure, governance and rewards).

5.3.1. NEW STEADY-STATE SYSTEM DESIGN

This section reflects on different modifications of the steady state system introduced in chapter 3. The major change on the steady state system is the introduction of the measurement methods for RFID and Barcodes in KCS-Production. Moreover, a new control structure within NSM-Planning is introduced. This control structure collects different measurements from the network nodes and makes a comparison with the strategy. The difference between the two influences different actions that the Area- and central planners are required to apply within the network to improve for example the efficiency, effectiveness and/or reduce costs. The most important change of the system is the introduction of a central control system (the NSM strategy part) and the introduction of measurements through RFID and Barcode. The following chapters discuss the additional system adjustments and tasks part of the new distribution control system.

STEADY STATE SYSTEM MODIFICATIONS

The paragraphs below discuss different steady state system design modifications proposed for the distribution control model. The system modifications focus on the introduction of central coordination wihtin NSM to determine, apply and control a distribution strategy, the introduction of new area- and central coordination, a new control structure for inventory management in KCS and the outstations is introduced. Moreover, the new measurement method is discussed (Barcode and RFI).

The first restructuring is the addition of a central control structure for NSM. This central coordination body collects all the measurements from the network nodes (KCS and OS). The first aspect system to discuss is the act level. This act aspect-system decides what action is required. The first action required for the implementation is to define strategy in the compare aspect system. Based on the strategy, the boundaries for the inventory levels are communicated through the network nodes via NSM-Planning. The measurements are coming in from the RFID and Barcode system that collects the measurements at KCS-Production. The new steady state system design focuses on the collection of measurements, monitoring of the minimum inventory levels in KCS-Warehouse and the monitoring and management of the bandwidths of equipment in KCS-Production. Rather than the reactive attitude, the new control approach is pro-active with a focus on improvement and forecasting in KCS-Production. The new forecasting system focuses on the forecasting of the inventory level in KCS-Centrum. This forecasting system is based upon the timetable, the allotment and 100% PSU loading and has a fixed timeframe of 1 week. Each Sunday evening after production, the inventory is counted and the result is filled in the forecasting sheet. The system calculates the lowest theoretical inventory level. If this level is negative, the difference between the negative value and 0 is replenished. Moreover, it is controlled if the inventory level at the each day is sufficient to cover the first 75 minutes of production. In this way, the replenishment is organized once a week. However, monitoring by the shiftleader remains important to observe deviations of the forecast on the production floor. The new design of the steady state system concerns also the re-design of the steady state model for the outstations. As proposed, the boundaries for the outstation inventory levels for the warehouse is defined based on the system efficiency target. The lower the target of the active loop efficiency, the higher the allowed inventory level in the warehouses. The maximum inventory level on the production floor is identfied as the allotment for the biggest type used for the specific outstation. The boundaries are communicated by NSM-Area to the outstations. The area-planners are required to keep the inventory levels between these boundaries.

5.3.2. CONTROL MECHANISMS IN NSM-PLANNING

This section focuses on the design of the control mechanisms in NSM-Planning. These actions focus on the system modifications for the control of the network, and different control mechanisms. These control mechanisms focus on the definition of the network strategy, the monitoring of the minimum levels at KCS-Warehouse, the monitoring of the maximum levels in the Outstations, and the allocation of equipment.

NSM CONTROL PROCEDURES

The sections below discuss different new control procedures new in NSM-Planning. The tasks discussed are the definition of the network strategy, the monitoring of the minimum levels in KCS-Warehouse, the monitoring of the maximum levels in the outstations, the allocation of equipment in/for KCS and the allocation of equipment in/for the outstations. The structure of the HPO model [56] is used to design each new control procedure. The structure of this model proposes different valuable recommendations for system design. Not only for the design of specific tasks, but also the tools, the structure, the required people, the governance and reward system are covered by the recommendations proposed by the model.

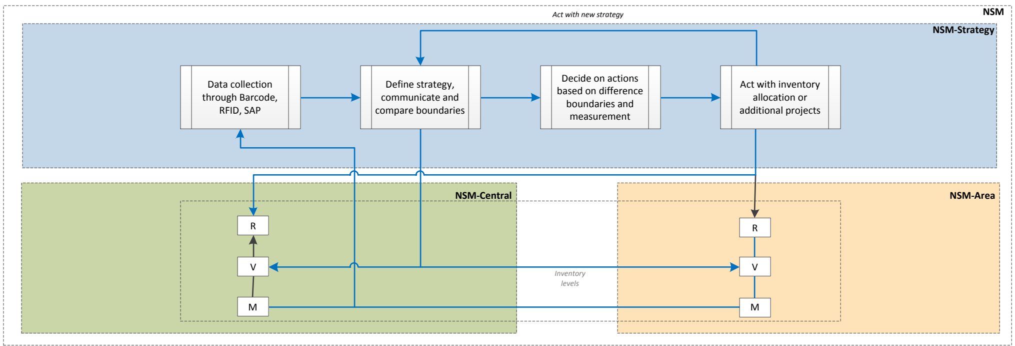


Figure 5.4: The new steady state system design for distribution control at NSM (Source: Own production)

The definition of the network strategy This task is focused on the definition of the strategy for the equipment distribution. This strategy is used to focus on increased efficiency, increased effectiveness and reduced costs. The tools used to determine strategy are the dashboard to see the current results and what the impact of the new strategy is on the thresholds and the boundary operations in the network. The people identifying the strategy for the network are the NSM-Planning manager together with the NSM-Regie manager since they both are responsible for the decision-making. The required structure is to make the decision for the strategy, as discussed in chapter 5.2.3, once a year. The required person responsible is the manager at NSM-planning because she is head of the NSM-planning part. The person accountable is the manager at NSM-operations since it is her responsibility. The persons consulted are the area- as the Central planners at NSM to investigate what they think is feasible and to involve them in decision-making. The informed people are the actors in the network. It is required that the two collaborate on the decision making for the strategy to obtain a feasible target. The rewards for the compliance with the task for strategy making are not yet defined. This is up to the VP of CIM to decide. It is a probability that the new strategy is released during the Christmas drinks as a starting point for next year's strategy. This provides also a good opportunity to involve all the actors and to motive them to work on the new strategy.

The minimum levels in KCS-Warehouse Based on the new distribution targets, the dashboard identifies the new minimum level in KCS-Warehouse for the inventory. As the previous paragraph discusses, the dashboard provides a threshold for KCS-Warehouse. This new minimum level is required to be monitored by the NSM Central Planner. The planner is required to observe this value each week to watch the inventory level in KCS-Warehouse. The area-planner is also the person responsible for the monitoring. The Accountable person is the NSM-Planning manager who overviews the responsibilities. The Consulted person is the Area-manager. The area-planner and the central planner are required to cooperate since the decline of KCS-warehouse leads to an increase of the OS inventory levels and vice versa. For the rewards system, it can focus on a functional bonus (in terms of salary) after a period (for example a year) without shortages in KCS-Warehouse. The tool to calculate the minimum levels in the KCS-Warehouse is elaborated upon in Annex D.

Monitor maximum levels in the OS-warehouses The task to monitor the maximum levels in the outstations is based on the same principle as the minimum levels in KCS-Warehouse. It is the task of the planners to monitor the inventory levels in the outstations. Hereby, it is important that they compare the inventory levels provided by the system with the inventory levels stated by the dashboard. It is the responsiblity to re-allocate the exceeding stocklevels to Amsterdam if this is not operated automatically by the OS-managers. The NSM Area-planner is responsible for the monitoring; the NSM-Planning manager is accountable for the application. The Central-Planner is consulted on the progress and the result of the monitoring of the network (and the re-allocation if required). The outstation managers are consulted with the feedback on the monitoring and to discuss further actions if required. The control on the outstations is further improved if the penalty structure, applied by NSM Contract management, is improved. For the rewards system, it can focus on a functional bonus (in terms of salary) after a period (for example a year) without a certain percentage of exceeding stocklevels in the outstations. The tool to calculate the minimum levels in the OS-Warehouses is elaborated upon in Annex D.

Allocate KCS Equipement The task is to allocate equipment from KCS-Production back and forth between KCS-Warehouse. Before, the inventory allocation in KCS was not the responsibility of NSM-Planning. However, with the urge to increase the collaboration between KCS and NSM-Planning, the allocation procedure is changed to improve collaboration. In the new procedure, the central-planners plan (using a fixed review period) the inventory. This is either long term forecast (based on return rate for the replacement replenishment) and short term forecasting (to solve daily dynamics in in- and outgoing flows). Based on the forecast, the requered inventory is allocated. Using this procedure, the logistics costs for transport between KCS-Production and KCS-Warehouse are reduced because the allocation is done based on planning. The planning is to do this procedure every Wednesday because this is the shift from increasing stock towards decreasing stock (based on timetable). The governance is focused on the accountability of the KCS-Planning manager. Moreover, the managers at KCS-Warehouse are informed (this is the actual replenishment order). An example is shown in picture 5.6. The dashed orange blocks show shortages at the end of the day. The shortages are avoided when replenishment is provided up front.

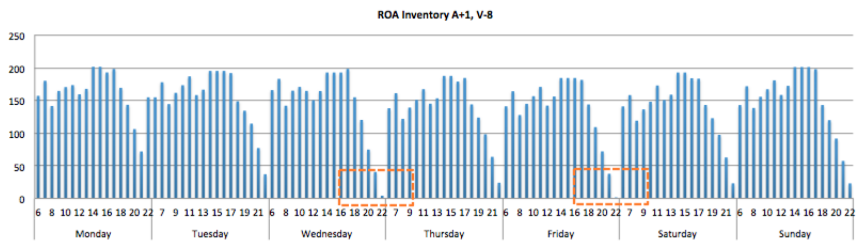


Figure 5.5: Forecast inventory level development week 20 2015 (Source: KCS inventory model 2015)

Allocate OS-Equipment This task is focused on the allocation from exceeding stocklevels back to Amsterdam. The task to order this allocation is applied by the area-planners. The tools that the planner is required to use are the dashboards provided by the ICT system. This dashboard indicates the outstations that have inventory levels that exceed the maximum thresholds. The area-planners are required to monitor these levels every one or two weeks. The frequency is increased if the inventory levels in KCS-Warehouse are low. The governance is focusing on the responsible area-planner and the NSM-planning manager is accountable. The OS-manager is involved because he is required to organize the loading of the inventory in the outstations. The reward structure for the outstations is to be determined by the NSM-Planning manager.

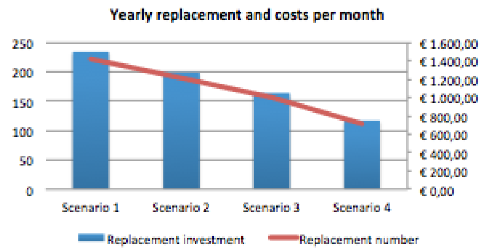


Figure 5.6: Foreseen monthly replacement of Square containers (Source: replacement dashboard 2015)

Design the replacement plan and identify budgets The replacement plan is required to cover the losses of equipment. These losses are calculated based on the return rate. The replacement plan provides information on the required financial investments per year to cover the losses. Moreover, the "vanish" time is calculated. This vanish time is used to reflect on the time that it takes before the equipment is vanished if KLM doesn't provide replenishment. In order to monitor the financial side of the replacement, it is important that annual budgets are identified for the replenishment. These budgets are decided upon based on the loss rate measured by the system. The task to identify the budgets is applied by the NSM-Planning manager Doze (2014) and NSM-Operations Veen (2014). The tool that they can use is the replacement-planning tool. The budgets are required to be identified each time new targets for the return rate are identified. If the return rate increases, thanks to specific projects, the budgets can decrease. The controling department is also required to be involved in these budgets. The buyers who negotiate contracts with suppliers need to be incorporated as well. In this way, NSM-Planning manages the budget; the Buying department negotiates prices for replenishment and controling observed the progress. THe NSM department manager is required to design a reward system if these departments manage to cut down budgets on replacement. The impact of increasing return rates is shown in chapter 6. This tool is discussed in Annex D.

Focus on cost reduction Aside from the efficiency and effectivenss targets, there are also targets for cost reduction. These can either be focused on the reduction of working capital as the focus on operational cost reduction. The first task is for NSM to specifically identify the cost drivers to reduce. The second task is to identify within these cost drivers the specific actors responsible for the procedure. The NSM-Manager is required to organize a kick-off activity with the actors concerned to identify the procedure, the current costs, the targeted reduction and how to realize the reduction. It is different per cost reduction target what the actual design of the procedure is. However, the structure of the HPO model is used to shape the procedure for cost reduction. It is up to the NSM Managers to shape the procedure per project. Chapter 6 (and Annex C) provide more information on the possible costs reduction.

5.3.3. CONTROL MECHANISMS IN KCS

The control mechanisms in KCS involve the activities for flow registration, inventory management and inventory allocation. First different changes to the system structure are proposed. Then, different tasks and (new) tools are discussed. After task and tools, the other parts of the HPO model are discussed. Below, different tasks and tools are elaborated.

KCS SYSTEM MODIFICATIONS

The steady state system modifications in KCS focus on the identification of new tasks for inventory management in the production facility. The following modifications are identified: the change of the push and

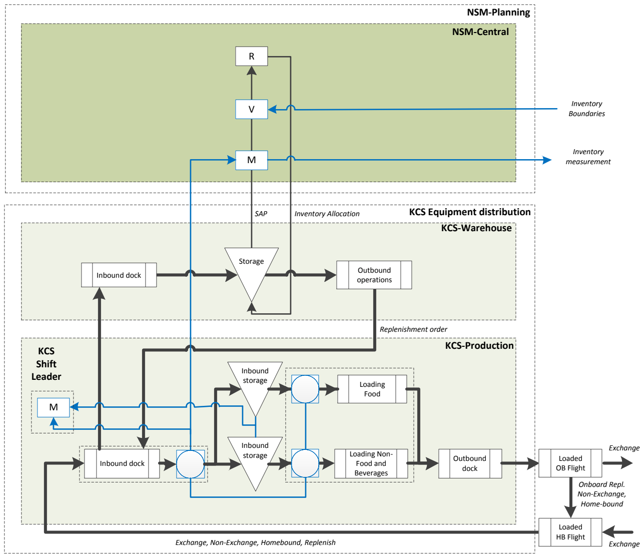


Figure 5.7: The new steady state system design for KCS and NSM-Central (Source: Own production)

pull boundaries, the scan-procedure for the incoming flow, the scan-procedure for the outgoing flow, the measurement of the inventory in the inbound storage

Perform the scanning The scanning of the incoming flow is different for the two types of identifications: the RFID technology and the barcode technology. The RFID tags are scanned when the driver who collected the equipment from the HB flight delivers the equipment at KCS-Production. When the driver offloads his truck, he performs automatically the inbound scan since he moves the equipment across the RFID-treshold at the inbound docks of KCS-Production. In this way, the equipment with the RFID tags is directly scanned the moment they enter the production node. The Barcode scanning is performed for identified equipment items in scope. It is important that the equipment is scanned the moment they enter the inbound storage area. The scanning system receives the measurement of the item and administrates that the piece of equipment returns from the outstation. Moreover, the efficiency parameters and the value of the inventory level in the production node are directly updated. The outgoing flow is scanned the moment it is pulled in production. The specific point of scanning is located at the border between the inbound storage and production. The scanning is performed manually or automatically in the robot used for production. The scanning is performed through RFID scanning for the loading equipment and barcode scanning for the equipment types that are equiped with barcodes.

Improve the production schedule The production schedule is another subject suitable for improvement. Analysis shows the influence of the production planning on inventory stock fluctations in the KCS-Production inbound storage area. The three scenarios combine an arrival scenario (Arrival (A) in KCS-Production 1 hour after arrival of the aircraft) with three possible production scenarios (8,10 and 12 working hours before the departure (V) of the flight). The scenario A+1, V-8 shows the lowest maximum inventory levels and less fluctuations than the other scenarios. Therefore, it is recommended that KCS-Productions shift from the current A+1, V-12 (Zwager, 2015) scenario to the A+1, V-8 scenario to reduce the dynamics of the inventory level in the KCS inbound storage area. Moreover, the observed shortages with the A+1 V-12 scenario is avoided.

5.3.4. CONTROL MECHANISMS IN THE OUTSTATIONS

The control mechanisms in OS involve the activities for inventory management and inventory allocation. First different changes to the system structure are proposed. Then, different tasks and (new) tools are discussed.

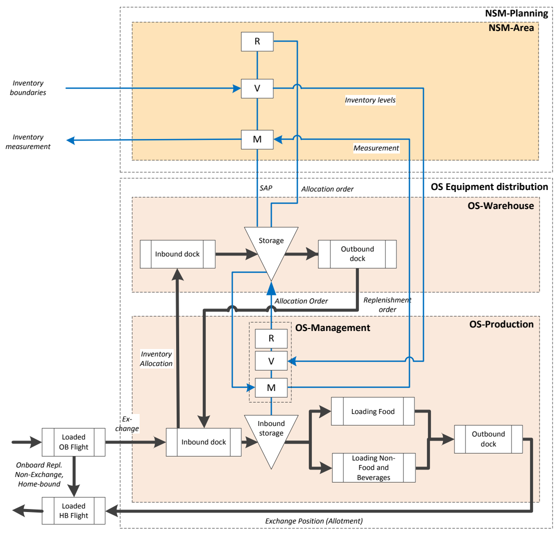


Figure 5.8: The new steady state system design for the outstations and NSM-Area (Source: Own production)

OUTSTATION SYSTEM MODIFICATIONS

The steady state system modifications in the Outstations are focused on the identification of new tasks focused on inventory management in the inbound storage facility. This is the facility where the inventory-set in the production facility is stored when KLM is not in production. There are two new points of measurement identified in the outstation. The first new measurement method focuses on the inventory level in the production node. The warehouse operators are required to measure each time after production the inventory levels and this is compared with the allotment. If the inventory level in production exceeds the allotment, it is required to re-allocate the surplus in inventory to the OS-Warehouse. In case there is a shortage, the operators are required to request a replenishment order. The second measurement method is the measuring of the maximum inventory level in OS-Warehouse. This maximum level is defined in the previous sections.

OUTSTATION CONTROL PROCEDURES

The allocation of the OS-Equipment is based on two tasks: 1) Allocate equipment between OS-Warehouse and OS-Production or 2) Allocate equipment from OS-Production back to KCS-Production. The allocation of equipment between OS-Warehouse and OS-Production is done either if there is a shortage or surplus in equipment on the production floor. The maximum stocklevel in the outstation is calculated based on the NSM-Strategy and communicated by the Area-planner. The normal regulation is to re-allocate exceeding levels in OS-Production towards OS-warehouse. In this way, it directly becomes visibile in SAP through the balancement of the in- and outgoing flows. NSM Area-planning decides when the exceeding inventory is going back to Amsterdam. As stated, the ICT system can give automated warnings on increasing inventory levels in the outstations. However, frequent communication and monitoring of the maximum level by the Area planner is required. If it shows to be insufficient, additional regulations are required. The person responsible for the control procedures is the warehouse operation, the person accountable is the OS-manager, the person consulted is the area-planner and the person informed is KCS-Production via the area planner.

5.4. THE FINAL STATE: IMPROVED EQUIPMENT DISTRIBUTION

This final phase reflects on the infinite optimization of equipment distribution. The infinite equipment distribution reflects the optimized state of the equipment distribution. The means that the service is ensured in all the network nodes. The efficiency rates are identified are based on the service levels and the therefore required safety stocks. This means that very little spare stock levels are allowed in the outstations and in KCS-Warehouse. Moreover, The number of control FTEs are reduced, the logistics costs go down and the reparation costs have decreased. The optimized state reflects also on the return rate. The improved return rate results in less replacement costs.

Required network control The improved equipment distribution means for NSM-Planning that the strategy is defined for the equipment distribution. These thresholds are translated towards the outstations. In the optimized equipment distribution state, the planners have a firm grasp on the network. Central planning has centralized control over KCS and monitors the inventory in the ROA area and the warehouse. The inventory dynamics are monitored and replenishment is forecasted if required. The warehouse inventories are monitored and if the minimum level is reached, immediate action with area planners is undertaken. Out of stocks in KCS-Warehouse are a subject from the past. The area planners have strong decentralized control of the outstations. The outstation operators are automatically warned (via Whatsapp or e-mail) by the system that their stock is observed to have increased. The area-planners are aware of these increasing levels and control of the increasing stocks return to Amsterdam. In this way, the low spare stock levels are maintained and are sufficient to provide service in the outstations. The increased efficiency results in equipment that has become obsolete. This is used to replace lost or broken equipment. This is incorporated in the designed fleet replacement plan. This replacement plan is applied by central planning to keep the fleet "in condition". The increased control in KCS means that the operators have actual insights in the forecasted inventory levels. Moreover, their production scheme has switched from departure minus 12 to departure minus 8 hours. Analysis has shown that this has a positive influence on the availability in the ROA area.

5.5. CONCLUSIONS ON SYSTEM DESIGN

The section below introduces different conclusions on the new design of the distribution control system at KLM. The new distribution control system focuses on the re-design of the distribution control system with the implementation of barcode and RFID identification systems and new control procedures in the network nodes. The new control is based on the centralized decision for strategy. This strategy is made by NSM-Managers. The central strategy focuses on targets for efficiency, effectiveness and costs. These targets are translated towards thresholds and boundaries for the operations in the network. It is the responsibility of NSM-Planning to implement the new thresholds in the network and to steer on improvement.

The control procedures in NSM-Planning The new control procedure in NSM-Planning focuses on the measurement of the system state, the comparison of the system state with the targeted situation and to undertake action to improve the state towards the targets. The decision for strategy targets (efficiency) influences the bandwidths and min/max inventory levels for the network nodes. The minimum and maximum levels in the network are communicated to the network nodes and it is their responsiblity to comply with these regulations. The area- and central planners monitor the network and undertake action if required. A good collaboration between Area and Central planning is essential within NSM-Planning because a decrease of inventory in Amsterdam is caused by an increase of inventory in the outstations. The NSM-Planning manager should focus on this collaboration and as is designed in the governance.

The control procedures in KCS The new control procedures in KCS are focusing on the control of the inventory levels in the inbound inventory at KCS-Production; this is the storage where equipment is pushed in from the incoming flights and equipment is being pulled into production. The inventory level in this location is automatically calculated by the RFID/Barcode system. It is very important that the equipment is scanned within KCS-Production. This accounts for both the incoming equipment as for the equipment pulled in production. In production, the equipment is directly assigned to the destination. Using the in- and outgoing flows, the balance is made per outstation of the inventory level. Based on the return rate of the equipment, there is a monthly automated replenishment order to cover the majority of the losses. However, it remains important to monitor the dynamics in the inbound inventory to avoid shortages of equipment due to unforeseen events (like arrival delays, foreign strikes). The shift-leaders at KCS are able to make additional orders for equipment. However, this is required to happen in collaboration with the NSM central-planning.

The control procedures in the outstations The new control procedures in the outstation are focusing on the control of the inventory levels based on the thresholds proposed by NSM-Planning. The minimum/maximum levels are communicated by NSM-Planning and it is the responsibility of the Outstation manager that this is applied. This accounts for both the inventory level in Production (Allotment) and the spare stock levels in the warehouse. The designed control procedures and tools are input for the design of the commitment based [5] implementation procedure. This is discussed in the next chapter.

6

QUANTITATIVE CASE STUDY

Chapter 6 provides the elaboration on the short-term and long-term quantitive benefits of the new control system. For this case study, two different implementation scenarios are compared. The first scenario represents the total control costs if NSM-Planning continuous with the current set-up of equipment distribution. The second scenario represents the implementation of the new control model. There are two sub-scenarios identified within the second scenario; 1) without the implementation of return rate improvement and 2) with the implemmentaiton of return rate improvement. The conclusion reflects on the possible cost savings when the new control model is implemented. A thorough description on the boundary conditions, formulas and comprehensive analysis resulsts is provided in Annex C.

6.1. IMPORTANT BOUNDARY CONDITIONS AND SCOPE

This section reflects on the boundary conditions and scope of the cost model. The boundary conditions discuss the equipment items in scope, the timetable and allotment per outstation, the used scenarios for the cost study and the identified input parameters. This quantitative case study compares the impact of three different scenarios on the total control costs for the period of 5 years. Each scenario exists of different phases. First, different phases are introduced. The second paragraph introduces different scenarios. The third paragraph describes the proposed implementation timeline.

Equipment and aircrafts in scope The equipment in scope is divided into carrying equipment and serving equipment. The loading equipment is defined by NSM-Operations manager Veen (2015) as "robust equipment used to carry and transport serving equipment". Therefore, the trolleys, containers, drawers, racks, ovens, inserts are defined as loading equipment. The serving equipment discusses the items used to serve the catering articles to the passengers. Moreover, this serving equipment is observed to be vulnerable for breakage, thus observed as less robust than the loading equipment. The timetable used for the calculation of the total costs for the catering distribution is the timetable for summer 2015. The aircraft types used for the ICA network at KLM are the Boeing 747-400 (774), The Boeing 747-Combi (74E), the Boeing 777-200 (772), the Boeing 777-300 (77W), the Airbus A330-200 (332) and the Airbus A330-300 (333). The 744 is, in terms of allotment, the biggest type. The second biggest is the airbus 777-300. The third biggest is the 777-200. Different allotments per outstation are provided in the ANNEX.

Timetable and identified flights The timetable that is used for the calculation of the total costs for the catering distribution is the timetable for summer 2015. For summer 2015, KLM expands its timetable with new destinations Edmonton and the roundflight Amsterdam, Bogota, Cali (AMS-BOG-CAL-AMS). The new timetable dictates the aircraft types used for the destination. Although the allotment is slightly different per destination, it is possible to identify an average number of equipment since it is calculated based on the maximum passenger configuration. The aircraft types used for the ICA network at KLM are the Boeing 747-400 (774), the Boeing 777-200 (772), the Boeing 777-300 (77w), the Airbus A330-200 (332) and the Airbus A330-300. The identified flights in scope are the flights towards the ICA destinations since the EUR flight are all loaded according to the "Homebound" status.

Input parameters The input parameters for the calculations are based on the control panel and the different identified scenarios (more on the scenarios in section 6.2). The required input scenarios are the efficiency ratios for the active and total loop (based on the required service levels) and the different additional operational parameters within NSM and KCS (Control FTE, logistics costs, reparameter costs, investments in ICT, operational system costs). Based on its impact, the return rate parameter is one of the most important parameters. Given the current unknown status of the parameters it is possible to calculate two type of total control costs. The first total system control cost is calculated without the influence of the return rate (i.e. with a return rate of 100%) to investigate the specific impact of the increased equipment efficiency. The second total system control cost scenario with the influence of (increasing) return rate. In this way, it is possible to compare the the cost reductions with both scenarios. The annex provides the background information on the specific types of loading equipment, the distribution per aircraft type, the used formulas and the description of the implementation timeline.

Proposed implementation timeline The case study reflect on the total cost after a period of 5 years. For scenario 1, there is no implementation and the system operates 5 years according to the parameters of phase 1. Below, The proposed implementation timeline for scenario 2 describes the length of each individual phase and the transition period between two phases. At the start of the period, phase 1 1 is operational. After three months, the implementation of phase 2 starts. It is foreseen that this implementation takes 5 months. During these five months, the cost profile switches from the phase 1 control profile to the phase 2 cost profile. Directly when the implementation of phase 2 is finished, the implementation of phase 3 starts (August, year 1). The total implementation of the barcode + RFID and the application of system optimization takes 5 months. After implementation, NSM-Planning operates 5 months according to phase 3. In June, year 2, the implementation of final equipment distribution optimization takes place. With several projects and further reduction of inventories, the efficiency ratios in the active network are further reduce to the desired state. The system runs according to the parameters proposed by table 6.1 for implementation scenario 2 (as shown in table 6.2 and table **??**).This is continued up till the end of year 5 for implementation scenario 2.

6.2. THE DESCRIPTION OF THE IDENTIFIED NSM SCENARIOS

This section introduces different scenarios used for the cost scenario. The first scenario is the current scenario. The second scenario is the first phase of implementation: improved manual counting. The third scenario discusses the implementation of RFID. The fourth phase is continuous improvement and optimization using the Barcode + RFID system. The fifth scenario is the alignment of the equipment load factor with the passenger loadfactor. Table 6.1 provides an overview of the imput parameters for different equations per scenario. The paragraphs below discuss the decisions for the parameters.

Alternative 1: The current scenario Scenario 1 in the cost scenario analysis represents the current scenario. Analysis applied in chapter 3 shows that the current efficiency rate of the total loop is 99 %. Although there are also examples of 100 % efficiency rates (empty warehouses), it is chosen to take the average rate of 99 %. The chosen rate for the active loop efficiency is 90 % (based on analysis). The load factor of equipment is 100 %. This means that all the flights are loaded according to the PSU rather than based on the passenger load factor. The current operational costs are €0 for the operational systems. The current operational system is SAP to monitor the inventory levels in the outstation and KCS warehouses. The reporting internally is performed using Excel files. The reparation costs are currently €25.000 per month. The reparation rate is 1 % of the total fleet. The interest rate used for the calculations is 4 % (Based on the ING Basis interest rate). It is chosen to continue working with the same interest rate (also for the future scenarios). The implementation time is 0 since scenario 1 is already operational. Because of the lack of forecasting, there is daily transport between KCS-Warehouse and KCS-Production. This means around 30 rides per month.

Alternative 2: The optimized scenario Scenario 2 in the cost scenario analysis represents the implementation of the new control model. This new control model focuses on increased automation (due to the implementation of barcode and RFID scanning), improved efficiency towards the identfied service levels, reduced logistics costs and reduced reparation costs. The implementation timeline exists of 4 different phases:

- Phase 1: The current equipment distribution is characterized through low efficiency within the active loop and high efficiency of the total loop. Thanks to the low forecasting capability, there is daily replenishment from KCS-Warehouse to KCS-Production. There are 2 FTE involved for the both the Area as central management. The reparation costs are €300.000 on a yearly base and the reparation rate is 1%.

- Phase 2: improved manual control: The second scenario is focused on improved counting. The barcode and RFID is not yet implemented. This phase is to increase the awareness and to start with the implementation of the control structure of the model. The final targets for this phase is a total efficiency rate of 98 %, an active efficiency rate of 94 %. The operational costs are €1250 per month for additional control in KCS-Production. For example a part time material planner focused on equipment management. The €1250 investments are used for training. The reparation costs are decreased with 20% compared to scenario 1. The reparation rate is still 1%. Because the control by NSM-Planning increases, the amount of rides between KCS-Warehouse and KCS-Production is reduced to 20 rides per month. The implementation of this phase takes around 6 months.
- Phase 3: Implementation Barcode+RFID: As decided, a system with barcode and RFID is implemented to track the equipment within the network of KLM. Scenario 3, whose implementation takes about 5 months, is used to implement this system. Once the system works, the aim is to improve the situation towards the targets stated in table 6.1. The efficiency rate of the total loop remains 98 % to keep sufficient equipment in KCS-Warehouse. However, the efficiency rate of the active loop is increased to 97 %. Because of increased automatization, the number of fte is reduced to 1,5. This doesn't mean that people are fired, they just have more time to work on other subjects! Due to increased control, NSM-Planning can take over the inventory planning at KCS-Warehouse. Therefore, the number of rides between KCS-Warehouse and KCS-Production decreases to 5 per month. However, automatization has a price; the implementation costs €110.000 and the monthly subscription to the program of SkyLogistiX costs €75000. Because the increased control enables NSM-Planning to make a reparation deployment, the reparation costs decrease together with the reparation rate of the fleet.
- Phase 4:Continuous improvement: Continuous improvement phase after the implementation of RFID and Barcode. The parameters of this state discusses the optimized state of the control system. There are currently two scenario's possible: KLM continues with this scenario (and loading on 100 % of the PUS) or they start with loading based on the passenger load factor. The current passenger load factor at KLM is 81,3 %. This scenario is discussed in the next paragraph. The final state of the fourth scenario discuss the final state of the optimized equipment distribution. The efficiency rate of the total loop is 99 %, the efficiency of the active loop is 99 %. The load factor of this scenario is still 100 %. The control fte's are reduced to one (1/2 area-planning and 1/2 central planning). The rides between KCS-Warehouse and KCS-Production are reduced to 1 per week. Because of further deployment of the reparation costs and the work on their reduction, the reparation costs are further reduced. The current reparation costs are reduced with 70 % compared to scenario 1.

These two scenarios above are used to reflect on the possible cost reduction for the implementation of the new control model. There is a possibility to calaculate the possible cost savings when the equipment is loaded based on passenger load factor rather than 100%. However, since standard deviations of demand are unknown, the reliability of the calculated results is very questionable. Therefore, the quantitative case study focuses on the combination of the two scenarios above. The pictures reflect also a phase 5, this scenario can be used to test the influence of the load factor. However, this is left out of scope in the specific quantitative case study for this thesis.

POSSIBLE COST REDUCTIONS

This paragraph discuses the total system control costs. Hereby, the graph (shown in figure 6.1), shows the comparison between the alternatives. The red line shows the cumulative system costs if KLM continues with the parameters according to the current strategy (scenario 1). The total system control costs of this scenario are calculated to be €2.989.597,08. The green line shows the cumulative system costs if KLM implement the new control model according to scenario 2. The total system control costs of this scenario are calculated to be €2.399.060,21. This results in a cost reduction of 19,75%. The cost reduction is enforced through the reduction of the following aspects:

- The working capital is reduced with €396.704,20. This reduction in working capital is balanced with the replacement costs and is therefore a direct cost recuction. The working capital is reduction through increased efficiency of the total loop and the active loop. This increased efficiency, based on the identified service levels for KCS-Warehouse and the OS-warehouses, results in lower safety stocks in the

Table 6.1: The input parameters for the quantitative case study

	Phase 1	Phase 2	Phase 3	Phase 4
Efficiency loading Total loop	99,00%	98,70%	98,70%	98,70%
Efficiency loading Active loop	90,00%	94,70%	98,70%	99,70%
Efficiency serving Total loop	99,00%	89,00%	89,00%	89,00%
Efficiency serving Active loop	90,00%	97,85%	97,85%	97,85%
Load factor equipment	100,00%	100,00%	100,00%	100,00%
Return rate loading	100,00%	100,00%	100,00%	100,00%
Return rate Serving equipment	100,00%	100,00%	100,00%	100,00%
Control NSM (Fte)	2	1,75	1,5	1
Rides KCS-P/W	30	15	5	4
Operational costs	0	1250	7500	7500
Investments	0	1250	110000,00	0
Reparation rate	1,00%	1,00%	0,50%	0,50%
Reparation costs	100,00%	95,00%	90,00%	85,00%

Table 6.2: The input return rates per phase for the quantitative study

	Phase 1	Phase 2	Phase 3	Phase 4
Return rate loading	99,8%	99,83%	99,86%	99,9%
Return rate Serving equipment	98,0%	98,3%	98,6%	99,9%

outstations and slightly higher stocks in KCS-Warehouse. The overal fleetsize reduces with 10% for the loading equipment. The fleetsize of the service equipment remains almost the same but the stocks are shifted from KCS-Warehouse to the OS-Warehouses. Due to the decrease of the working capital, there is a linear decrease of the financial cost using the

- The operational costs reduce slightly. Although many operational costs are reduced (the number of FTEs, the logistics costs between KCS-W and KCS-P and the reparation costs), there is also a cost increase due to the implementation of the barcode + RFID system. Moreover, significant investments (€110.000) are required for the set-up of the barcode and RFID system. The assumption is drawn, based on the expected impact of the tracking system, that most of the cost reduction is found in loss reduction. Additional studies on loss reduction are discussed in the section "the impact of loss reduction".

The cost study shows the potential of the implementation of the new control model resulting in reduced costs while the service is ensured. The foreseen cost reduction is around 15%. However, additional research is required to investigate the feasibility of FTE reduction, increased automation and the impact of the barcode and RFID scanning.

THE IMPACT OF THE LOSS REDUCTION

This section reflects on the impact of the return rate and the loss reduction on the total system control costs. The assumed current return rate, based on analysis, is 99,8% for the loading equipment and 98% for the service equipment. The proposed return rate improvement is based on the scenario that the return rate is improved with 50% in the coming 5 years. Although the feasbility requires additional research, it is used for this analysis to see the financial impact of NSM-Planning if they are able to obtain this result. The improvement in return rates per phase is shown in table 6.2. Per phase, the return rate increases from phase 1 (current) towards the optimized state in phase 4. The optimized state reflects the 50% loss reduction.

The replacement costs of the current scenario The first analysis is performed on the cost increase of the current scenario if the return rate is incorporated in the control costs. The impact of the return rate and

Figure 6.1: The possible cost reduction without influence of return rate

its reduction on the total control costs is shown in figure 6.2. With a return rate of 100%, the total control costs for 5 years are calculated to be €2.989.597,08. However, if the return rate for loading equipment (99,8%) and serving equipment (98%) are applied, the control costs after 5 years are €11.871.645,24. Based on the difference between the two values, the component for the replacement costs is €8.882.048,24. This value represents the total costs for the replacement of the equipment that is broken or lost during distribution. This value has already incorporated the financial value of the "liberated" loading equipment due to the increased efficiency. The monthly replacment costs are €147.542,33 whereby 28,7% is covered by the service equipment and 71,3% by the loading equipment. Within the loading equipment, the biggest drivers are the expensive equipment types (Business class trolley and normal trolleys).

The impact of the control model The control model involves the tracking of equipment due to the implementation of RFID and Barcodes. Using this automation, it is possible to identify the exact routes responsible for the breakage of the equipment. The total system control costs after 5 years, with the implementation of the control model and the reduction of losses, is €7.407.795,20. This means a reduction of 37,6% (or €4.463.850,03) for the total control costs. This would also provide (financial) evidence that the implementation of the barcode+RFID system pays off because of the possibility to reduce losses. The impact of the loss reduction is seen in the required replacements per year. The yearly replacements in phase 4 show that the replacements are half of the yearly replacement in phase 1.

6.3. REFLECTION ON RESULTS

The quantitive case study shows the benefits of the implementation of the new control model. If the new control model is implemented according to implementation scenario 2, the control cost reduction after 5 years is over €590.000. This is a reduction of 19,75% compared to the control costs if KLM continues with the current practice. This implementation scenario means that KLM implements the Barcode + RFID scanning, that KLM optimizes the fleet control towards maximum service and that they actively control the maximum thresholds within the network. An additional cost reduction of over €3,8 million is possible when NSM-Planning is able to reduce the replacement costs with 50%. These calculations show the potential of the implementation of

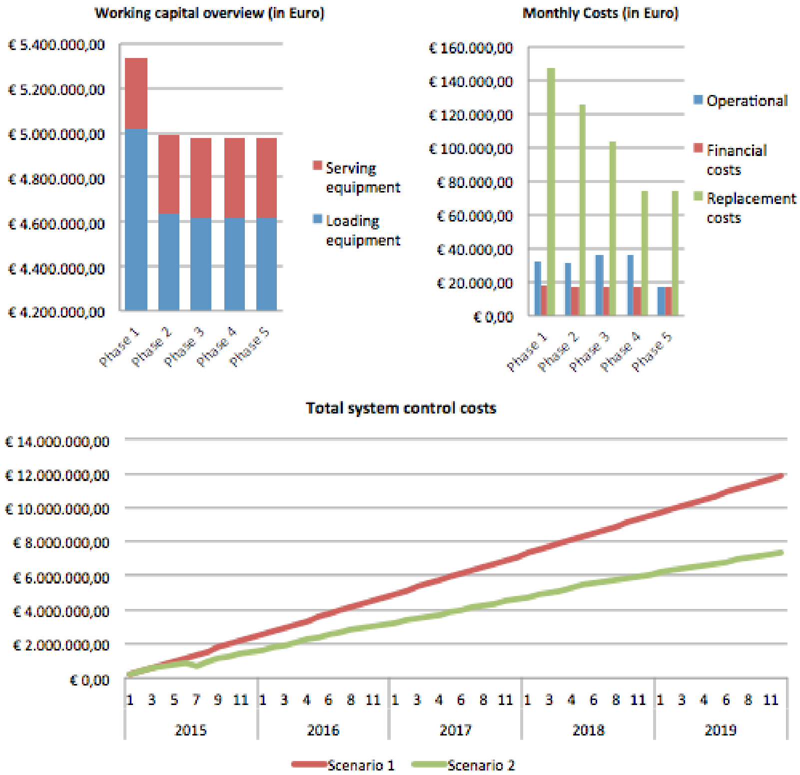


Figure 6.2: The possible cost reduction with influence of return rate

the cost reductions for the new control model. One of the other insights is the big influence of the laoding equipment on the total equipment costs. Therefore, it is concluded that, for the implementation, the first focus should be on loading equipment. This accounts both for the availability as for the return rate improvement.

7

Implementation of the new Control Model

This chapter elaborates on the implementation of the new control model at KLM. The past chapters introduce the new control panel and the different procedures for the control aspect-systems are introduced. The first phase elaborates on the theoretical framework used for the design of the implementation. This theoretical framework reflects on the use of the HPO model [56], the commitment model [5] and the iterative implementation procedure. The second section elaborates on the implementation of the barcode + RFID scenario. Section four describes the state of the optimized equipment fleet.

7.1. Theoretical framework for the implementation design

This section reflects on the theoretical framework used to design the implementation. The reflection on the theoretical framework for design is reflected in 7.1. The elements of the framework exist of the definition of the goals and tasks. The implementation procedure is designed using the commitment model. The projects within the different phases are based on the iterative procedures. The different elements are discussed below.

Define goals and tasks The first task concerns the formulation of the goal of the project. It is recommended to quantify the goals to make the progress measurable. Based on the goals, the main task to be performed by the system is performed. An example is the goal to reduce the control costs by 10%, this can concerns the tasks to reduce FTE or other operational costs. The next phase is to define the subtask for the different actors. Each subtask is required to be designed in a procedure according to the HPO model regulations [56]. This will increase the embeddedness of the procedure in the organisation. Within the HPO-model, it is particularly important to give sufficient attention to the design of the reward system. When actors concerned are rewarded for a good performance, they are increasingly commited to the change.

Design implementation using the commitment model It is recommended to use the commitment model [5] (as shown in picture 7.1) to design the implementation procedure. Using this model, the required commitment level is designed per phase. Moreover, it is easy to define sub-activities to increase the commitment of actors concerned to a required level. For example, actors are required to shift from awareness to understanding; additional workshops are possible to realize this goal. At the start of the design of the implementation procedure, it is important to define all the different actors involved in the organisation concerned for the project. People higher in the organization can have the power to increase commitment of certain actors but can have limited interest. It is important to design specifically when and how which actor is required to be commited. During acceptance, the new technology or procedure is implemented. In this phase, it is recommended to implement the technology using an iterative design procedure whereby the new procedure is repeadetly scored against the requirements of the operators. This improves the commitment of the implementation since they are actively included in the implementation procedure and are able to influence the final design of the procedure.

The leading actor for the design of the future improvement procedures is NSM-Management. Based on the difference between the measured system state and their strategy, NSM is required to identify specific projects and procedures to improve the system state. As the past chapters state, this is either focusing on reducing costs or increasing the maximum productivity of the equipment.

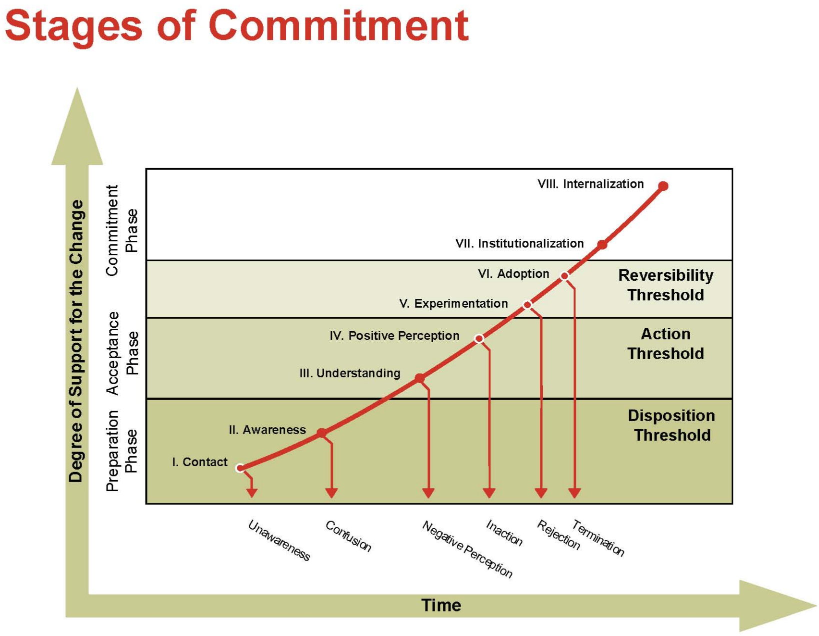


Figure 7.1: The Patterson-Conner Change adoption model [5]

7.2. THE IMPLEMENTATION OF BARCODE AND RFID

The focus of the implementation phase is to implement the different elements of the control model that uses Barcodes and RFID as the main method to collect the right data from the network. The sections below discuss the different recommended steps for implementation for the three phases concerned (Preparation, Acceptance and Commitment) [57] . The required state of the actors is reflected in figure 7.2. The picture shows that the outstation operators are only involved until the positive perception. This is because the implementation mainly involves changes in NSM and KCS. The outstations managers are required to be aware of the tasks to be performed. However, there are no additional actions required compared to the manual counting in the outstation.

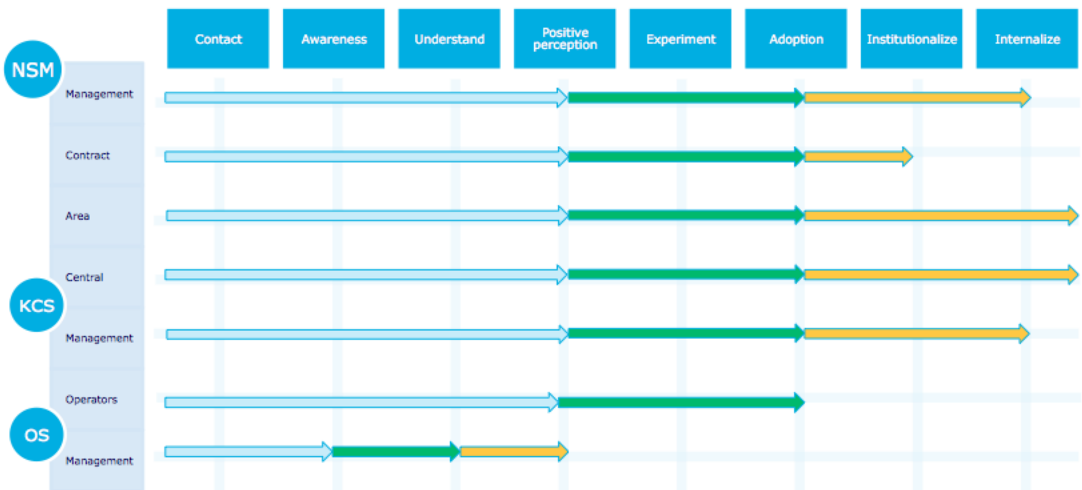


Figure 7.2: The proposed implementation (Own production based on the commitment model [5]

PREPARATION PHASE: 3 MONTHS

The focus in the first phase, preperation, is to prepare the actors involved for the implementation of the RFID and Barcode. Hereby, it is important that the implementation of the technology is precisely prepared. A strict planning with intermediate milestones and sub-projecst increases the ease of the implementation. Moreover, the additional infrastructure and ICT systems are required to be prepared before the physical implementation of the measurement means can start. The 3 months implementation phase is indicated as a feasible period for implementation based on the required activities.

Activities within NSM-Planning The preparation activities wihtin NSM-Planning focus on the increase of commitment through the preparation activities for the implementation of RFID and Barcode. The first activity concerns the organisation of a kick-off to reflect on the requested steps for the implementation phase. This agenda focuses on the scheduled activities to prepare the physical implementation of RFID and Barcode. It is also important that the ICT infrastructure is designed and that the planners concerned are prepaired for the coming changes in the ICT systems. The Excel Dashboard with the inventory countings is about to be replaced by an automatically updated dashboard that measures the required parameters identified to steer the network. However, the governance on the observation of the measurements and the activities for area planners (monitor and control maximum levels in outstations) and the central planners (monitor and control minimum levels in KCS-Warehouse) needs to be updated. It is proposed to organize different projects to prepare the implementation, new governance and the control mechanisms for the network with the actors involved. It is important to invite the end-users of the system to increase insights in their requirements. This enables the design of the iterative implementation projects. The specific preparation activities can concern workshops, training (with a possibility to use serious gaming),

Activities within KCS There are many things about to change within KCS. The implementation of new measurement systems requires new infrastructure and a change of the loading and offloading of equipment. The target for this phase is that both KCS-Management and KCS operators have a positive perception towards the upcoming change. It is important for NSM-Planning to ensure the actors with KCS with the benefits (more insights, less required inventory counting and real insights in the availability of equipment). Moreover, it is also important that KCS is convinced that there is no operational delay due to the (manual) scanning. Within KCS, it is recommended to organise a kick-off event to introduce the different actors with the foreseen changes. It is also important to have the different field operators trained on the new procedures for scanning. In advance, instruction manuals need to be prepared in order to enable the field operators to review the instructions before and after the training. It is important that these procedures are documented in the contracts between KCS and KLM to ensure that KCS operates according to the required regulations of KLM.

Activities with OS There are not many activities involved in the outstations since the majority of actions is required to be performed by NSM and KCS. However, the outstations are updated that the RFID and Barcodes are implemented and that they are required to continu the control activities in the outstation. It is to be decided by NSM whether they continu with the manual counting in the outstation or that they require the outstation to scan each piece of inventory. The outstations are required to be updated on the different subjects within their field of interest.

ACCEPTANCE PHASE; 3 MONTHS

The acceptance phase covers, for the actors within KCS and NSM the trasnsformation from positive percention towards complete adoption of the new system. This transformation is realized through the implementation of the new technology, the process of experimentation and finally the adoption of the new technology. The different sub-activities within the different organizations are elaborated below per department. The 3 months implementation phase is indicated as a feasible period for implementation based on the required activities.

Activities within NSM-Planning Within NSM, it is required for all the actors involved to move from positive perception towards adoption. The main task for NSM-Management is to coordinate the implementation of the infrastructure, both for the planning side at NSM as the measurement side at KCS. Therefore, a comprehensive planning with sub-projects to foster experimentation is required. This concerns both the experimentation activities in KCS to find, through trial-and-error, the best procedure to perform the scanning also for the planners, it concerns the experimentation with the new dashboard. In contrary to the manual counting, the new dashboard provides the parameters of all the parameters rather than only information on inventory. The area planners can experiment with the increased inventory control in the outstations since the new dashboard provides real information on the inventory levels. The central planners can increase the collaboration with the KCS operators on the equipment flow through KCS. A possibility to increase collaboration is that the central planners continue their work once a week in the office of the control center at KCS. Contract management starts the expirementation of the outstation control based on the input delivered by both the new dashboard and the area managers. The acceptance phase is finalized when the actors involved understand the dashboard, when they can use it independently, the realibility of the data is confirmed and the governance for the control mechanisms (with contract management) is put in place.

Activities within KCS The activities within KCS in the acceptance phase concern the adoption of the measurement methods and the tools for equipment management. The focus on the activities to raise commitment is focused on the implementation and experimentation of the barcodes/RFID. It is recommended to divide the implementation into a specific project for the scanning of the incoming flow and the scanning of the incoming flow to give special focus to the two different proces. It is recommended to involve the shopfloor operators in the final design of the scanning procedures. Through an iterative design procedure, whereby the procedure is scored against the operator requirements, it is possible to work. Active supervision on the implementation by the shift-leaders on the production floor is requird to observe the compliancy with the 100 % scanning. Internal audits are required to provide feedback on the percentage of right applied scans. This is required to be 100% at the end of the adoption. Another required procedure is for the inventory allocation with KCS-Warehouse. For this procedure, the collaboration with the Central planning at NSM is essential. At the end of the acceptance phase, both the management and operators are required to have fully adopted the new procedures and regulations.

Activities with OS It is required for the outstations to be updated with the results of the automated tracking system. In this way, they become aware of the implemented system and understand that NSM-Planning have an insight in the fluctuations of inventory levels in the outstations. It is possible to implement an automated update within the system for the outstation managers. For example, automated updates via email or whatsapp on the monthly measured inventory fluctuation.

Commitment phase; 2 months

The commitment phase focuses on the institutionalization and internalization of the new system within the different departments. As figure 7.2 shows, the focus in the commitment phase is on the NSM actors and KCS-Management. The following paragraphs discuss the activities within NSM and KCS. The 2 months implementation phase is indicated as a feasible period for implementation based on the required activities.

Activities within NSM-Planning Within NSM-Planning the focus is on the internalization of the systems at NSM-Planing and contract management. The system provides a daily data flow about the equipment types scanned coming from the different destintations. This phase is focused on increasing the number of tools and (forecasting) systems that increase the insights in the equipment flow. To increase even more insights, it is possible to implement an increasing number of serving equipment to the scanning. The choice for the barcode system enables KLM to attach the barcodes to the loading equipment. The intitutionalization is increased even more when NSM-Planning starts to think how the results of the tracking system is used to increase the network strategy. It is possible to start with the deviation of PSU loading and to focus towards the loading profile of the aircrafts (85,3%). NSM-Planning can also start, besides operational improvement, with the focus on cost reduction. The first proposition is to focus on the current operational costs for logistics between KCS-Production and KCS-Warehouse. IF NSM-Planning can increase the control of the allocation orders of KCS-Production is results in less rides between the two nodes and therefore reduced operational costs.

Activities within KCS and the outstations The internalization activities within KCS focus on increased use of the data, expanding the existing tools and designing new tools to increase forecasting. Moreover, it is possible that KCS increases the amount of articles that they can scan; improve the scanning procedure that it is less time consuming/reduced impact in the operation. It is important that the KCS-Managers keep focused on improvement and that they identify targets for optimized equipment flow management for the coming years. The outstations are required to conintu the monthly counting to balance the inventory levels with the counted levels. The NSM-Area planners continue providing information on the inventory levels to focus on optimized utilization of the equipment. The specific preperation activities can be hosted using workshops, training or simulations to show the impact of the change on the workfloor.

7.2.1. BOTTLENECKS FOR IMPLEMENTATION

There are different bottlenecks identified that can prevent the succesfull implementation of the new technology. The four substantial bottlenecks are identified as lacking commitment KCS-Production, insufficient technology, resistance in CIM department and wrong implementation planning. The four causes are discussed below.

Lacking commitment KCS-Production The identification of the best means for data collection showed the reluctance by KCS-Production towards scanning on the production floor. The KCS-operations manager Zwager (2015) has indicated her concerns to the scanning using a barcode scenario. She indicates that the impact is severe on the production floor. Lacking commitment by the KCS managers can delay the implemenation. Lacking commitment by the floor operators can results in reduced data reliability. The decisions for replenishment planning are centralized towards NSM-Planning. This reduces the ability for decision making within KCS-Production. This is also something that requires commitment. If this idea is not adopted by KCS-Production, the centralized control model will fail.

Insufficient technology and planning The technology used for the collection of the data is barcode + RFID. The collected data is required to be administrated through supporting ICT structure that provides data on the balances and returnrates through automated updates per fixed time frame. However, if the technology is not functioning well, not reliable or subject to malfunctions, the implementation will fail. The implementation of the different elements requires carefull planning. The planning involves change mangement in NSM-Planning, KCS (Production and Warehouse) and the Outstation. A comprehensive and feasible planning is required to be made. Delays of activities can result in confusion and incomprehension. Therefore it is required to start with the identificaiton of a project manager. The project manager is the central spokesperson for the project and controls the time line.

Resistance in CIM department During the design process, the NSM-Planning managers have been very supportive. Although the area- and central planners are aware of the change and supportive to the idea of optimization, the implementation and commitment required carefull planning. Due to the fact that theoretical reference could increase at most of the planners, they can become confused. The confusion can occur when the implementation goes too fast, the planners are not involved or the iterative implementation procedure is not applied. The infrastruture and the new system is not the only aspect that changes within NSM-Planning. The new control model, with a strategy applied with clear network tresholds is applied within the network. This requires also a mind-set switch for the planners. As indicated in chapter 5, the collaboration between area- and central planning is required to increase. Since they operate and control the network together, repetitive meetings are required. This is something that the NSM-Planning manager needs to facilitate.

7.3. CONCLUSION ON THE IMPLEMENTATION PROGRAM

The designed implementation is based on the commitment model. This model proposes clear guideliness for different stages of commitment towards full implementation of the new procedure [5]. The implementation is divided into three phases: 1) Increase the commitment of the actors concerned towards a positive perception towards the foreseen changes. 2) The implementation of the new procedure and 3) the internalization of the new procedure to complete the full implementation within the department. For each phase, it is possible to apply (among others) workshops, training, specific education, different forms of collaboration or visits to other departments. It is recommended to introduce the commitment model to the actors concerned and to verify their position on the commitment curve. Also when actors are reluctant to change, it is possible to let them point their position on the curve. This enables NSM-Planning to organize additional and specific activities to increase the commitment for the specific actor towards the required level. Moreover, it increases the visibility in the state of commitment from the different actors.

8

Conclusions and recommendations

8.1. Conclusions

This research aims to develop a new control model that enables NSM-Planning to improve the distribution of catering equipment in the logistics network of KLM. The goal with the new control model for KLM is to increase the efficiency and the effectiveness of the equipment distribution while reducing control costs at the same time.

The first step to determine the required equipment levels is to identify the inventory policies. Based on these inventory policies, the required safety stocks are identified to ensure service and maximum inventory levels in the network nodes. Based on these maximum levels, the target efficiency ratios for the network are identified. Using the efficiency ratios, it becomes possible to calculate the required fleetsize using the theoretical fleetsize with maximum productivity. The inventory thresholds and efficiency ratios are input for the NSM-Planning department. They are responsible for monitoring and inventory allocation in the network. To ensure availability, it is also important to proactively replace broken equipment. The loss is observed through the measurement of the equipment return rate. NSM-Planning is required to manage the replacement, per fixed time frame, of the equipment flow in KCS-Production. Active monitoring and allocation of equipment is required to identify required additional allocation to ensure service.

The new control model is based on the implementation of barcode + RFID to measure the supply chain data. This choice is based on actor requirements for the data collection method. The data focuses on inventory level in the network nodes, the return rate and inventory balances. The implementation of the technology increases the ability to collect reliable data in the network. The data processed in a supporting ICT system that generates reports on performance and automated updates towards the outstations on their behaviour. Without the barcode + RFID tracking, NSM-Planning can't increase the control on the network but sufficient and reliable insights in required network data is still lacking. This lacking insight reduces the precizeness of the equipment management.

The foreseen additions and modifications to the existing control model are focusing on updated procedures within NSM, KCS and the outstations. NSM-Planning is required to define their strategy on service levels, identify the required efficiency parameters and the requird fleetsizes. It is their responsibility to maintain the fleetsize through the replacement program and monitor the effectiveness of the distribution. Moreover, cost monitoring is required to keep focused on costs and its potential reduction. The inventory levels within KCS-Production are monitored by NSM-Planning. However, observation on the availability, scanning of the flows and mutual agreements on demand remains important at KCS-Production. The outstations are required to maintain the inventory according to the proposed minimum and maximum levels. In addition, they ar required to perform manual/mechanical counting of the inventory if it is demanded by NSM-Planning.

A quantitative case study is used to analyse the total control costs for a period of 5 years. The study shows the potential benefits (19% cost reduction) through the implementation of the new control model. When the influence of the return rate and its foreseen improvement is incorporated, the potential benefits of the system are a cost reduction of 37,5% (or €4.463.850,03). It should be noted that this potential is still hypothetical and that additional studies are required to calculate definite savings. For the implementation of the new control model, it is important to focus on commitment within the teams involved. The implementation program provides a structured approach for different phases of implementation. For the implementation, it is important to be aware of the identified bottlenecks for for implementation (lacking commitment KCS, insufficient technology, NSM-Planning resistance and Insufficient Planning). For the implementation itself, continuous use of the commitment model, to guide the implementation procedures, is recommended.

The implementation of the model enables NSM-Planning to ensure the availabbility of equipment while avoiding excess levels of spare stock at the same time. This leads to improved service and improved efficiency compared to the current distribution. Moreover, the insights in control costs enable NSM-Planning to undertake further action (increased collaboration, increased forecating) to reduce control costs. This cost reduction supports both the relations with caterers as the urge at KLM to reduce operational costs.

8.2. RECOMMENDATIONS

Different recommendations are added to the conclusions. These recommendations focus on increase the return rate capabilities within the distribution network, additional research on the barcode scanning in the network nodes and increasing logistics managemement capabilities within NSM-Planning. These recommendations are made based on observations during research and their possible impact on the distribution network and its foreseen improvements.

INCREASE RETURN RATE CAPABILITIES

The current loss rate is calculated to be 98% for the service equipment and 99,8% for the loading equipment. For the research, the calculated return rate for specific items are extended for the category. The measurement aspect system focuses on detailed measurement of return rate and deployment per equipment type per destination. This deployment supports decision making on the required initiatives to improve the return rate. The quantiative case study in this thesis supports the hypothesis that return rate improvement leads to significant cost reduction. Therefore, it is recommended that NSM-Planning applies further research on the improvement of the return rate.

BARCODE SCANNING IN THE NETWORK NODES

The report identified via a MCA analysis that barcode + RFID scanning is the preferred method for supply chain data collection based on actor utilities. However, the system design also showed practical constraints for barcode scanning in the network nodes. Further research is required to identify the balance between the equipment articles in scope and the scanning feasibility on the working floor. Moreover, the degree of automation is a topic for further research, together with the scan policy (centralized or decentralized) and the governance to ensure effective and reliable scanning. A last topic suitable for further research is to identify a suitable procedure and frequency for barcode scanning in the outstations nodes. It is recommended to use the theory on Value Stream Mapping[10] to investigate the impact on the shopfloor procedures. This shows the impact on the flows and the required activities to perform the scanning.

INCREASE LOGISTICS CAPABILITY LEVELS OF THE PLANNING DEPARTMENT

The last recommendation focuses on increasing the capability level of the planners at NSM-Planning. The current planners have the capability to perform their operational tasks but improvement of their theoretical frame of reference and improve the collaboration will increase their effectiveness. Together with PhD student Shalini Kurapati (Technical University of Delft, Faculty of Policy Analysis, System Engineering and Management), a serious gaming session is organized to train different planners concerned for equipment distribution. The choice for serious gaming as a training method is based on literature on the impact of serious gaming on planning teams [58] [59]. These serious games can either focus on increasing the collaboration between the planners [58] or on increasing the capability level of the planner [59]. Based on the result of the organized gaming session, further research can be applied to investigate what the required training is to improve the logistics management capabilities within NSM-Planning and the role of serious gaming within the education at KLM.

A

ANNEX: SYSTEM DESCRIPTION AND ANALYSIS

A.1. INTERVIEWS

- NSM manager A. Joosten (2014)
- NSM manager A. Dasler (2015)
- NSM Operations manager H. ten Veen (2014)
- NSM Planning manager A. Doze (2014)
- NSM Area planner J. Bakema (2014)
- NSM Area planner P. Roos (2014)
- NSM Area planner M. Tempels (2014)
- NSM Central planner C. Stroobach (2014)
- NSM Central planner A. Willemsen (2014)
- NSM Contract manager I. Schoenmakers (2014)
- NSM contract manager M. Reijndorp (2014)
- NSM Contract manager M. Kramsu (2014)
- NSM Contract manager R. Oosterom (2014)
- NSM L& O manager V. Brethouwers (2014)
- NSM Supply Chain Specialist M. Gerrits (2014)
- NSM Supply Chain Specialist M. Gonzalez (2014)
- Project manager S.Dubelaar (2014)
- Business analyst M. Groenendijk (2014)
- KCS-Planning manager D. Buijs (2014)
- KCS-Planning employee L. Kloek (2014)
- KCS-Operation manager E. Zwager (2014)
- KCS Contract manager G. de Koning (2014)
- ICA-F Flow shift leader P. van der Kelen (2014)
- ICA-F Flow shift leader K. Furman (2014)
- KCS-Warehouse shift leader H. Swanepoel (2014)
- KCS-Warehouse manager O. Hensen (2014)
- KCS-Warehouse manager B. Kuijper (2014)
- SkyLoGistiX Consultant B. App (2015)
- SkyLoGistiX Consultant F. Clauss (2015)
- Do& Co Operator (2014)
- Do& Co Operator (2014)
- E&M Supply Chain Manager B. Kroes (2014)

A.2. THE IDENTIFICATION OF THE PERFORMANCE MEASUREMENT CONTROL PARAMETERS

This section discusses a standard set of performance indicators proposed [11]. This set proposes a holistic set of parameters to review the different parts of performance. However, given the control model at KLM, not all

Table A.1: Current ICA destinations with catering production facilities

ALA	Almati	GIG	Rio de Janeiro	NBO	Nairobi
ACC	Accra	GRU	Sao Paolo	NRT	Narita
ATL	Atlanta	GYE	Guayaquil	ORD	Chicago
AUH	Abu Dhabi	HAV	Havana	PBM	Paramaribo
BKK	Bangkok	HGH	Hangzhou	PEK	Peking
BOG	Bogota	HKG	Hong Kong	PTY	Panama
BON	Bonaire	IAD	Washington	PVG	Sjanghai
CAI	Cairo	IAH	Houston	SFO	San Francisco
CPT	Cape Town	ICN	Seoul	SIN	Singapore
CTU	Chengdu	JFK	New York	TPE	Taipei
CUR	Curacao	JNB	Johannesburg	XMN	Xiamen
DAR	Dar es Salaam	KGL	Kigali	YEG	Edmonton
DEL	Delhi	KIX	Kansai	YUL	Montreal
DFW	Dallas	KUL	Kuala Lumpur	YVR	Vancouver
DMM	Dammam	KWI	Kuwait	YYC	Calgary
DOH	Doha	LAD	Luanda	YYZ	Toronto
DXB	Dubai	LAX	Los Angeles	AMS	Amsterdam
EBB	Entebbe	LIM	Lima		
EZE	Buenos Aires	LOS	Lagos		
FUK	Fukuoka	MEX	Mexico-city		

the aspects are required to be review. Therefore, first the different items are discussed and their connection with elements at KLM is discussed. The conclusions focuses on the selection of elements that is suitable for to measure the required performance of the distribution control at KLM.

THE REVIEW OF THE GENERIC PERFORMANCE MEASUREMENT PARAMETERS

Effectiveness - The effectiveness criterion measures the extent to which the system meets its goals. It represents the ratio between the result that is planned and the result that is actually established. The effectiveness criterion for the equipment distribution at KLM is represented by the goal. The goal is that in each production node, there should be sufficient capacity for production. It is required to track effectiveness in the control model for the availability in the passive nodes of equipment, the compliance with maximum stock levels in production nodes and the fleet balance.

Efficiency and productivity The efficiency and productivity criterion assesses the amount of resources needed to accomplish the goal. It represents the ratio between the resources planned and the amount of resources used eventually. For the distribution network at KLM, the theoretic focus is a 100% active asset fleet. If the efficiency decreases, there is more equipment required to fulfil the same amount of work. The efficiency of the total system (equation A.2) reflects on the ratio between the number of equipment outstide KCS-Warehouse divided by the total number of equipment. This ratio indicates what the percentage of active equipment is within the distribution network at KLM. Within the percentage of active equipment in the total system, it is also possible to investigate further efficiency. The ratio, shown by equation A.3, shows the percentage of equipment in the total equipment that is active. The efficiency in the specific network nodes can be observed as the ratio between the allotment and the total amount of equipment in the node. A node with 100% efficiency has one complete set on the production floor and no spare stock in the warehouse. Rather than the other two levels mentioned, this level can only be calculated when the KLM batch is not in production and no KLM aircraft is in the outstation because it means that 2 sets of equipment are in the production facility. The three efficiency ratios enable NSM-Planning to have both an aggregate and a disaggregated efficiency overview of the network. If the aggregated ratio indicates decreasing efficiency, further investigation using the disaggregated ratio's can assist when observing the specific drivers for the efficiency decrease.

The second approach for efficiency is that efficiency of the system is measured in costs. If the same function is performed with fewer costs, the efficiency of the total operation increases. Different types of logistics costs are identified by Eidman (2005) and Jacobse (2013), the different cost drivers specifically defined for

$$n_{active} = n_{total} - I_{KCSW} - I_{VRR} \tag{A.1}$$

$$\eta_{total} = \frac{n_{active}}{n_{total}} \tag{A.2}$$

$$\eta_{active} = \frac{n_{active} - (\sum n_{OSW})}{n_{total}} \tag{A.3}$$

$$\eta_{OS} = \frac{A_{OS}}{I_{OS}} \tag{A.4}$$

η_{total}	Efficiency total distribution loop
η_{active}	Efficiency active loop (outside KCS-Warehouse)
η_{OS}	Efficiency for specific outstation
n_{active}	Number of items in the active loop
n_{total}	Number of items in the total distribution loop
I_{KCSW}	Inventory at KCS-Warehouse
I_{VRR}	Inventory in the reparation facility van Riemsdijk
$I_{warehouse}$	Sum outstation warehouse stocks
I_{OSW}	Inventory OS-Warehouse
A_{OS}	Allotment Outstations
I_{OS}	Total inventory outstations

closed loop logistics, defined by Johansson and Hellstrom (2007) are used. The first cost component is fleet investments. Fleet investments discuss the working capital, the replacement costs and the repair and maintenance costs. The total working capital is the amount of financial investments in the fleet is called the working capital. This working capital is stuck in the assets and is released if the total number of assets is reduced due to, for example, increased efficiency. The second cost component is for replacement. Replacement costs are involved for shrinkage or counterfeiting. The third component (repair and maintenance costs) is concerned for the repair and the maintenance of the fleet of equipment. Currently, only the equipment labelled as "broken" by the cabin crew is pushed out of the active fleet and transported. Maintenance is, in most occasions, only passively applied. It is important to measure the reparation costs to see the impact of this cost driver. Moreover, the decision can be made to include scheduled maintenance to avoid incidental, and often, higher costs for reparation. The fourth cost component, Transport costs, involves all the costs for transportation. In the current distribution system of KLM only the transportation between KCS-Warehouse and KCS-Production are important to measure NSM-Planning. The distribution to outstations via sea-freight is not part of the steady state modus and therfore not part of the cost monitoring. The other cost components are paid by the outstation. The last component is discusses the warehousing and handling costs. These costs involve the costs for the storage, sorting, handling and cleaning. The handling costs also cover the activities for measurement since this is part of the handling. Currently there are no warehousing costs accounted for the storage in the outstations nor costs accounted for handling and control costs.

Flexibility The flexibility describes the extent to which a system is able to react to changes. It the case of the distribution control model, it reflects how easily the operators of the system can change the model to changing environments without too many difficulties. Is is possible to identify three types of flexiblity: Product flexibliity, process flexibility and design flexiblity. For the distribution control system at KLM, it is required to be able to react to changing products and operations. The flexibility is not observed as one of the major process performance parameters because parts of flexibility are part of effectiveness and efficiency of the operation. The recommendations for system design, to make the system easily adaptable for new environments, are taken into consideration during the system design.

Control of the system The control of the system is something that is performed when the individual items are named. In environments with low maturity, like in the current environment for equipment distribution management, it is recommended by Gartner (2010) to cover on the most important drivers. Since KLM is mainly interested in service and costs, it is required to cover on the availability of equipment in the network in an efficient way. Shortages are required to be avoided under all circumstances, although a superabundance of equipment is to be avoided at the same time.

Quality of work The quality of work concerns the actual function and the content of the different employees, groups and aspect-systems. Quality of work can involve, among others, the following items: The issue behaviour of the outstation, the loading in the Production nodes, the loading in the Production nodes, Quality of the equipment, Quality of inventory management at outstations. The aspects above are either outside the scope of NSM-Planning (namely the responsibility of the production operators, contract managers or actors outside the scope) or already part of the efficiency and effectiveness monitoring. Therefore, the actual monitoring of the quality of work is not incorporated in the general control model.

Ability to innovate The ability to innovate discusses the ability of a subsystem, in this case a KLM network node, either production or warehouse, within the network to innovate its procedures when required by KLM. This means that the caterer needs to evaluate this under performance and propose a solution to improve. The aim is that the caterer not only performs this evaluation when it is demanded from KLM but performs evaluations on a continuous basis. The ability to innovate is coherent with the quality of work. When the quality of work is low, innovation of procedures is required. However, the innovation of for example outstations or KCS-Production is something that is managed outside the scope of NSM-Planning (namely, it is managed by Contract Management).

The purpose of the six main process criteria is to provide input for the definition of the standards of the process. However, given the current scope of the project, not all the process criteria for performance are relevant. There are no parameters included that reflect specifically on the state of the closed loop logistics. Therefore it is required to review these parameters. The next chapter provides information on RPM indicators.

RPM management performance measurement

Aside from the different generic performance indicators for systems as indicated by Bikker (1994), it is possible to use the specific performance indicators for closed loop logistics. The performance indicators for closed loop logistics have been identified in literature[38]. The performance indicators are the core of the RPM management model. The RPM management model proposes significant guidance in management of closed loop logistics since it proposes different control mechanisms based on the state of the parameters. These indicator, already shortly introduced in chapter 3 to analyse the current state of the closed loop control.

Return rate The return-rate is defined by as "the percentage of returnable assets that eventually return to the depot after having been is- sued to the market"[38]. Specific benchmarks for return rates for inflight loading equipment network are not available but similar environments. Differet case studies shows, using 10 different case studies, that in each returnrate in each environment is above 90%. However, it should be remarked that the character of the closed loop logistics distribution system at KLM has more control on the return than for example with beercrates or palletes. The return rate is measured often as a moving average of a certain period. For example at HEINEKEN, it is a 12-month moving average.

Cycle time The second parameter is the cyle time, defined as "the time elapsed between the issue of an article and its return to the depot to be reused again"[38]. The cycle time can be described through a statistical distribution. The cycle time is calculated for the returned articles. However, the finite cycle time for the articles not returned it not included. According to the definition of turnover, reduced inventories helps to increase the turns. On the other hand, reducing inventory will lead to uncertainties and consequently stockouts. The conclusion is drawn that the cycle time reflects on both the efficiency and the effectiveness. The effectiveness is whether or not the cycle time is according to the required cycle time. The efficiency reflects on the average cycle time. If, with the same production rate, the cycle time increases, this means that the efficiency is reduced.

inventory The third parameter "inventory" states that inventory reflects on " The on-hand inventory in each location (how much RA inventory is available in each stage of the supply chain) is sometimes difficult to quantify, due to the lack of visibility". When item-level tracking is not available or not economically justified, the inventory associated with a given location can also be obtained through registration of the incoming and outgoing quantities (account management), although this approach is not exempt of some shortcomings. This approach shows similarities with the proposed RFID implementation for tracking of returnable packaging materials Motorola2010[57].

Table A.2: The equipment control panel for NSM-Planning

Category	**Control aspect**	**Control parameter**
Efficiency	Efficiency total network	Total % equipment
	Efficiency active network	Total % equipment
Effectiveness	On-hand inventory	Total % per outstation
	Inventory balance	Total % per equipment type
	Return-rate	M A in % per equipment type
Costs	Total working capital	Total value in €
	Maintenace and replacement costs	Total value in €
	Transportation costs	Total value in €
	Warehousing costs	Total value in €
	Control costs	Total value in €

The RPM management model indicators are used because they provide sufficient information on the state of the closed loop. However, these parameters only provide information on the state of the loop, rather than a holistic overview of the performance of the total control system. Therefore it is required to merge this set of parameters with general performance indicators. The next chapter discusses the final set of parameters for the measurement of performance.

THE CONTROL PANEL TO MEASURE OF THE PERFORMANCE

The identification of the relevant parameters is made based on the analysis of Bikker (general performance of systems) and Gallego (performance of RPM management). The relevant parameters are identified as ratios for efficiency and effectiveness. For costs, it is important to monitor the development of the different components. Table A.2, the different parameters are shown. As discussed the efficiency is controled using the ratios for efficiency for the different indicates loops (Total, active and outstation). The effectiveness is controled by verifying the on-hand inventory in the nodes, the inventory balance and the return rate. Moreover, the costs are monitored for the cost components Working capital, Maintenance and replacement, transportation, warehousing and control costs. In this way, NSM-Planning can monitor the biggest operational requirements (efficiency and effectiveness) as the effects it has on the cost components. Based on the monitoring, a strategy can be defined to improve the (current) state of the parameters and to define actions how to improve the individual components. The acutal use of the system is defined in the next chapter. This discusses the control approach for NSM-Planning of the network, how to define strategy and how to translate strategy to the network.

A.3. THE SAFETY STOCK LEVELS FOR THE NETWORK NODES

Based on the main performance criteria service, it is required to identify how NSM-Planning can ensure the availability of equipment in the network. The purpose of NSM-Planning hereby is to reduce the probability of out of stock situation. The method proposed by literature to compensate supply chain weakness, is safety stock. Safety stock is used as an essential element to cover external issues ow delivery performances, improper scheduling, inadequate product capacity, bad maintenance (amirjabbari, bhuiyan). The calculation of the safety stock, together with the allotment, leads to the calculation of the minimum required inventory levels.

Items in scope The safety stock levels for the network nodes are calculated for three different levels; 98%, 99% and 99,9% of the time. This comparison enables to reflect on the impact of the service levels. The calculated levels are compared with the preferred levels indicated in the interviews by KCS (Janssen, 2014), contract management (Schoenmakers, 2014) and Loading and Ordering (Brethouwers, 2014). The equipment is calculated for two types equipment (1/2 lightweight trolley diethelm and ovenracks) and for two types of service equipment (Casserol round and the Delft Blue side dish). This calculation enables to compare the required safety stock levels for loading equipmnet with the required safety stock levels for service equipment.

Table A.3: The input parameters for the safety stock calculations

$$I_{safety} = Z * \sqrt{(T_{leadtime} * SD^2_{demand}) + (I_{demand} * SD_{leadtime})^2} \tag{A.5}$$

I_{safety}	Safety stock inventory
Z	Z-value (service level)
$T_{leadtime}$	Leadtime in days
SD_{demand}	Standard deviation of demand in units
I_{demand}	Average demand per timeframe
$SD_{leadtime}$	Standard deviation leadtime in days

Calculations	network	Calculations	KCS-Warehouse
Average leadtime	1 day	Average leadtime	5 days
SD demand	0,1*Breakage	SD demand	0,1*Breakage per month
Average demand	Breakage per month	Average demand	Breakage per month
SD leadtime	0,25 day	SD leadtime	0,5 day

Formulas and input parameters The model used for the safety stock calculation is shown by equation A.5. The safety stock is calculated using the average leadtime (and its standard deviation) and average demand per calculated timeframe (and its standard deviation). The demand is based on the return rate per equipment type (loading or serving) and the amount of shipped articles to the network, demand is calculated. The input parameters for the calculation of the safety stock at KLM are provided in table A.3. The calculations are made for a fixed period of 31 days. The demand during this period for the products is calculated using the return rate. The demand reflects the amount of replacement required due to breakages and additional losses. In accordance with Veen (2015) and Doze (2014), it is decided to use the standard deviation of demand as 0.1 of the demand. The leadtime with the suppliers of replenishment is identified as 31 days with a standard deviation of 1 day. For the network nodes, the leadtime is identified as 1 day (because the replenishment is applied with the next flight) with a standard deviation of 0,25 days.

The required service levels The safety stock levels are calculated using the formula and the input parameters. The safety stocks are calculated separetely for KCS-Warehouse and the outstation warehouses. This seperate calculation enables NSM-Planning to calculate the efficiency for both the active- and total loop. The active loop has a quick rotation period (1 day). A high service level is required since otherwise a high number of stock outs occur per year. The total loop makes use of the KCS-warehouse to store spare equipment. The cycle time for the KCS-Warehouse is identified as 31 days. In this way, the monthly fluctuations in KCS-Warehouse are used for both the maintenance and the identification of the safety stock. The identification of the required service levels is based on the preference to have less than 1 stock-out per month with 47 different catering equipment types. Table A.4 shows the influence of the service level on the probability of the stock-outs in KCS-Warehouse and OS-Warehouses. The table shows that for the service level in KCS-Warehouse, the desired service level is 98%. This results in 0,94 stock-outs per month. The desired service level for the OS-warehouses is identified as 99,9 percent. This results in 1,43 stock-outs per month. This is the lowest possible amount of stock-outs given the standard service levels. The total amount of stock-outs for the equipment distribution is 3 per month.

Calculated safety stock levels The service levels reflects on the probability that a cycle is prone for shortages. The combination of cycle time, cycle stock and service is shown in picture 5.3. Since rotation time is short (1 day) in the active loop, a high service level is required. The rotation time in the total loop is low (31 days), therefore a low service level is sufficient. Together with Doze (2014) and ten Veen (2015), it is decided to choose the 99,9% service level in the network. The calculated safety stock levels are shown in table A.5. The inventory for outstations is grouped under "spare inventory outstations". The inventory in KCS-Warehouse is a combination of the safety stock and the average inventory level the cycle stock. The monthly cycle stock is the required replacement per month.

Table A.4: The calculated stock-outs per network location based on the service level

	OS-W		KCS-W	
Service level	Yearly stockouts	Monthly stockouts	Yearly stockouts	Monthly stockouts
84,00%	2744,80	228,7	90,24	7,52
85,00%	2573,25	214,46	84,6	7,05
90,00%	1715,50	142,95	56,4	4,7
95,00%	857,75	71,47	28,2	2,35
97,00%	514,65	42,88	16,92	1,41
98,00%	343,10	28,59	11,28	0,94
99,00%	171,55	14,29	5,64	0,47
99,90%	17,16	1,429	0,564	0,047

Table A.5: The required efficiency thresholds and safety stocks in the network

Ovenracks	Spare inventory outstations	10
Loading equipment	inventory KCS-Warehouse	50
	Total loop	98,70%
	Active loop	99,70%
Trolley 1/2 Light Weight Diethelm	safety network	13
Loading equipment	inventory KCS-Warehouse	70
	Total loop	98,70%
	Active loop	99,70%
MW China Casserole Round	safety network	124
Service equipment	inventory KCS-Warehouse	717,34
	Total loop	89,00%
	Active loop	97,85%
MW Delft Blue Small Dish	safety network	99
Service equipment	inventory KCS-Warehouse	570
	Total loop	89,00%
	Active loop	97,85%

A.4. THE CURRENT STEADY STATE SYSTEM DESCRIPTION

THE STEADY STATE DESCRIPTION: KLM CATERING SERVICES

KCS-Production KCS-Production is the central node in the distribution network. The function of KCSProduction is to produce all the catering, and assemble the inflight articles, for the outbound flights from Amsterdam. The equipment that is used for production is the incoming flowfromhomebound flights towards Amsterdam. The differences between the out- and inbound flows result in fluctuations in the inventory level in KCS-Production. These fluctuations are balanced with the spare stock inventory in KCS-Warehouse.

Currently there are no active or standardized measurement methods that are applied within KCS-Production. This means that there is no active monitoring of RPM management parameters (inventory levels, circulation time and return rate). The measurements that are applied are observations by the shift leaders from KCS. The PSU compliance of the inbound flights is not measured. The incoming flow of equipment is offloaded from the flights and pushed into KCS-Centrum. The PSU compliance of the outbound flights is measured in production. However, it is not counted on individual pieces. The conclusion can be drawn that the PSU compliance for loading equipment is currently measured; the PSU compliance for serving equipment is unknown. As described, there is no measurement of the inventory in KCS. This means that there is no information available on the total inventory levels in KCS-Production, nor in the individual compartments. Especially the point between the washing machines (where equipment is pulled into production) and inbound docks (where equipment is pushed into the location) is required. This is the point where the decision for replenishment is taken. Since the RPM management parameters are currently not measured it is not possible to compare the levels with historical data. The current comparison that is made is made by the shiftleader who compares his observation with tacid knowledge based on experience. In the outbound docks the final scanning is performed per flight. Hereby the scans compare the prepared equipment with articles with the alotment generated by the program BAAN. In case articles are missing or the compliance is not 100%, additional actions are required in order to prepare the flight according to the PSU. If the observed levels observed to be either too high or too low, the shiftleader decides for balancing activities. This means that either equipment is subtracted or added to the flow (using the spare-stock levels at KCS-Noord). The current decision is made based on the actual stock-levels in KCS-Production; the timetable of in- and outbound flights is not used for the current planning procedure. This means that the current in- and outflow for KCS-Production is not used to forecast the balance between equipment supply and demand. If the loading is observed to lack compliance with PSU during the final scan, it is decided that the missing items are subtracted fromthe earlier stages of production. Given the fact that in- and output at KCS-Production is not used to forecast the equipment demand, it can be concluded that the current equipment control at KCS-Production is insufficient. The aspect system "act" focuses on the production of catering, the balancing of equipmen between KCS-Production and KCS-Warehouse and the loading and unloading of equipment from commercial (KLM) aircrafts.

KCS-Warehouse Measurement of stock levels in the warehouse – The measurement of the stock-levels are required to be able to maintain the required levels. The current stock-levels are measured in SAP based on movements towards and from the warehouse. Hereby is the assumption that everything that is taken from the warehouse and brought to the warehouse clearly administrated in SAP. The store-stock levels are not measured in the warehouse. Stroobach (2014) indicates that there is often misalignment between physical movements and administration in SAP. This can result in the fact that SAP indicates sufficient stock while the warehouse actually is empty. Measurement of stock levels of in-bound logistics – The inbound logistics flows are required to be measured by the shop floor operators. This should be done in order to be able to monitor the incoming flows in SAP. However, Stroobach (2014) indicates that this not always happens. Sometimes, the inbound logistics are not monitored and directly transported to KCS-Production. Based on the function of KCS-warehouse within the distribution of loading equipment,the measurements should be compared with standard levels. The actions are decided on the gap between measured levels and minimum or maximum required levels. The following comparison actions take place in KCS-Warehouse. Compare with stock levels in replenishment order from KCS-Production – In order to verify incoming orders of equipment, the incoming flow should be verified with the incoming shipping bill. This procure is currently sufficient. Compare with stock levels in arriving delivery from external node to KCS –warehouse – Currently, there are no minimum stock levels required for KCS-warehouse. Figure **??** shows the current levels in KCS-warehouse. Given the fact that there are no minimum required levels and no fixed period review of current levels, some levels have clearly declined. As can be seen for the Oven Rack (60280), there is almost no inventory left. A procedure

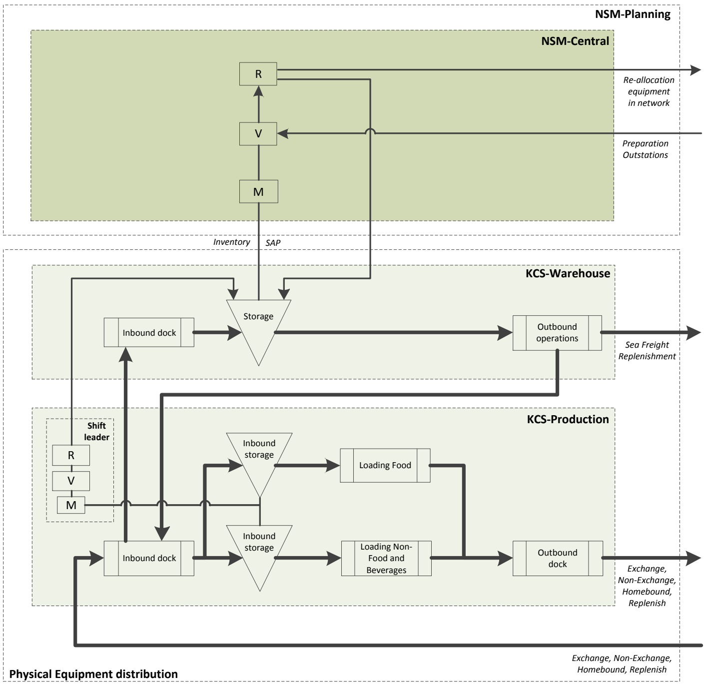


Figure A.1: The current steady-state model of KLM Catering Services (Source: Own production)

for active stock level maintenance or fixed—period review is not clearly defined. NSM-Planning makes the decisions for KCs-warehouse. No decision responsibilities within KCS-warehouse. Based on the function of KCS-warehouse within the distribution of loading equipment, different actions should be undertaken based on the gap between measured level and required levels. The following tasks are identified: Process order in warehouse the incoming order, either incoming or outgoing flows should be processed in the warehouse. This involved the physical handling to either store or pick the equipment and move it towards the final destination. Process the order in SAP – Based on the activity (either to issue equipment for KCS-Production or to administrate incoming flows from van Riemsdijk), the flow should be exactly monitored in SAP. For the procedures that are currently administrated, this procedure is sufficient. However, as discussed in the past chapter, not all the equipment is administrated. Communicate to area planners to recall equipment – The central planner warns the area planners that the stocks in KCS-Warehouse are declining and that therefore, the outstations are requested to send inventory surplus back to Amsterdam. However, this is not a procedure that is applied on a regular base.

THE STEADY STATE DESCRIPTION:OUTSTATIONS

OS-Production The measure tasks focus to track the inventory levels within the catering facility. The inventory levels for loading equipment are part of the "active" stock. Therefore, it is not tracked in SAP. This makes it hard for NSM planning to investigate the inventory levels in the outstations. Measure stock levels on working floor – The working floor stock is something that is not actively administrated in SAP. The area planners from NSM planning organize the manual counting of stock on the working floor from time to time. Currently this is once every 6 months. The outstations send the observations to Amsterdam. Reliability is questionable but assumed to be 100%. Measure the loading of aircrafts A second tasks for the outstations is to measure the incoming flow of equipment in order to see what is actually offloaded from the incoming flight. According to Schoenmakers (2014), the contract managers verify the loading by the outstations from time to time but there is no fixed period for the procedure and no standardized guidelines for the procedure are formulated. Some of the outstations (for example the DoCo Production unit in Istanbul) currently measure all the loading equipment that arrives in their unit. However, this is not a standard practice in the outstations. Measure the available loading equipment for production – The outstation should measure the availability of loading equipment for the production they want to do for the outbound flight. Normally the catering is prepared before the inbound flight arrives. As soon as the inbound flight arrives, the prepared catering for the outbound flight is loaded and the used catering is offloaded. Given this procedure, the outstation catering facility has 2 complete catering set at that moment for the loading equipment at the exchange positions. Compare stock levels with allotment - No regular comparison with allotment by the outstation manager. This is only from time to times done by the area managers. According to Tempels (2014), the procedure should be that the management in the production facility operator should compare the available levels with the allotment. Compare stock levels with loading program – Outstations almost never experience shortages on loading equipment according to Tempels (2014) and Roos (2014). The surplus in equipment is often because there are certain scenarios where more equipment arrives than has to be send back with the catering articles. The latter exists due to different meal programs whereby, for example, empty ovens need to be placed on board. Since these empty ovens are not used in production and are therefore prone to be "forgotten". This shows that the comparison between the required loading of an aircraft and the actual loading is not completely sufficient.

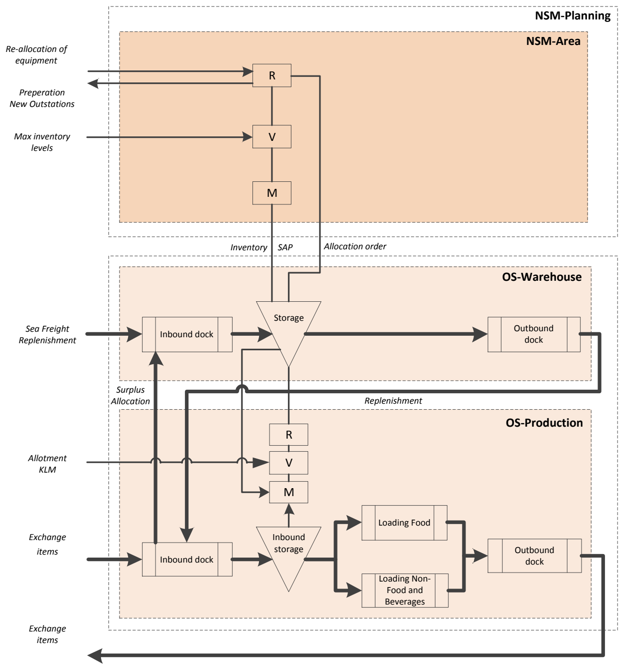


Figure A.2: The current Outstation steady-state model (Source: Own production)

OS-Warehouse In order to be able to provide sufficient replenishment to ensure availability of articles, the following aspects should be measured in the outstation warehouses.The stock levels in the warehouse are measured to be able to reflect on the availability for production. The stock levels are found in SAP and are communicated through the SAP portal that is installed in each of the outstations. Measurement of stock levels of in-bound logistics – The stock levels at the inbound logistics should be measured if equipment is transferred from the production facility to the outstation facility. According to Tempels (2014), the outstations are not allowed to keep any safety stock in their warehouses. The only safety stock that is allowed is for drawers and for this type of equipment, a maximum of 2 items is allowed. So the levels are defined but the procedure for comparison is not sufficient. Decisions for OS-Warehouse are either ordered by OS-Planning or made by OS-Warehouse management based on the regulations proposed by NSM-Planning. The tasks related to action upon the measurements are focusing on rebalancing the surplus in equipment back to the KCS-warehouse facility. This is important to mention because it is not intended to end up in de working stock. In case the inventory levels exceed the maximum levels, they should actively manage their warehouse levels by sending equipment back to Amsterdam. This procedure is not automatically applied by the outstations. In most of the times, the area planners manually control it. This procedure starts in most of the times after the area planners observe shortages in KCS-warehouse. The different movements from the warehouse towards the catering facility should be administrated in SAP. However, the low issue behavior, as calculated by Tempels (2014) Roos (2014) and Bakema (2014) shows that the administration in outstations warehouse shows signs for improvement.

INVENTORY- AND REVIEW POLICIES

Inventory policies This section discuses the identification of the inventory policies for the network nodes. The different inventory policies compared with eachother are Just In Time (JIT), safety stock, re-order point and the min-max inventory policy. JIT, as part of the lean management philosophy aims to minimize the costs of inventory [50]. In addition, the degree of time laps between materials arrivals, processing and assembly of the final product for consumers is minimized by the JIT technique [51]. Although benefits focus on reduced costs there are also limitations identified. First of all it requires great compliance to the philosophy, there is a loss of autonomy of the individual supply chain components, it is very industry specific and often there is a great resistance to change towards JIT. In contract to JIT, safety stock makes use of a back-up inventory level calculated using the trends and variability of sales, lead-time and service levels. The safety stock is the inventory level that, in case everything happends according to the forecast that is reached when the replenishment order arrives [52]. However it is required to have average sales (issue behavior). Therefore the safety stock is not a suitable method to apply in the network nodes since there is no regular utilization pattern. However, the re-order point is the point where new replenishment orders are made based on the size of the order and the leadtime vs. utlization per timeframe and proposes a solution for the network [52]. The min-max policy can be seen as the opposite of the JIT policy [50]. With the min-max policy, there is a comfort of knowning that the inventory is available and ready for a customer. In order to compute the maximum in these systems, it is required to determine the production rate that required by production but, in the case of KLM, also the supply that arrives at the production facility [60].

Review policies The question how often the measurements are reviewed is based on the review policy that is decided for the specific node based on their function. The possible review policies are either continuos or once per fixed time period. The paragraph below discusses the two different options. Continuous review is the fixed 0order quantitity model used when the purpose is to maintain an item "in-stock", and that for teh resupply, a certain number ofunits must be ordered each time [52]. Although there is not a fixed-order quantity model, whereby only a fixed number of items can be ordered, there is a continuous review policy currently at KLM. Namely, the warehouses are monitored in SAP and since every movement is (required) to be administrated in SAP, the system continuously monitors every movement. However, this is only for the warehouses in KCS and the outstations. Continuous review of the production locations is observed to be insufficient if manual measurement is required. However, the measurement methods RFID and barcode show reasonable control cost for continuous review. Fixed time period review is used to review the inventory at a standardised moment in time (for example once a week, month)[52]. In environments with low dynamics or low possibilities for tracking, it is recommended to review the inventory using a fixed period time review. Based on the variability of the node, it is decided what the fixed periode time is for the differ- ent network nodes. Given the decision to start with manual measurement until a decision for further me- chanical development is made, the fixed-time period review policy is implemented in KCS-Production and OS-Production. An additional fixed-time period review is proposed for KCS-Warehouse and OS-Warehouse to verify the SAP data with the actual levels of the inventory.

CONTROL POLICIES

Centralized approach The defintion of centralized management is "Management practice in which all or most decision makers (who have the authority, control, and responsibility for the entire organization) are located in one central office (the headquarters)"[47]. In case of the Equipment distribution it means that NSM-Planning makes the decisions and that there is no autonomous equipment management decision authority in the outstations. This requires close connection between NSM-Planningk and the network nodes to receive accurate and up-to-date measurements from the network. The continuous review of the dynamics is inevitable for centralized control approaches. Otherwise, it is possible that there are sudden changes in demand for equipment and that the nodes cannot decide to, for example, issue new equipment from their warehouse. Both for the monitoring as for the amount of decisions required to be made for the network nodes, it is foreseen that the workload for NSM-Planning (and thereby the centralized control costs) increase dramatically.

Decentralized approach The definition of decentralized management is "An organization wherein the decision-making authority does not sit with a central figure or group. Some decentralized organizations empower all levels within the hierarchy with decision influence"[45]. This decentralized approach for the equipment distribution network means that each node is able to make their decisions for the equipment distribution. These decisions are influenced and/or according to the regulations proposed by the strategy of NSM-Planning. Using this decentralized approach, the control costs are shifted from NSM-Planning towards the network nodes. Contrary to centralized control, it gives NSM-Planning less control over the network. Therefore, active monitoring by NSM-Planning of the network nodes is required to see the impact of decentralized decision making. Also regarding the implementation and tracking of the NSM strategy, it takes more time to implement strategy since the decision making for the distribution network is outside NSM. Therefore, first the outstations need to understand the new strategy before they can apply it.

Figure A.3: The ROA area in KCS-Warehouse

B

ANNEX: The selection of the data collection method using an Analytic Hierarchy-Process

This ANNEX elaborates on the Analytic Hierarchy-Process (AHP) that is used to define the best data collection method in the distribution network of KLM. The method that is used for the selection is AHP [39]. The first section describes the method, the aim of the AHP and the important aspects used for the calculations. The second section discusses the different input variables and the scenarios that are used in the AHP. The requirements focus on operational costs, investments, implementaiotn time and completeness. The scenarios for the measurements focus on the use of Barcode, passive RFID, a combination of passive RFID+Barcode and two types of manual counting. Also the actors that provided their input are elaborated. The fourth section discusses the scorign of the measurements means. The section elaborates on the separate scoring of the requirements, the means and the introduction of different scenarios for additional balanced scoring. The fifth section elaborates on the results and the choice for the final measurement collection method.

Methodolgy for the Analytical Hierarchy Process

The method used for the analytical hierarchy process is the procedure [39]. Saaty states that the main advantage of the AHP procedure is that it enables the user to rank choices in the order of their effectiveness in meeting conflicting objectives. It proves to be a usefull technique, in several instituations (US Departments of Defence, British Airway and the US Public Administration [39]). The model constructs a matrix expressing the realtive values of a set of attributes. For the application of the model, it is important to view some important remarks. First of all it is important to watch the correlation factor of the comparisons. Moreover, the model only shows the relative value for money.

Introduction of the input variables

This section discusses the different input variables for the AHP process. The first paragraph discusses the requirements used to score the measurement means. The second paragraph discusses the different measurement means and technologies that are identified to be valuable for the data collection. The third paragraph discusses the different scenarios that are constructed as input for the AHP analysis. The third paragraph discusses the actors that are identified to fill in the analysis.

Requirements Based on the interviews with NSM-Planning manager Doze (2014), NSM-Regie manager ten Veen (2015), Buijs (2014) and review of literature, different requirements are identified. The identified requirements are operaitonal costs, implementation time, completeness and reliability, investments and scalability. The different aspects are discussed below.

- Operational costs - The operational expenditure of the measurement systems discusses the costs to run the system in steady-state. The costs are related to the manual costs (amount of FTE required), ICT costs (maintenance and costs of running the system) and general operation costs). Manual operations have high manual costs since it is completely operated by humans. However, active RFID has really low manual labour costs. The ICT-costs are low for manual operated systems and high for the active RFID system maintenance in all of the network points is required.

- Investments - The capital investments discuss the total investments that are concerned for the initial set-up of the set-up. The required investments for manual measurements are low since no big investments are required except for the design of (Excel) tools and training of the people. The investments grow if additional features (bar-codes, RFID tags, antennas, readers) or additional (ICT) infrastructure is required. Open-source software can reduce the capital investments.

- Implementation time - The requirement implementation discusses the difficulties regarding the implementation. The method for manually observations is easily implemented: people are trained and governance is designed for reporting. No additional ICT structures are required, only Excel and email. For the bar-code system, the equipment should be equiped with barcode, the ICT-system to read the barcodes should be designed and people should be trained to use the scanners. The passive RFID required according to [57] and [3], only boundaries in the main production hub.

- Completeness and reliability- The data reliability depends on both the type of observation, the structure for data administration, the governance and whether the system is prone for errors. Manually observations are sensitive for error making and there are many steps between the field observation and the final tracking of the observations in the system. People can misread the trolleys, make errors in observations or have lack of compliance with the designed procedure.

- Scalability equipment - This requirement discusses the extend to which a means of measurement is scalable towards the other types of equipment. Is introduced in chapter 2, the NSM-Plannings scope of responisbilities is also on serving equipment (Cans, Dishes etc. etc.).

One of the items that are also important is the Robustness of the measurement method. According to the Accidental Action Eurocode (EN 1991-1-7), the definition of robustness is:"the ability of a structure to withstand events like fire, explosions, impact or the consequences of human error, without being damaged to an extent disproportionate to the original cause". Analysis showed that the distribution process requires a robust technology that can resist the impact of the operation. However, it is Robustness is left out of scope. Given the requirements the methods with RFID tags are the least robust since they cannot function if their tracker is damaged.

Measurement methods This section discusses the possible measurement methods for the (mechanical) data collection in the distribution network. The possible technologies/methods are Barcode, Passive RFID, active RFID, PAssive RFID+Barcode, WiFi and GPS. The conclusion provides the selection of the methods that are input for the AHP method.

- Barcode: Barcode technology, companies can more effectively track, control, recover, and secure returnable shipping assets during their entire lifecycle. Barcode systems offer relatively accurate identification rates and have a low misread ratio [49]. On the other hand, disadvantages also exist with a barcode system because each individual asset must be manually scanned and the barcode must be visible. Moreover, barcode systems do not provide for realtime automatic locating of the assets, and damage to the barcode could cause it to be unreadable (McCathie, 2004)

- Passive RFID: : Passive RFID systems consist of a reader, a tag, and a computer [48]. Passive RFID tags have no internal power source such as batteries. Passive RFID only gives a snapshot of nearby assets at a given time. Due to the short communication read range of only three meters; passive tags should be used when the movement of assets is consistent and controlled. One advantages of passive RFID technology for managing containers is that it does not require the reader or scanner to see or contact the tag. When the tag crosses the path of a reader, the information is automatically interpreted [61]. At a cost of approximately 0,20 to 3 dollar, passive RFID tags are considerably less expensive than the tags for active RFID [62].

- Barcode + RFID: The combination of barcode + RFID is a combination of measurement means. It is according to the scenario proposed by SkyLogistiX [3]. This scenario described the scanning activities of the inbound and outbound flows. In addition to the scenario of SkyLogistiX, it is possible to expand the use of the barcodes towards other types of loading equipment rather than only trolleys. This scenario discusses the application of barcodes and RFID on a selection of equipment types. RFID is applied on the suitable equipment types that are able to ride across the thresholds. The barcodes are applied on a selection of additional equipment types. The input for the AHP is the possibility of the application of barcodes on all the types (which in theory is possible).

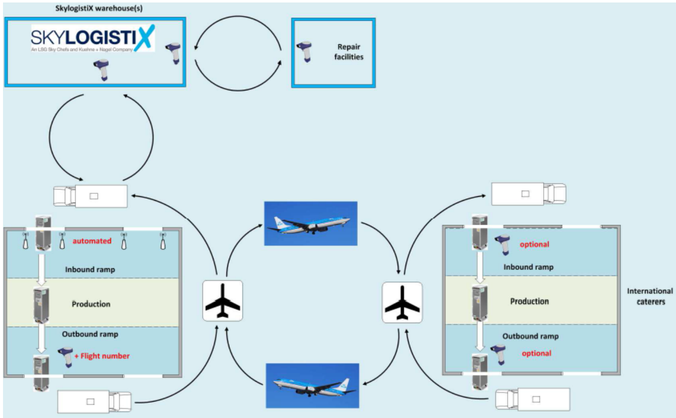


Figure B.1: The scanning scenario as proposed by SkyLogistiX [3]

- Active RFID: Another possibility is the introduction of active RFID tags, wifi or GPS tracking. An active RFID system includes a reader, tags, and a computer [63] [64]. Active RFID tags have a unique, embedded DC battery power source that allows the RFID tag to continuously send out a stronger signal that can be received by a reader up to 100 meters away (Tesoriero, R., et. al, 2008). An active RFID system is part of a realtime location system (RTLS) that is capable of continually monitoring assets and personnel. The embedded power source increases the cost of the tag from 20 to 150 dollar [62]. The reliable implementation of RFID should include three stages mainly designed to evaluate the technology, the impact of tagged products in the technology, and the impact of the overall application environment [65].

- Wifi: Wi-fi is a tracking option that has extra communicational benefits compared to passive RFID [WIFI UPDATE]. Similar to active RFID, WiFi tags can have sensing capabilities that allow them to collect data related to the temperature and pressure of products. Though, Wi-fi is relatively costly to implement and if the Wi-Fi coverage is weak, the strength of the signal is low.

- Manual counting: The manual counting data collection method concerns data collection by shopfloor operators. It can concern counting of inventory levels, in- and/or outgoing flows, the amount of broken units and additional features. The drawback of the manual counting is the operational costs for the required fte's, the reliability of the calculations and the capacity constrains.

- GPS: A Global Positioning System (GPS) is a type of RTLS technology that is very useful for tracking vehicles, but GPS is not an appropriate technology for tracking hundreds or thousands of tags in a fixed space, especially indoors ([66]; [67]). The indoor spaces are out of reach of the GPS satellites, so the use of this technology at this point in time is not suitable for tracking of returnable containers that are occasionally stored indoors.

Conclusions: Focus on manual counting 1 and 2, RFID passive, Barcode and RFID+Barcode. However, these three technologies prove to be not sufficient for equipment tracking. Active RFID is too expensive because the whole network required antennas and a comprehensive ICT infrastructure. WIFI tracking is costly and GPS tracking shows bad readability. Moreover, the scalability for the three technologies is low.

Introduction if the used scenario description This section elaborates on the different scenarios that are used for the AHP procedure. Each procedure describes how the technology is implemented at KLM and what the different aspects of the scenario include for the items reliability, OPEX, CAPEX, scalability and implementation time.

Table B.1: Summary of the scenario description (Source: Own production)

Alternatief	Implementation	Operational	Investments	Scalability	Reliability
Passief RFID	9 months	3750	E80.000	Trolleys	High
Barcode	6 months	3750	E30.000	Everything	Medium
Barcode+RFID	9 months	7500	E110.000	Trolleys	High
Handmatig 1	0 months	0 months	0	Everything	Low
Handmatig 2	4 months	1250	E1000	Everything	Low

- Barcode: All types of equipment can be counted (barcodes also on cuttlery etc.). The reliability is good as long as everything is scanned. Barcode investment has been 30,000 (tags + ICT scanning system). The ROA is equipped with scanners and the B scan KCS is integrated into the current process. All control aspects can be measured. Operating costs are estimated at 3,750 euros depending on the system. All aspects of the control panel can be measured. Implementation time is 3 months and 3 months for decision-making training and instruction of the various points in the network. KCS is measured from the network and balance created by outstation. Material planning is coordinated jointly by NSM and KCS.

- Passive RFID: Only trolleys with RFID can be counted. Reliability is good considering the low human impact on the measurements. Measurements are automatically processed. Investment is focused on E80.000 for the tags, the thresholds in KCS-center and IT system. Operating costs are estimated at 3750 per month. There are no FTEs needed for this method. Measured at the entrance and exit of KCS, the system writes the stream to the outstations. Implementation time is 6 months for decision-making, 3 months for construction and equipping of KCS with thresholds. KCS is measured from the network and balance created by outstation.

- Passive RFID + Barcode: All types of equipment can be counted. Reliability is good as long as everything is scanned. Measurements are automatically processed. Only barcode products are removed manually along a scanner. Operating costs are estimated at EUR 7,500. The movements are measured at the entrance and exit of KCS with barcode scanners. RFID scans automatically. The system assesses the outstations. Implementation time is 6 months for decision-making, 3 months for preparation and installation infrastructure and training. Material planning is coordinated jointly by NSM and KCS.

- Manual counting 1: (current situation) the equipment is kept only in the warehouses via SAP. Total stock per station is counted one time per half year. Reliability is unclear and not all outstations actually count. Process is time consuming and can be error prone, reporting via Excel. Operational costs are borne outstations. KCS Center is not counted. Investment is required and operational costs are negligible. The scalability concerns all types of equipment, but the feasibility of this weekly/monthly observations is low. Material Planning arranged from KCS, NSM coordinates the KCS-Warehouse.

- Manual counting 2: When this count are outside stations counted weekly and KCS Center daily. It is not possible to collect all the data to the control panel, only inventory levels. No possibility to balance out stations. All types of equipment can be counted but feasibility question therefore focus on key types. Reliability is unclear. The required investments are low; Process measurement takes time and is prone to error. Reporting via Excel or via Portal. The operating costs are 1250 for the counter of stock in ROA. These costs are for KCS. The investments are 1000 for training. Implementation time is 2 months for decision is 2 months for training and instruction of the various points in the network. Material planning is coordinated jointly by NSM and KCS.

Table B.1 shows the summarized aspects of the scenarios. This first observation shows that the current data collection method is best since it scores the best on four of the five aspects. However, the AHP is used to identify the scoring using relative weights of the requirements. The actors are asked to score the scenarios for the requirements. The next section provides a description of the actors chosen to participate in the AHP analysis.

Table B.2: Requirement scoring per actor (Source: Saaty Scoring NSM)

Function	NSM-O	NSM-P	KCS-O	KCS-P	Central	Area	Research
Reliability	0,32	0,47	0,16	0,28	0,41	0,45	0,442
Scalability	0,10	0,33	0,09	0,47	0,26	0,25	0,26
Implementation	0,13	0,12	0,02	0,06	0,05	0,05	0,06
CAPEX	0,14	0,04	0,23	0,05	0,17	0,09	0,10
OPEX	0,28	0,05	0,48	0,14	0,11	0,15	0,16
CR	0,262	0,202	0,314	0,143	0,10	0,139	0,16

Introduction of the actors for the MCA For the MCA, it is chosen to collect the scoring from different actors in the environment of the equipment distribution management. It is important to identify the requirements and the preferred methods for the different actors within both NSM as the network. Within NSM, it is important to investigate if the managers and the planners have a different hierarchy of the attributes. It is also important to have insights in the hierarchy for the attributes in the network. Therefore, Kloek (2015) from KCS-Planning is involved. The researchers is also involved in the AHP since he has an objective viewpoint for the AHP. The final list of participants is Veen (2015) as manager NSM-Regie, Doze (2015) as manager NSM-Planning, Kloek (2015) from KCS-Planning, Stroobach (2015) from Central-Planning, Bakema (2015) from Area-Planning and Stolk (2015) as the researcher. The next chapter discusses the scoring of the AHP method.

THE SCORING OF THE MEASUREMENT MEANS

This section discussses the scoring of the measurement means using the AHP method. The first paragraph discusses the scoring of the requirements to decide the hierarchy between the requirements. The second paragraph discusses the scoring of the measurement methods on the attributes. Since the CR factor is important when using the AHP method, the CR of the input values is discusses independently. The final scoring is discussed using both the normal outcome as different scenarios whereby the hierarchy of the actors is changed. These scenarios are identified based on discussion with Doze (2015) and Veen (2015).

The scoring of requirements This paragraph discusses the scoring of the requirements. The final target is to identify the general hierarchy of the requirements. The results of the scoring are provided by table ??. The scoring of NSM-Operations shows the focus on Reliability and operational expenses. The scoring of NSM-Planning manager shows that she has her focus on reliability and scalability. This is the exact same viewpoint as the planners (both area and central). The scoring of KCS-Operational shows their preference for scoring on operational costs. As indicated before by Buijs (2014) and Zwager (2014) their focus on cost reduction. Their low preference for data reliability and scalability shows that they are not concerning forecasting or additional administrative activities. The scoring of KCS-Planning shows their preference for the attribute scalability. This is as expected since they suffer from shortages for China porcelain. Their low preference for implementation is also as expected since they are not involved for the financial costs. The scoring of Central- and Area-Planning shows the same pattern. Expect the scoring for OPEX and CAPEX is switched. Area-planning prefers lower CAPEX and Central-planning prefers lower CAPEX. The scoring of the Researcher shows the importance of the reliability and scalability. The least important aspect is the implementation. In general, it is concluded that the reliability is for everyone very important. Everybody has indicated reliability as the most important aspect (except NSM-Operations management but she indicated it as the second most important aspect). A remarkable insight is the low scoring of scalability by the NSM-OPS manager. This would indicate that she doesn't favour scalability and therefore, a technology that can only scan one type of equipment can meet her requirements. However, it is expected that her focus is broad (both financial as operational) and therefore, the low scoring for scalability can be misleading but is proportional to the other requirements. Almost all the actors give low importance to the attribute implementation time.

The method describes that only results with a CR<0.1 are allowed to used. Table ?? shows that the CR of the results of NSM-Operations, NSM-Planning, KCS-Planning and Area-Planning are too high. However, it is decided that the results are used since the preferences for the attributes can be decreased (less extreme) and it is still possible to focus on the same results. Moreover, the focus is to investigate the general hierarchy of the attributes.

Table B.3: Scoring per actor for the requirements (Source: Saaty Scoring NSM)

Requirement	Data method	NSM-O	NSM-P	KCS-O	KCS-P	Central	Area	Researcher
Reliability	Bar-code	0,215	0,138	0,135	0,123	0,160	0,089	0,155
	Passive RFID	0,215	0,253	0,495	0,202	0,224	0,257	0,254
	Passive+Barcode	0,468	0,524	0,288	0,497	0,493	0,587	0,437
	Manual 1	0,054	0,030	0,049	0,084	0,045	0,044	0,050
	Manual 2	0,048	0,055	0,034	0,093	0,078	0,023	0,103
Impl. time	Bar-code	0,113	0,399	0,188	0,160	0,171	0,242	0,160
	Passive RFID	0,335	0,215	0,500	0,112	0,265	0,127	0,097
	Passive+Barcode	0,462	0,306	0,234	0,051	0,412	0,557	0,062
	Manual 1	0,032	0,042	0,045	0,416	0,060	0,023	0,417
	Manual 2	0,058	0,038	0,034	0,262	0,093	0,050	0,263
CAPEX	Bar-code	0,155	0,541	0,069	0,160	0,160	0,233	0,146
	Passive RFID	0,240	0,184	0,069	0,053	0,053	0,126	0,069
	Passive+Barcode	0,497	0,202	0,021	0,032	0,032	0,570	0,040
	Manual 1	0,047	0,027	0,420	0,521	0,521	0,047	0,430
	Manual 2	0,061	0,046	0,420	0,234	0,234	0,025	0,316
OPEX	Bar-code	0,145	0,459	0,080	0,133	0,133	0,230	0,111
	Passive RFID	0,311	0,205	0,558	0,140	0,140	0,088	0,123
	Passive+Barcode	0,429	0,256	0,071	0,040	0,040	0,613	0,073
	Manual 1	0,061	0,027	0,265	0,436	0,436	0,023	0,424
	Manual 2	0,054	0,053	0,027	0,250	0,250	0,046	0,268
Scalability	Bar-code	0,150	0,507	0,087	0,180	0,180	0,247	0,217
	Passive RFID	0,322	0,269	0,590	0,243	0,243	0,031	0,038
	Passive+Barcode	0,401	0,146	0,093	0,359	0,359	0,595	0,515
	Manual 1	0,063	0,035	0,204	0,109	0,109	0,035	0,090
	Manual 2	0,062	0,043	0,026	0,109	0,109	0,092	0,140

The scoring of measurement means This chapter discusses the scoring of the measurement means for the methods. Table **??** shows the scoring of the means on the attributes without the hierarchy of the attributes. Table B.4 shows the CR factors for all the input values by the actors. Table B.5 shows the final results of the AHP process. This result is preliminary and is further discussed in the next subsections. First, the three tables are discussed below. As discussed, table **??** shows the different final scoring results (without the weight factors of the means involved) for the different requirements and the measurement methods. It is remarkable that some of the actors seem biased when scoring certain methods. As can be observed for the CAPEX and OPEX scoring for the methods. Some actors (NSM-OPS, AREA-Planning) score RFID and RFID+Barcode high on the CAPEX and OPEX and manual counting low while actually manual counting is much cheaper. Therefore, it is expected that they would score higher. The three actors that don't seem biased by this attitude towards barcode + RFID are KCS-Operational, KCS-Planning, Central-Planning and the researcher. This is also something that is observed for the requirement implementation time. The same set of actors score the technologies higher on implementation time while their implementation time takes longer than the manual counting scenarios. The reliability is very important for the departments that are involved in the control of the distribution: NSM. The different NSM-Planning do confirm this hypothesis and all give the highest scoring for reliability to the method that is observed to be the most reliable: the barcode + RFID scenario. The scoring of the manual counting 1 (the current method) shows that most of the actors observe this method as inreliable. The average scoring of this method for reliability has average below 5%. The next step is to calculate the final scoring using the eigenvectors with the eigenvectors of the requirements. However, first the correlation factors are discussed.

MCS: Reflection of consistency ratios Table B.4 shows the correlaction factors of the input scoring. As indicated in the introduction of the method, CR factors higher than 0,1 show too little correlation and can

Table B.4: |Correlation factors of the input values (Source: Saaty Scoring NSM)

Function	NSM-OPS	NSM-P	KCS-O	KCS-P	Central	Area	Researcher
Reliability	0.03	0.10	0.18	0.08	0.17	0.26	0.04
Implementation	0.20	0.11	0.11	0.03	0.14	0.39	0.02
CAPEX	0.04	0.05	0.14	0.07	0.10	0.37	0.09
OPEX	0.06	0.13	0.21	0.01	0.08	0.28	0.10
Scalability	0.09	0.18	0.22	0.07	0.17	0.22	0.09

Table B.5: Total scoring of the saaty analysis (Source: Saaty Scoring NSM)

Method	NSM-OPS	NSM-P	KCS-O	KCS-P	Central	Area	Researcher	Share
Barcode	0,17	0,32	0,09	0,16	0,16	0,17	0,17	17,50%
RFID	0,27	0,25	0,43	0,20	0,25	0,16	0,15	24,35%
Barcode+RFID	0,45	0,35	0,10	0,32	0,47	0,59	0,34	37,34%
Manual 1	0,05	0,03	0,25	0,19	0,05	0,04	0,18	11,41
Manual 2	0,05	0,05	0,12	0,14	0,08	0,05	0,17	9,40%

therefore not be used (printed in red). When this criterion is respected, only the results of the researcher and KCS-Planning are allowed to be used. When a maximum of 1 exceeding CR is allowed, the input of NSM-Operation can be incorporated as well. However, this would consider that the input values of NSM-Planning, KCS-Operational, Central- and Area-Planning couldn't be used. Therefore, it is decided to make different scenarios whereby both the results with and without these exceeding CR value actors is used. This is decided because the correlation factor shows the spread of the input values. However, the purpose is to identify the distribution of the preference for the attributes. This insight is provided by the data collection and observed to be valuable and usable, regardless the exceeding CR values.

Final results of the calculation Table B.5 discusses the final result of the calculation whereby the scoring input are balanced using the preferences for the individual requirements/attributes. The average scoring for measurement methods indicates the following hierarchy: 1) Barcode+RFID measurement (37,34%), 2) Passive RFID (24,35%), 3) Bar-code (17,50%), 4) Manual counting 1 (11,41%) 5) Manual counting 2 (9,40%). In general, it is stated that all the actors have the preference for the implementation of the Barcode+RFID scenario. The sole exception is KCS-OPS. They have the preference for only the RFID scenario. Given the interview with Zwager (2015), this is as expected. She indicated the doubts for the feasibility of the implementation of the barcode scanning in production. This is also indicated by the scoring for the barcode scanning scenario by KCS-OPS (0,09). Moreover, KCS-OPS also indicates that they prefer to remain with the current manual scenario Therefore, the hypothesis can be drawn that they are reluctant to change since the sole implementation of RFID also won't change something to their process. This is something to pay attenation to during the implementation of a technology with barcode scanning involved. Mainly every measurement method that involves change on the production floor is low scored (manual 2: 0,12; Bar-code: 0,09 and Passive+Barcode: 0,10). The fact that manual counting 1 is preferred above manual counting 2 is thanks to the high scoring for manual counting 1 by the KCS actors. The results also indicate that NSM is in favour of avoiding the manual counting scenarios. This is strongly correlated with the preference for the attribute reliability. Moreover, the results indicate that the actors within NSM agree on the fact that something needs to change given their low preference for the current sceanrio (average score of 0,04). However, as indicated, it is possible to score the methods with an additional scenario study using different weights for the different actors. The next section discusses these (7) different scoring scenarios.

Scoring using relative weights for actors

Analysis of the results shows that it is possible to make different scenarios to weight the results per actor. In total, 7 different scenarios are identified. The scenarios are discussed below.

The equal weights scenario assigns a weight factor of 1 to all the different actors. This outcome is how the

Table B.6: Weight factors for a scenario study (Source: Own Production)

Scenario	NSM-R	NSM-P	KCS-O	KCS-P	Central	Area	Researcher	Comment
1	1	1	1	1	1	1	1	Equal weights
2	1	1	0	0	1	1	0	NSM Only
3	1	1	2	2	4	4	0	Operational focus
4	2	2	0	0	1	1	0	NSM Hierarchy
5	0	0	1	1	0	0	1	Filter on CR
6	0	0	0	1	0	0	1	Bias filter
7	0	0	0	0	0	0	1	Researcher only

Table B.7: Scenario study results (Source: Saaty Scoring NSM)

Scenario	1	2	3	4	5	6	7	Average
Barcode	17,50	19,60	16,37	21,73	15,95	15,95	16,37	17,64%
RFID	24,35	21,43	24,23	24,07	17,39	17,39	14,87	20,53%
Barcode+RFID	37,34	43,91	41,88	44,33	32,72	32,72	33,75	38,09%
Manual 1	11,41	7,13	9,52	4,37	18,42	18,42	18,01	12,47%
Manual 2	9,40	7,94	8,01	5,50	15,52	15,52	16,99	11,27%

AHP process proposed by Saaty (1980) is normally used. The "NSM Only" is used to identify the result if only the actors within NSM-Planning are involved. The operational focus is to investigate the result with increased weigh to the operational functions within KCS and Area- and Central planning. Since Area- and Central planning are concerned for the planning of equipment distribution, their weight is higher than the KCS weight (4 vs. 2). The NSM Hierargy incorporates the hierarchy of the different functional levels within KLM. The "filter on consistancy ratio" filters the results out of the final result that were too high. These CR values are shown in table B.4. The Bias filter focuses on the two actors (Actor and KCS-P) whose results don't show the biased attitude towards Barcode+RFID that is shown by the other actors. The "researcher only" scenario observes the objective scoring since the research has no functional preference for a collection method. Table **??** shows the results of the scoring with the different scenarios. Hereby the final scoring per scenario with the weights per actor is provided. The first observation is that for all the scenarios, barcode+RFID is the preferred method; the preference varies between 32,72% (for the no exceeding CR scenario and biased) 44,33% (the NSM hierarchy scenario). The preference for barcode + RFID increaes if the relative weight for NSM is increased. Within NSM, this is mainly through the influene of the management (observed through the comparison between scenario 2 and 4). The scenario with the exclution of the exceeding CR values shows a slightly different result than the other scenarios. The scoring of scenario 5 and 6 are the same since the actors that are observed to be neutral (not biased) also have scores with the right CR value. The results of the 5/6 scenarios show the preference for Barcode-RFID that is lower than the other scenarios but still the highest. The scenario scores Manual 1 as the second-highest scenario. However, given the scoring of the other actors, the scoring deviates too much from the observations of the other scenarios for manual counting. The result of the researcher only shows the preference over the manual counting over the technologies. This is mainly because of the relative high value for scalability (this results in a low value for RFID only), a high value for OPEX (this results in a relatively low value for RFID, Barcode and RFID+Barcode). The manual counting methods score relatively good since they score good on scalability, CAPEX and OPEX. The conclusion can be drawn that barcode+RFID is the preferred method given the preferences and the scoring on the attributes by the actors involved. Even different scenarios, whereby the weight of the actors is varied show the preference for Barcode + RFID. The results also show the low preference for the current method (manual counting 1). Also it is possible to suggest that there is reluctance at KCS-Production towards the implementation of a scenario with barcode scanning or changes for the production floor in general. Therefore, extra attention should be awarded to change management and commitment within KCS-Production since this is the most important node in the mechanical scanning scenarios. However, the choice for Barcode and RFID measurement collection is used for the new

Table B.8: The inflow of loading equipment per hour with value higher than 25€

Time	Inflow	500	750	1000	1500
6	1720	1220	970	720	220
7	270	990	490	0	0
8	179	669	0	0	0
9	280	449	0	0	0
10	157	107	0	0	0
11	468	75	0	0	0
12	72	0	0	0	0
13	147	0	0	0	0
14	339	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	317	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0

design of the control model.

THE IDENTIFICATION OF THE SCANNED ITEMS

The decision of the barcode and RFID scenario means that manual scanning of barcode is required for certain items. The amount of items in scope for the scanning influences the required scanning actions. The current scope of the project is that manual scannning is performed during the unloading of the equipment in the inbound storage of KCS-Warehouse. This section compares the total inflow of equipment in KCS-Production hour with the scanning capacity per hour.

The scan capacity Table B.8 shows the inflow of loading equipment with a value higher than 25 €. These equipment types concern the ComboCub (60020C), the ovenrack (60280), the Square container (60590) and the standard container (60600). The table compares the cumulative inflow of equipment with the scanning capacity per hour. The table shows that the peak of the inflow is in the morning. The values in the table show the amount of scans left after each hour. The different scan capacities show that with a scan capacity of 1500 scans per hour, each hour (expect the first hour) is able to finish the required scans per hour. For the lowest scan capacity, the scanning is finished just after 12PM with additional scanning at 14PM and 17 PM. Table B.9 shows the inflow of loading equipment with a value higher than 155 €. Besides the equipment types shown in table B.9, the following equipement types are added: Drawer 08cm (60680), Drawer 11cm (60780), Drawer 11cm 1/2 size (60783), Glass Rack 14 cm 8 holes (60789), Drawer 14cm (60790), Mug Rack 08cm (60795), Drawer 17cm (60810). The table compares the cumulative inflow of equipment with the scanning capacity per hour. It is shown that the total inflow is 3950 for scanning scenario 1 (table B.8) and 18112 for scanning scenario 2 (table B.9). The values in the table show the amount of scans left after each hour. The table shows that KCS-Planning is only capable to perform the required scanning with a scan capacity of 1500 per hour. If the scanning capacity is decreased, KCS-Production is not able to perform the required scans. Based on the research above, it is recommended to focus on the scanning of the high valued loading equipment. If the items with a value above 50 €are equipped with barcodes and scanned when they enter the production facility, the scanning capacity of 500 per hour is sufficient although 1000 per hour reduced the total scanning time. Additional research is required to determine the scanning capacity per hour per person since the current focus is on human scanning. Moreover, a study can be performed whether there is either centralized scanning by a responsible person or decentralized scanning through the drivers that are responsible for the

Table B.9: The inflow of loading equipment per hour with value higher than 15€

Time	Inflow	500	750	1000	1500
6	7757	7257	7007	6757	6257
7	1830	8587	8087	7587	6587
8	715	8802	8052	7302	5802
9	1445	9747	8747	7747	5747
10	664	9912	8662	7412	4912
11	1906	11317	9817	8317	5317
12	341	11158	9408	7658	4158
13	623	11281	9281	7281	3281
14	1414	12195	9945	7695	3195
15	14	11709	9209	6709	1709
16	27	11236	8486	5736	236
17	1319	12055	9055	6055	55
18	0	11555	8305	5055	0
19	0	11055	7555	4055	0
20	57	10612	6862	3112	0
21	0	10112	6112	2112	0
22	0	9612	5362	1112	0

unloading of the equipment.

For example with an Airbus A330 with this scenario. The equipment articles are transported from the home-bound aircraft with 3 trucks. When the articles are equally distributed, each container contains 21 items to be scanned. The truck driver can perform these scans. In this way, the decentralized scanning required from each driver to perform 21 scans. The current inbound unloading procedure takes around 5 minutes. When the scanning takes 10 second per scan, the length of the unloading procedure increases with 70%. Since this is a severe increase of length, the scanning procedure requires extra attention

C

ANNEX: QUANTITATIVE CASE STUDY

This Annex described the quantitative case study on the benefits of the implementation of the new control model. The first section describes the overall methodology of the quantitative case study. This methodogly leads to a dashboard that is used to perform different scenario analysis and studies. Annex D provides more background information on the dashboard. The second chapter provides boundary condition on the equipment items in scope, the destinations and allotments per aircraft type and different important formulas to make the calculations. The quantitative case study is performed through the comparison of two scenarios: 1) the total control costs for equipment distribution if KLM continuous with the current approach and state of the distribution or 2) If KLM implements step-wise the new control model and obtains the optimized state after 2,5 years. For scenario 2, both the situation with and without the influence of the return rate is studied. This decision is made since small deviations of the return rate have a big influence on the financial outcomes. The conclusion provides reflections on the financial impact and cost savings of the new control model.

THE APPROACH FOR THE COST STUDY

This section described the approach for the cost study. The approach is to construct a dashboard in Excel that enables NSM-Planning to perform scenario analysis based on input parameters. Also after this project, the dashboard remains available for NSM-Planning to continue the scenario analysis. The choice for Excel is made based on the experience that the program is relatively easy to use and adjust and it doesn't require comprehensive programming experience. Moreover, it suits the requirement that data should be put in easily and that the output is both in graphs as in quantitative results. The appraoch for the cost study itself (as shown in picture C.1) concerns three phases: 1) the preparation phase, 2) the scenario construction and 3) the cost study performance. The three different bases are discussed in the following paragraphs.

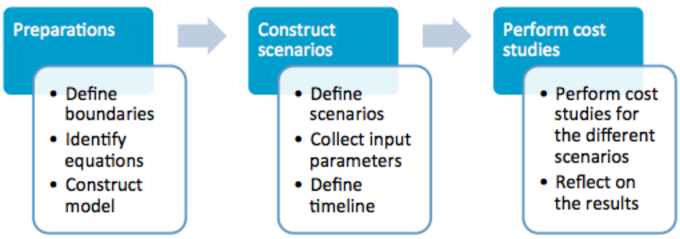


Figure C.1: The approach for the cost study

Preparations The first phase concerns the preparation. The preparation concerns the identification of the equipment types in scope, the allotments per aircraft type and the data collection of the ICA fleetsize, the allotments per outstation and the costs per equipment type. It is also important that the right equations are collected for the calculations. Based on these equations, it becomes clear what the required input parameters are for the calculations. The required equations concern (among others) the required fleet, the efficiency of the total and active loop, the operational cost and the financial costs. The third phase of the preparation is the construction of the excel model to calculate the total system costs for a period of 5 year. It is also possible to extend the timeline but the period of 5 year was chosen because of the urge to have sufficient time for the implementation of the control model but also sufficient time to see the impact of the control model. In discussion with NSM-Planning manager Doze en NSM-Regie manager (Veen), 5 years was decided as reasonable.

The construction of scenarios The second phase concerns the construction of the scenarios used for the scenario analysis. The choice is made to compare the control costs of the current distribution with the control costs of the implementation. This choice is made since this provides both insights in the costs if KLM would continue with the current distribution and the possible reductions. It is up to NSM-Planning to identify additional scenarios to test in the cost model (but these additional scenarios are left out of scope in this quantitative study). The second phase is to collect the required parameters for these scenarios. Most of the required input parameters are either from the analysis in chapter 3 or based on the identified distribution strategy in chapter 5. The implementation timeline is based on mutual agreements on feasibility with NSM-Planning manager Doze (2014) and NSM-Regie maner Veen (2015).

The reflection on results The last phase is to put the parameters into the model and to reflect on the results. The cost model provides both aggregated information (total control costs, total costs for replacement, maintenance and operational costs) as disaggregated information (detailed costs per month for the different topics). Based on these results, the reflection is provided on the impact of the new control model.

IMPORTANT BOUNDARY CONDITIONS AND SCOPE

This section reflects on the boundary conditions and scope of the cost model. The first subsection reflects on the equipment items in scope. The second subsection reflects on the aircraft routes and types in scope, this reflects on the allotment per flight. The third subsection reflects on the calculation of the total system equipment demand based on the allotment and the different logistics decision made by NSM-Planning. The fourth subsection reflects on the logistics costs in scope. The fifth subsection reflects on the different scenarios and decisions in scope together with the service levels in the network.

Equipment items in scope The equipment in scope is divided into carrying equipment and serving equipment. “Loading equipment” is defined by Veen (2015) as "robust equipment used to carry and transport serving equipment". Therefore, the trolleys, containers, drawers, racks, ovens, inserts are defined as loading equipment. The serving equipment discusses the items used to serve the catering articles to the passengers. Moreover, this serving equipment is observed to be vulnerable for breakage, thus observed as less robust than the loading equipment. It is decided to leave the current sea-freight loading out of scope. The different equipment items in scope are shown in table C.1. As shown, there is a distribution between loading and service equipment; there is a clear difference between high valued equipment (trolleys) and low priced equipment (dishes, cuttlery). The allotment of the loading equipment per aircraft type is provided in table C.2. It is clearly shown that the loading profile differs per aircraft type. For example the high amount of ovenracks for the 744 compared to the 332 and 333.

Timetable and allotment per outstation The timetable that is used for the calculation of the total costs for the catering distribution is the timetable for summer 2015. The timetable can be found at KLM.com. For summer 2015, KLM expands its timetable with new destinations Edmonton and the roundflight Amsterdam, Bogota, Cali (AMS-BOG-CAL-AMS). The new timetable dictates the aircraft types used for the destination. Although the allotment is slightly different per destination, it is possible to identify an average number of equipment since it is calculated based on the maximum passenger configuration. The aircraft types used for the ICA network at KLM are the Boeing 747-400 (774), the Boeing 777-200 (772), the Boeing 777-300 (77w), the Airbus A330-200 (332) and the Airbus A330-300. The 744 is, in terms of allotment the biggest type. The second biggest is the airbus 777-300. The third biggest is the 777-200. The major difference between the 777 series and the 747 is the size of the galley and therefore more space in the 744 to place loading equipment. The smallest types are the A330 whereby the 300 is slightly bigger than the 200. As described, the timetable assigns different aircrafts per destination. For example, to Curaçao (CUR) the 744 and the 332 are used. Since the 744 is the biggest type flying on this station, the 744 allotment is the maximum allotment in this station. If the 332 arrives, a part of the allotment of the 744 is not used and stored again. Table C.3 shows the biggest aircraft type per station. It is observed that not all 68 ICA-destinations are used in table C.3. This is because

Table C.1: Equipment types, price and categorization (Source: SAP)

Type	price	L/S	Description	Price	L/S
Combo Cup	175	S	MW Spoon Stainless Steel	0,3	S
Ovenrack	49,28	L	MW Coffee Spoon Stainless Steel	0,19	S
Oven Skid	3,22	L	MW Dessert Spoon Stainless	0,29	S
FS Trolley 1/1 Business Class	400	L	MW Cake Server Stainless Steel	0,72	S
HS Trolley 1/2 Business Class	250	L	MW China Plate Medium	1,29	S
Universal Trolley Light Weight Driessen	261,91	L	MW China Casserole Round	1,32	S
Trolley 1/2 Light Weight Diethelm	377,03	L	MW Coffee Mug	0,61	S
Square Container	80,67	L	MW Side plate round	0,594	S
Standard Container	106,33	L	MW Delft Blue Small Dish	1,73	S
Drawer 08cm	16,26	L	MW Delft Blue Large Dish	1,5	S
Drawer 11cm	11,41	L	MW Saucer round	1,26	S
Drawer 11cm 1/2 size	11,75	L	MW Rectangular Plate Medium	1,86	S
Glass Rack 14cm	14,85	L	MW WBC Soup Bowl	1,01	S
Glass Rack 14 cm 8 holes	16,7	L	MW Water Glass	0,98	S
Drawer 14cm	17,33	L	MW Wine Glass	1,15	S
Mug Rack 08cm	19,85	L	MW Liquor Glass	1,76	S
Drawer 17cm	18,28	L	MW Tray 1/1 KSSU	1,42	S
WBC Thermosbottle soup	6,69	S	Display Tray 1/1 black	0,01	S
Ice tong	5,6	S	1/1 Tray	1,43	S
Cheese Tong	5	S	1/2 Tray black	0,79	S
Tray Basket	5	S	Display Tray ½ Black	0,1	S
Water Jug	4,95	S	MW Linen Napkin	0,76	S
MW Knife Stainless Steel	0,39	S	MW Table Cloth	0,944	S
MW Fork Stainless Steel	0,26	S			

Table C.2: Load factor per aircraft type (Source: L& O)

item	332	333	744	74E	772	77w
Combo Cup	5	5	6	5	5	5
Ovenrack	20	24	39	26	25	33
Oven Skid	135	163	244	158	167	225
FS Trolley 1/1 Business Class	6	6	9	8	6	6
HS Trolley 1/2 Business Class	3	3	5	5	3	3
Universal Trolley Light Weight Driessen	9	10	18	11	13	15
Trolley 1/2 Light Weight Diethelm	33	39	43	34	36	46
Square Container	12	15	0	0	6	7
Standard Container	26	29	59	44	36	49
Drawer 08cm	117	134	173	128	122	149
Drawer 11cm	52	62	94	68	69	87
Drawer 11cm 1/2 size	2	2	3	3	2	2
Glass Rack 14cm	12	12	15	15	12	12
Glass Rack 14 cm 8 holes	3	3	4	3	2	2
Drawer 14cm	16	17	25	23	16	18
Mug Rack 08cm	4	4	6	6	5	5
Drawer 17cm	12	14	19	13	14	17
WBC Thermosbottle soup	2	2	2	2	2	2
Ice tong	7	8	11	8	8	10
Cheese Tong	2	2	2	2	2	2
Tray Basket	6	7	9	6	7	9
Water Jug	7	8	11	8	8	10
MW Knife Stainless Steel	141	141	141	71	141	141
MW Fork Stainless Steel	141	141	141	71	141	141
MW Spoon Stainless Steel	74	74	74	37	74	74
MW Coffee Spoon Stainless Steel	48	48	48	24	48	48
MW Dessert Spoon Stainless	54	54	54	27	54	54
MW Cake Server Stainless Steel	2	2	3	3	2	2
MW China Plate Medium	64	64	64	32	64	64
MW China Casserole Round	44	44	44	22	44	44
MW Coffee Mug	75	75	75	338	75	75
MW Side plate round	95	95	95	48	95	95
MW Delft Blue Small Dish	35	35	35	18	35	35
MW Delft Blue Large Dish	27	27	27	14	27	27
MW Saucer round	35	35	35	18	35	35
MW Rectangular Plate Medium	35	35	35	18	35	35
MW WBC Soup Bowl	18	18	18	9	18	18
MW Water Glass	144	144	144	72	144	144
MW Wine Glass	156	156	156	78	156	156
MW Liquor Glass	18	18	18	9	18	18
MW Tray 1/1 KSSU	77	77	77	39	77	77
Display Tray 1/1 black	2	2	3	3	2	2
1/1 Tray	100	100	100	50	100	100
1/2 Tray black	13	13	13	7	13	13
Display Tray ½ Black	2	2	3	3	2	2
MW Linen Napkin	56	60	68	64	65	70
MW Table Cloth	64	64	76	76	83	84

Table C.3: The outstations and their maximum allotment (Source: KLM timetable summer 2015)

744	333	772	77W	332
CTU	IAD	ACC	BKK	ALA
CUR	KGL	ATL	EZE	AUH
DXB	LOS	BKK	KIX	BON
HKG	YUL	BOG	KUL	DEL
IAH	YVR	CLO	LIM	DFE
ICN		CPT	PTY	DMM
JFK		FUK	SIN	DOH
LAX		FUK	TPE	EBB
MEX		GIG		HAV
NBO		GYE		KWI
NRT		HGH		LAD
ORD		JNB		YEG
PBM		XMN		
PEK		YYX		
PVG				
SFO				
YYZ				

several routes use a tail-part or round-flight. For example, the flight to Bogota is also flying to Cali before returning to Amsterdam. Another example is the roundflight from Amsterdam to Buenos Aires and Santiago de Chile (AMS-EZE, EZE-SCL, SCL-EZE, EZE-AMS). In total, there are 58 destinations that operate with a catering station. These stations are in scope for the calculations since the other destinations receive their service from another node that is part of the route or from Amsterdam.

Implementation timeline The case study reflect on the total cost after a period of 5 years. For scenario 1, there is no implementation and the system operates 5 years according to the parameters of phase 1. Below, The proposed implementation timeline for scenario 2 describes the length of each individual phase and the transition period between two phases. At the start of the period, phase 1 1 is operational. After three months, the implementation of phase 2 starts. It is foreseen that this implementation takes 5 months. During these five months, the cost profile switches from the phase 1 control profile to the phase 2 cost profile. Directly when the implementation of phase 2 is finished, the implementation of phase 3 starts (August, year 1). The total implementation of the barcode + RFID and the application of system optimization takes 5 months. After implementation, NSM-Planning operates 5 months according to phase 3. In June, year 2, the implementation of final equipment distribution optimization takes place. With several projects and further reduction of inventories, the efficiency ratios in the active network are further reduced towards the desired state. The system runs according to the parameters proposed by table 6.1 for implementation scenario 2 (as shown in table C.4, table C.4 and table C.6).This is continued up till the end of year 5 for implementation scenario 2.

Important equations for fleetsizes and inventory levels

The Calculation of the minimum fleetsize In order to be able to reflect on the efficiency of the fleet, it is important to reflect on the equiment demand of the network. Literature does not provide a standardized approach to calculate the fleetsize in the network for lequipment. Therefore, equation C.1 is identified to calculate the fleetsize with maximum productivity in the distribution network. This formula is constructed in agreement with Doze (2015) and Veen (2015). The calculation of the fleetsize exists of twice the alotment, the number of sets reserved in outstations for timetable changes and new stations and finally, the number of sets in KCS-Production. The assumption for the fleetsize calculation is made that there is always one set in the outstations and one set in the aircraft between the outstation and KCS. In KCS, it is required to have sufficient equipment available for production. The average amount of equipment reserved is used for outstations is for various reasons. The first is if they have 2 flight per day and therefore require more equipment. The second reaons is if new outstations are openend and a set is transported using sea freight (for this season, Edmonton

$$n_{fleetsize} = (\sum n_{OS} * A_{OS}) + (\sum n_{aircraft} * A_{aircraft}) + n_{Reserved} + n_{KCS}) * f_{load} \quad (C.1)$$

$n_{fleetsize}$	*Fleetsize with maximum productivity*
n_{OS}	*Number of catering facilities in the network*
A_{OS}	*Allotment for the catering facility*
$n_{aircraft}$	*Sum of aircraft fleet at KLM*
$A_{aircraft}$	*Allotment per aircraft type*
$n_{Reserved}$	*Amount of sets reserved to equip facilities*
n_{KCS}	*Amount of equipment in KCS-Production*
f_{load}	*load factor of the flight*

and Bogota). The last reason for the "reserved status" is for outstations closed for a season but the equipment remains there until the station is opened again. It is questionable if the reserved status is part of the equation if the fleetsize with maximum productivity is calculated. However, these decisions are part of strategic decisions and therefore part of the active equipment since they are used for a certain reason rather than that they are stored in a passive state. The total fleetsize is reflects the fleetsize if there is 100% efficiency for the total loop and 100% efficiency for the active loop.

The last aspect to be discussed is the load factor. The current load factors for equipemnt is 100% for all the flights. However, the current load factor of passengers is 85,3% [6]. Based on discussion with Doze (2014) and Veen (2014), it is decided to calculate also a scenario using a load factor for the equipment aligned with the load factor of passengers. Therefore, the minimum fleetsize is directly proportional with the load factor. The fleetsize formula is validated through the calculation of the theoretic cycle time. The calculated cycle time using the fleetsize formula and the average flow towards the network is 3,1 days. This is according to the theoretic cycle time (based on analysis) that covers 1 day in KCS-Production unit, one day for the outbound flight and one day for the homebound flight.

The fleetsizes for the different distribution levels The different levels are introduced in chapter 2. Figure C.2 shows these levels and the identification of the distribution levels (total distribution, active distribution). The total distribution fleet reflects on the complete fleet of equipment at KLM. This is the sum of the equipment in the total network nodes. The active distribution fleet reflects on the sum of the equipment outside KCS-Warehouse and therefore part of the active distribution). The fleetsize for the active distribution is calculated by equationC.3. The active fleetsize is calculated through dividing the minimum fleetsize divided by the active fleetsize efficiency. The total fleetsize is calculated through dividing the active fleetsizy by the total fleetsize efficiency. This is shown by equation C.4.

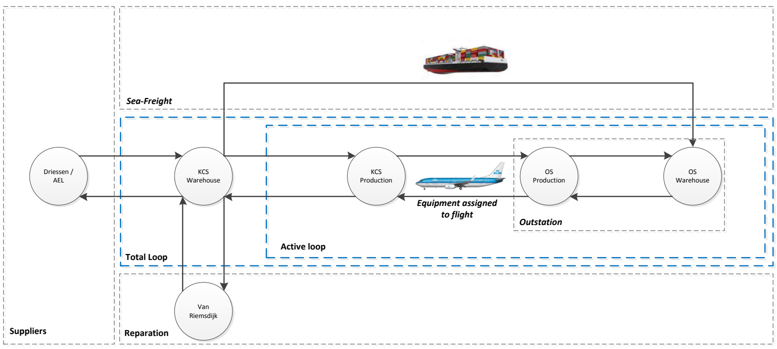


Figure C.2: Loop overview of the distribution network at KLM (Source: Own Production)

Network inventory tresholds This section elaborates on the minimum inventory levels in KCS-Warehouse and the maximum levels in the outstation. The equations used for the calculations are shown by equation C.3, C.4, C.6, C.7 and C.8. The minimum inventory level in KCS-Warehouse is calculated using equation

$$\sum n_{equipment} = \sum n_{total} + \sum n_{reparation} + \sum n_{seafreight} \tag{C.2}$$

$$n_{active} = \frac{n_{fleetsize}}{\eta_{active}} \tag{C.3}$$

$$n_{total} = \frac{n_{active}}{\eta_{total}} \tag{C.4}$$

$$n_{reparation} = n_{fleetsize} * r_{reparation} \tag{C.5}$$

$\sum n_{Equipment}$	*Total equipment in distribution network*	
n_{active}	*Fleetsize active distribution network*	
η_{total}	*Efficiency rate total distribution network*	%
n_{total}	*Total required fleetsize distribution network*	
$n_{reparation}$	*Number of equipment at storage facility*	
$r_{reparation}$	*reperation percentage of minimum fleetsize*	
$n_{seafreight}$	*Total amount of equipment currently transported by sea-freight*	

$$I_{KCSW} = n_{total} - n_{active} \tag{C.6}$$

$$\sum I_{OSW} = n_{active} - n_{fleetsize} \tag{C.7}$$

$$I_{OSW} = \frac{\sum I_{OSW}}{n_{OS}} \tag{C.8}$$

n_{active}	*Fleetsize active distribution network*	%
η_{total}	*Efficiency rate total distribution network*	%
n_{total}	*Total required fleetsize distribution network*	
I_{OSW}	*Maximum inventory level OS-Warehouse*	
n_{OS}	*Number of catering production facilities*	
η_{OS}	*Efficiency catering production facility*	%
I_{OS}	*Inventory oustations (Production+Warehouse)*	

C.6 by substracting the total fleetsize by the active fleetsize. This number is influences by the decisions for the efficiency targets for the active distribution and the total distribution. Equation C.3 and Equation C.4 show this influence. The lower the active efficiency gets, the higher the active fleetsize. The lower the total efficiency, the higher the minimum required level in KCS-Warehouse. The maximum inventory level in OS-W is calculated by dividing the total spare stock fleet by the number of production locations in the network (equation C.8). The total warehouse spare stock for the outstation is calculated through substraction the minimum fleetsize from the active fleetsize. The minimum level for KCS-Warehouse is for the central planner to monitor. The maximum level in OS-Warehouse is for the area planners to monitor.

Equations to calculate financial aspects

The equations to calculate the financial costs are equations to calaculate operational costs, the working capital, the replacement costs and the financial costs.

The calculation of the operational costs For the operational costs, it is decided to focus on the personnel costs (equation C.10, the ICT costs (combined the control costs) the transport costs (equation C.11) and the reparation costs (equation C.12). The first component, the personnel costs per month is calculated through the multiplication of the required amount of FTE within NSM with the costs per FTE. The second component, the ICT costs, is the costs per month to run the system. For the Barcode + RFID scenario, these monthly system costs are identified as 7500 €(SkyLogistiX, 2015). The transport costs are calculated through the multiplication of the amount of rides per month with the costs per ride. The costs per ride are calculated using the personnel costs, depreciation and fuel costs. The reparation costs are calculated using the current reparation costs. For each scenario, the reduction in reparation costs is proposed. For example, the reparation costs in scenario 3 are 50% of the reparation costs in scenario 1. This is shown in table C.4.

$$\sum C_{operational} = C_{personnel} + C_{ICT} + C_{transport} + C_{reparation} \tag{C.9}$$

$$C_{personnel} = C_{FTE} * n_{FTE} \tag{C.10}$$

$$C_{transport} = C_{ride} * n_{rides} \tag{C.11}$$

$$C_{reparation} = C_{t=0} * r_{reparation} \tag{C.12}$$

$C_{operational}$	*Total operational costs*	€
$C_{personnel}$	*Total personnel costs*	€
C_{FTE}	*Costs per FTE*	€
n_{FTE}	*Number of FTE required for control in NSM*	
C_{ICT}	*ICT system costs per month*	€
$C_{transport}$	*Total transportation costs*	€
C_{ride}	*Total transportation costs per ride*	€
n_{rides}	*Number of monthly rides between KCS-Warehouse and Production*	
$C_{reparation}$	*Total reparation costs*	€
$C_{t=0}$	*Reparation costs at t0*	€
$r_{reparation}$	*Reparation costs share compared to t0*	

$$W_c = \sum n_{Equipment} * V_{value} \tag{C.13}$$

$$\sum C_{replacement} = C_{replacementserving} + C_{replacementloading} \tag{C.14}$$

$$C_{replacementserving} = \frac{(1 - r_{returnserving}) * \sum W_{cserving}}{12} \tag{C.15}$$

$$C_{replacementloading} = \frac{(1 - r_{returnloading}) * \sum W_{cloading}}{12} \tag{C.16}$$

W_c	*Total working capital in*	€
$n_{equipment}$	*Number of individual equipment items*	
V_{value}	*Value of equipment per item*	€
$\sum C_{replacement}$	*Total replacement costs*	€
$C_{replacementserving}$	*Replacement costs for serving equipment*	€
$r_{returnserving}$	*Return rate serving equipment*	%
$W_{cserving}$	*Total working capital serving equipment*	€
$C_{replacementloading}$	*Replacement costs for serving equipment*	€
$r_{returnloading}$	*Return rate loading equipment*	%
$W_{cloading}$	*Total working capital for loading equipment*	€

Working capital and replacement costs The working capital is the total financial value that is invested in the equipment. The working capital can be divided into the working capital for the loading equipment and the working capital for the serving equipment. Equation C.13 shows that the total working capital is calculated using the sum of the equipment times their financial value. Based on discussions with Doze (2014) and Veen (2015) it is decided to use the acquisition price as the value of the equipment. Hence, there is no depriciation involved in this financial scenario. The main argument for this decision is that the equipment that is "liberated" is used to cover the acquisition of new equipment. Therefore, the value of new equipment is assigned to all the equipment types (regardless their age). The replacement costs discuss the financial costs made per month in €to replace the non-returning equipment. Per scenario, the return rate is indicated as can be observed in table C.4. There is a different return rate for the loading equipment and for the serving equipment. This different return rate is because the return rate for serving equipment is lower since the chance is higher that it breaks during the distribution. The total replacement costs are the sum of the financial costs to replace the non-returning loading equipment (equation C.16) and the non-returning serving equipment (equation C.15). The replacement costs are calculated through the multiplication of the share of non-returning items times the total working capital of the specific category.

$$\sum C_{financial} = \frac{C_{fWC} + C_{fReplacement} + C_{fOperational}}{12} \tag{C.17}$$

$$C_{fWC} = r_{interest} * \sum W_c \tag{C.18}$$

$$C_{fReplacement} = r_{interest} * \sum C_{replacement} \tag{C.19}$$

$$C_{fOperational} = r_{interest} * \sum C_{Operational} \tag{C.20}$$

$\sum C_{financial}$	*Total financial costs per month*	€
C_{fWC}	*Total financial costs to financia the working capital*	€
$r_{interest}$	*Interest rate)*	%
$\sum W_c$	*Sum of working capital*	€
$\sum C_{fReplacement}$	*Sum of financial costs to finance replacement*	€
$\sum C_{replacement}$	*Sum of costs for replacement*	€
$C_{fOperational}$	*Sum of financial costs to finance operational costs*	€
$Operational$	*Sum of operational costs*	€

Financial costs The financial costs are to incorporate the financing of the costs in the calculation of the total costs. The interest rate that is used to calculate the financial costs is 3%. After a discussion with Doze (2015) and Veen (2015) it is decided to standardize the interest rate for the whole implementation period. The total financial costs is the sum of the financial costs to finance the working capital (equation C.18)plus the financial costs to finance the replacement costs (equations C.19) plus the costs to finance the operational costs (equation C.20). The sum of the financial costs is calculated per month. The financial costs to finance the working capital are the interest rate times the working capital. The same construction (value times interest) is used to calculated the financial costs for the operational costs (equation C.20) as for the replacement costs (equation C.19).

It is possible to calculate the Net Present Value (NPV) and the Weighted Average Cost of Capital (WACC) for the financial costs. The net present value (NPV) or net present worth (NPW)[1] is defined as the sum of the present values (PVs) of incoming and outgoing cash flows over a period of time (Lin, 2000). A calculation of a firm's cost of capital in which each category of capital is proportionately weighted. All capital sources - common stock, preferred stock, bonds and any other long-term debt - are included in a WACC calculation.

The influence of the return rate

The influence of the return rate is severe. The analysis of the current return rate for loading- and serving equipment showed the lacking reliability of the identified rate. Therefore, it is decided to perform the regular scenario study with 100% return rate. This represents the actual improvements financial benefits when the system efficiency improves. The paragraph additional studies reflect on certain scenario studies with assumed improving return rates.

The description of the identified NSM scenarios

This section introduces the different scenarios used for the cost scenario. The first scenario is the current scenario. The second scenario is the first phase of implementation: improved manual counting. The third scenario discusses the implementation of RFID. The fourth phase is continuous improvement and optimization using the Barcode + RFID system. The fifth scenario is the alignment of the equipment load factor with the passenger loadfactor. Table C.4 provides an overview of the imput parameters for the different equations per scenario. The paragraphs below discuss the different decisions for the parameters.

Alternative 1: The current scenario Scenario 1 in the cost scenario analysis represents the current scenario. Analysis applied in chapter 3 shows that the current efficiency rate of the total loop is 99 %. Although there are also examples of 100 % efficiency rates (empty warehouses), it is chosen to take the average rate of 99 %. The chosen rate for the active loop efficiency is 90 % (based on analysis). The load factor of equipment is 100 %. This means that all the flights are loaded according to the PSU rather than based on the passenger load factor. The current operational costs are €0 for the operational systems. The current operational system is SAP to monitor the inventory levels in the outstation and KCS warehouses. The reporting internally is performed using Excel files. The reparation costs are currently €25.000 per month. The reparation rate is 1 % of the total fleet. The interest rate used for the calculations is 4 % (Based on the ING Basis interest rate). It is chosen to continu working with the same interest rate (also for the future scenarios). The implementation time is 0 since scenario 1 is already operational. Because of the lack of forecasting, there is daily transport between KCS-Warehouse and KCS-Production. This means around 30 rides per month.

Alternative 2: The optimized scenario Scenario 2 in the cost scenario analysis represents the implementation of the new control model. This new control model focuses on increased automation (due to the implementation of barcode and RFID scanning), improved efficiency towards the identfied service levels, reduced logistics costs and reduced reparation costs. The implementation timeline exists of 4 different phases:

- Phase 1: The current equipment distribution is characterized through low efficiency within the active loop and high efficiency of the total loop. Thanks to the low forecasting capability, there is daily replenishment from KCS-Warehouse to KCS-Production. There are 2 FTE involved for the both Area- as Central management. The reparation costs are €300.000 on a yearly base and the reparation rate is 1%.
- Phase 2: improved manual control: The second scenario is focused on improved counting. The barcode and RFID is not yet implemented. This phase is to increase the awareness and to start with the implementation of the control structure of the model. The final targets for this phase is a total efficiency rate of 98 %, an active efficiency rate of 94 %. The operational costs are €1250 per month for additional control in KCS-Production. For example a part time material planner focused on equipment management. The €1250 investments are used for training. The reparation costs are decreased with 20% compared to scenario 1. The reparation rate is still 1%. Because the control by NSM-Planning increases, the amount of rides between KCS-Warehouse and KCS-Production is reduced to 20 rides per month. The implementation of this phase takes around 6 months.
- Phase 3: Implementation Barcode+RFID: As decided, a system with barcode and RFID is implemented to track the equipment within the network of KLM. Scenario 3, whose implementation takes about 5 months, is used to implement this system. Once the system works, the aim is to improve the situation towards the targets stated in table C.4. The efficiency rate of the total loop remains 98 % to keep sufficient equipment in KCS-Warehouse. However, the efficiency rate of the active loop is increased to 97 %. Because of increased automatization, the number of fte is reduced to 1,5. This doesn't mean that people are fired; they just have more time to work on other subjects! Due to increased control, NSM-Planning can take over the inventory planning at KCS-Warehouse. Therefore, the number of rides between KCS-Warehouse and KCS-Production decreases to 5 per month. However, automatization has a price; the implementation costs €110.000 and the monthly subscription to the program of SkyLogistiX costs €75000. Because the increased control enables NSM-Planning to make a reparation deployment, the reparation costs decrease together with the reparation rate of the fleet.
- Phase 4:Continuous improvement Continuous improvement phase after the implementation of RFID and Barcode. The parameters of this state discuss the optimized state of the control system. There is currently two scenario's possible: KLM continues with this scenario (and loading on 100 % of the PUS) or they start with loading based on the passenger load factor. The current passenger load factor at KLM is 81,3 %. This scenario is discussed in the next paragraph. The final state of the fourth scenario discusses the final state of the optimized equipment distribution. The efficiency rate of the total loop is 99 %, the efficiency of the active loop is 99 %. The load factor of this scenario is still 100 %. The control fte's are reduced to one (1/2 area-planning and 1/2 central planning). The rides between KCS-Warehouse and KCS-Production are reduced to 1 per week. Because of further deployment of the reparation costs and the work on their reduction, the reparation costs are further reduced. The current reparation costs are reduced with 70 % compared to scenario 1.

These two scenarios above are used to reflect on the possible cost reduction for the implementation of the new control model. There is a possibility to calaculate the possible cost savings when the equipment is loaded based on passenger load factor rather than 100%. However, since standard deviations of demand are unknown, the reliability of the calculated results is very questionable. Therefore, the quantitative case study focuses on the combination of the two scenarios above.

POSSIBLE COST REDUCTIONS

These paragraph discuses the total system control costs. Hereby, the graph (shown in figure **??**), shows the comparison between the alternatives. The light blue line shows the cumulative system costs if KLM continues

Table C.4: The input parameters for the quantitative case study

	Phase 1	Phase 2	Phase 3	Phase 4
Efficiency loading Total loop	99,00%	98,70%	98,70%	98,70%
Efficiency loading Active loop	90,00%	94,70%	98,70%	99,70%
Efficiency serving Total loop	99,00%	89,00%	89,00%	89,00%
Efficiency serving Active loop	90,00%	97,85%	97,85%	97,85%
Load factor equipment	100,00%	100,00%	100,00%	100,00%
Return rate loading	100,00%	100,00%	100,00%	100,00%
Return rate Serving equipment	100,00%	100,00%	100,00%	100,00%
Control NSM (Fte)	2	1,75	1,5	1
Rides KCS-P/W	30	15	5	4
Operational costs	0	1250	7500	7500
Investments	0	1250	110000,00	0
Reparation rate	1,00%	1,00%	0,50%	0,50%
Reparation costs	100,00%	95,00%	90,00%	85,00%

with the parameters according to the current strategy (scenario 1). The total system control costs of this scenario are calculated to be €2.989.597,08. The dark blue line shows the cumulative system costs if KLM implement the new control model according to scenario 2. The total system control costs of this scenario are calculated to be €2.399.060,21. This results in a cost reduction of 19,75%. The cost reduction is enforced through the reduction of the following aspects:

- The working capital is reduced with €396.704,20. This reduction in working capital is balanced with the replacement costs and is therefore a direct cost recuction. The working capital is reduction through increased efficiency of the total loop and the active loop. This increased efficiency, based on the identified service levels for KCS-Warehouse and the OS-warehouses, results in lower safety stocks in the outstations and slightly higher stocks in KCS-Warehouse. The overal fleetsize reduces with 10% for the loading equipment. The fleetsize of the service equipment remains almost the same but the stocks are shifted from KCS-Warehouse to the OS-Warehouses. Due to the decrease of the working capital, there is a linear decrease of the financial cost using the

- The operational costs reduce slightly. Although many operational costs are reduced (the number of FTEs, the logistics costs between KCS-W and KCS-P and the reparation costs), there is also a cost increase due to the implementation of the barcode + RFID system. Moreover, significant investments (€110.000) are required for the set-up of the barcode and RFID system. The assumption is drawn, based on the expected impact of the tracking system, that most of the cost reduction is found in loss reduction. Additional studies on loss reduction are discussed in the section "the impact of loss reduction".

The cost study shows the potential of the implementation of the new control model resulting in reduced costs while the service is ensured. The foreseen cost reduction is around 15%. However, additional research is required to investigate the feasibility of FTE reduction, increased automation and the impact of the barcode and RFID scanning.

The impact of the loss reduction

This section reflects on the impact of the return rate and the loss reduction on the total system control costs. The assumed current return rate, based on analysis, is 99,8% for the loading equipment and 98% for the service equipment. The proposed return rate improvement is based on the scenario that the return rate is improved with 50% in the coming 5 years. Although the feasbility is questionable, it is using for this analysis to see the financial impact of NSM-Planning if they are able to obtain this result. The improvement in return rates per phase is shown in table C.5. Per phase, the return rate increases from phase 1 (current) towards the optimized state in phase 4. The optimized state reflects the 50% loss reduction.

Table C.5: The input return rates per phase for the quantitative study

	Phase 1	Phase 2	Phase 3	Phase 4
Return rate loading	99,8%	99,83%	99,86%	99,9%
Return rate Serving equipment	98,0%	98,3%	98,6%	99,9%

Table C.6: The yearly replacement of loading equipment (source: NSM equipment dashboard)

	Phase 1	Phase 2	Phase 3	Phase 4
Combo Cup	197	168	138	99
Ovenrack	1027	873	719	514
Oven Skid	6701	5696	4690	3350
FS Trolley 1/1 Business Class	258	219	181	129
HS Trolley 1/2 Business Class	147	125	103	73
Universal Trolley Light Weight Driessen	468	398	327	234
Trolley 1/2 Light Weight Diethelm	1428	1214	999	714
Square Container	223	189	156	111
Standard Container	1534	1303	1073	767

The replacement costs of the current scenario The first analysis is performed on the cost increase of the current scenario if the return rate is incorporated in the control costs. With a return rate of 100%, the total control costs for 5 years are calculated to be €2.989.597,08. However, if the return rate for loading equipment (99,8%) and serving equipment (98%) are applied, the control costs after 5 years are €11.871.645,24. Based on the difference between the two values, the component for the replacement costs is €8.882.048,24. This value represents the total costs for the replacement of the equipment that is broken or lost during distribution. This value has already incorporated the financial value of the "liberated" loading equipment due to the increased efficiency. The monthly replacment costs are €147.542,33 whereby 28,7% is covered by the service equipment and 71,3% by the loading equipment. Within the loading equipment, the biggest drivers are the expensive equipment types (Business class trolley and normal trolleys).

The impact of the control model The control model involves the tracking of equipment due to the implementation of RFID and Barcodes. Using this automation, it is possible to identify the exact routes responsible for the breakage of the equipment. The total system control costs after 5 years, with the implementation of the control model and the reduction of losses, is €7.407.795,20. This means a reduction of 37,6% (or €4.463.850,03) for the total control costs. This would also provide (financial) evidence that the implementation of the barcode+RFID system pays off because of the possibility to reduce losses. The impact of the loss reduction is shown in table C.6. This table shows the required replacements per year. The yearly replacements in phase 4 show that the replacements are half of the yearly replacement in phase 1.

Reflection on results

The quantitive case study shows the benefits of the implementation of the new control model. If the new control model is implemented according to implementation scenario 2, the control cost reduction after 5 years is over €590.000. This is a reduction of 19,75% compared to the control costs if KLM continues with the current practice. This implementation scenario means that KLM implements the Barcode + RFID scanning, that KLM optimizes the fleet control towards maximum service and that they actively control the maximum thresholds within the network. An additional cost reduction of over €3,8 million is possible when NSM-Planning is able to reduce the replacement costs with 50%. These calculations show the potential of the implementation of the cost reductions for the new control model. One of the other insights is the big influence of the laoding equipment on the total equipment costs. Therefore, it is concluded that, for the implementation, the first focus should be on loading equipment. This accounts both for the availability as for the return rate improvement.

D
ANNEX: NEW TOOLS FOR EQUIPMENT DISTRIBUTION IMPROVEMENT

This annex describes the designed tools that can be used by klm to optimize the distribution of equipment. There are 5 different tools that are designed to serve the newly designed procedures for equipment distribution management. The five tools are combined in one single Excel Dashboard. Although other (software) programs are available, the choice for excel is made based on the current experience and installed base of Excel at KLM. The Excel file is a collection of the tools desribe and several tabs to put in the data (allotment, timetable, calculations).

THE STRUCTURE AND INTERCONNECTIVENESS OF THE DASHBOARD ELEMENTS

The dashboard exists basically of three different types of elements. The first set of elements focuses on the input of required elements for equipment distribution. The second set of elements requires the input based on the decisions for NSM-Planning equipment strategy. THe third set of elements discusses the output of the model. The structure of the different elements is shown in picture D.1 and further discussed in the paragraphs below.

The required input of KLM elements The first aspect that is required to put in the model are the different drivers for the equipment fleet. These aspects discuss the timetable, the allotment and the configuration for of the outstations. The timetable shows the different flights per day between origin and destination, the time of departure or arrival and the applied aircraft type. The allotment discusses the loading per aircraft type. It is possible to easily adjust the amount of loaded equipment types per aircraft. The third element required is the configuration of the outstations. The configuration identifies the alltoment per outstations. This is based on the timetable and decisions made by the L& O department. The dashboard is suitable to add new equipment types, new aircraft types and new destinations easily. Moreover, the timetable can be added easily by just pasting the standard Excel structure of the timetable in the dashboard.

The required input of NSM and equipment aspects The second set of elements enable NSM-Planning to put in their strategic decisions and behavior of the distribution. These elements discuss the (measured or assumed) return rate of the equipment, the service level for the warehouses in the network, the leadtime towards the network nodes and the operational aspects (concerned FTE, Operational costs, ICT costs). The adjustment of these aspects influence the amount of equipment required and the impact on costs. The input in these elements enables NSM-Planning to see the impact of improvements or changing decisions.

The deliverd calculations The output of the equipment dashboard are the different insights and elements that provide the state and required actions for equipment distributions. As shown in figure D.1, the input of different aspects is used to calculate the specific outputs. The fleetsize uses the elements indicated with the red dot. The fleetsize is calculated using the timetable, the allotment and the configuration per outstation. This results in the calculation of the fleetsize with maximum productivity. However, this fleetsize is influenced by service levels. Based on the service levels and using the leadtimes and the return rate, it is possible to calculate the spare stock levels in the outstations. Using the spare stock levels in the warehouses, it is possible to

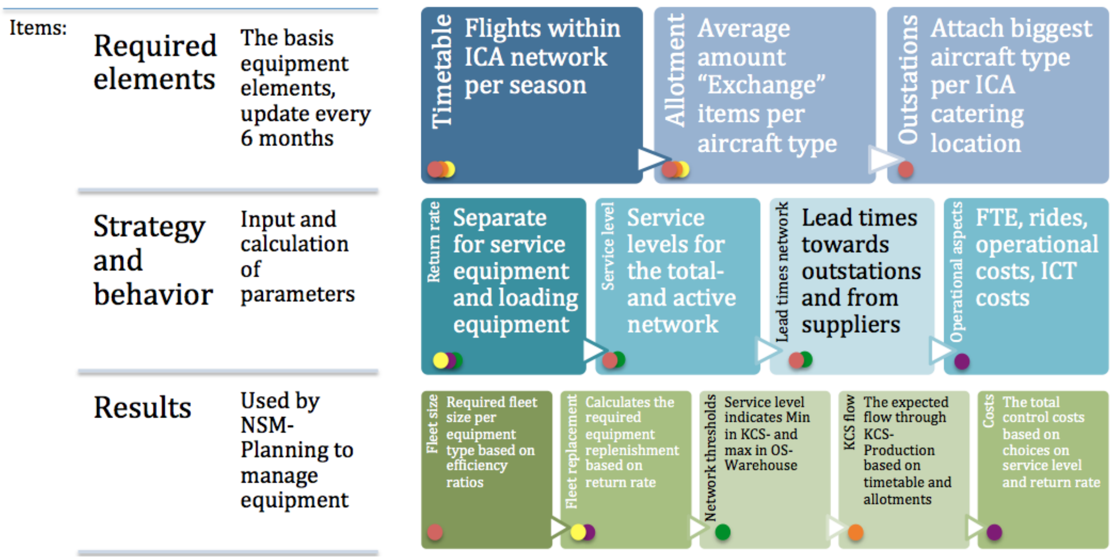


Figure D.1: The representation of the model structure for the equipment management dashboard

calculate the required efficency ratios and total fleetsizes. The fleet replacement uses the elements indicated with the yellow dot. For the fleet replacement program, the flow in the network is multiplied by the return rate. The deviation between the total outgoing flow and the returned flow is required to be replenished. The allotment and the timetable dictate the outgoing flows. The network threshold calculations use the elements indicated with the green dot. These thresholds are calculated based on the return rate, the service levels and the leadtimes from the suppliers and leadtimes towards the OS-Warehouses. The KCS-flow is calculated using the elements indicated with the orange dot. The KCS-Flow is based on the timetable and the allotment per flight. The return rate is not incorporated in these flows since this is already covered by the return rate. The costs are calculated the elements indicated with the purple dot. The costs are a cumulative value for the financial costs, the replacement costs and the operational costs.

THE SCENARIO DASHBOARD

This subsection introduces the scenario dashboard. The function of the dashboard is that it translated the strategy paramters into tresholds in the network. The following paragraphs reflect on the model, the governance for its use and the practical use the tool has for NSM-Planning. The reflection of this dashboard is shown in figure D.2.

Model introduction The first tool discussed in the scenario input dashboard. The dashboard is shown in picture D.1. The pictuture shows the parameter input fields for the different alternatives. Each alternative represents a period of the implementation. Alternative 1 represents the current state of the operation. If additional analysis shows that the parameters are different for the current state, it is easily changed. It is also possible to put in the return rate, the amount of FTE concerned for control, the reparation rate and the reparation costs. Per phase, it is possible to put in the target state of the parameters. These parameters are automatically translated into target boundaries for the network. The lower part shows the automatic calculation of the network tresholds required to be monitored by the NSM planners. The "Inventory KCS-W" fields represent per phase the minimum required inventory levels in the warehouse of KCS. This level is required to be monitored by the NSM central-planner. The "Inventory "Os-totaal" fields represent per phase the total amount of spare equipment available to among over the outstations. The "Inventory-OS" field shows the average amount of spare equipment per OS. The "Inventory Repa" shows the maximum amount of inventory at the reparation facility. This inventory is monitored by the central planner. The maximum fleet-size is calculated based upon the inventories in the network and the required fleetsize (with maximum productivity). The required fleetsize is calculated based upon the formula provided in Annex C.

The utilization of the model The task defined it to use the dashboard to translate the strategic targets (for efficiency, return rate) towards tresholds in the network. The task is carried out using this strategy dashboard.

	Phase 1 Current	Phase 2 Phase 1	Phase 3 Phase 2	Phase 4 Infinite	Phase 5 Loadfactor
Service level	Unknown	START	IMPROVED	OPTIMIZED	ADDITIONAL
Efficiency loading equipment					
Total loop	99,00%	98,70%	98,70%	98,70%	98,70%
Active loop	90,00%	99,70%	99,70%	99,70%	99,70%
Efficiency serving equipment					
Total loop	99,00%	89,00%	89,00%	89,00%	89,00%
Active loop	90,00%	97,85%	97,85%	97,85%	97,85%
Load factor equipment	100,00%	100,00%	100,00%	100,00%	100,00%
Return rate					
loading equipment	99,80%	99,83%	99,86%	99,90%	99,90%
Serving equipment	98,00%	98,00%	98,00%	98,00%	98,00%
Control NSM (Fte)	2	1,75	1,5	1	0,50
Rides KCS-P/W	810	15	5	4	1,00
Operational costs	0	1250	7500	7500	7500
Investments	0	1250	110000,00	0	100000
Reparation rate	1,00%	1,00%	0,50%	0,50%	0,50%
Reparation costs	100,00%	100,00%	100,00%	100,00%	30,00%
Interest rate	4,00%				
KLM Loadfactor	85,30%				

Figure D.2: Strategy imput and treshold calculation (Source: Own production)

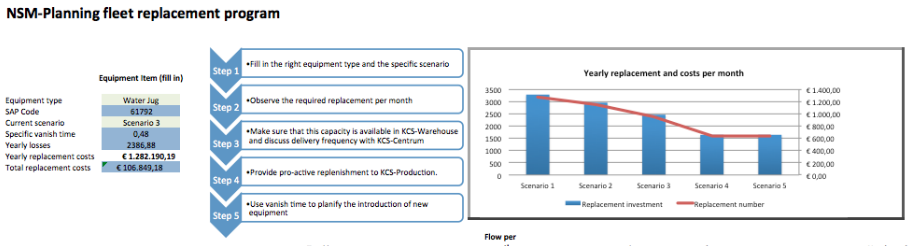
The task is required to be carrier out by the NSM-Planning manager Doze, she is the responsible person for the task. The accountable person is the NSM-Regie manager ten Veen. It is recommended that they discuss together the strategic targets for the equipment distribution. The consulted person is the NSM manager Dasler. The persons informed on the results are the NSM central- and area-planners. The are required to apply the results in their control of the network nodes. The task is required to be carried out each 6 months. Each 6 months, it is required to compare the state of the operation with the target state. If the required state is obtained, the strategy can be revised towards further increased efficiency. The information on the current efficiency is required to be shared before the tasks is carried out. If the task is carried out, it is required that the calculated tresholds are shared with the planners. Moreover, the targeted efficiency state and the foreseen cost reductions are shared with NSM manager Dasler. The reward for the application of the tasks is up to NSM management to determine. During the implementation of the tool, it is recommended to revice the HPO-use reflection above. As stated in chapter 7, an implementation using an iterative implementation procedure.

Practical use for NSM This model provides the possibility for NSM to identify their (efficiency) strategy and to quantify this to actual required tresholds in the network. Before, the definition of strategy and its translation towards quantified boundaries were not possible since sufficient tools lacked. The practical use is that this tool provides tangible boundaries for the network. This will increase the effectiveness of the planners since boundaries for the inventories are clear and based on actual strategy.

FLEET MAINTENANCE PLANNING PROGRAM

This subsection introduces the maintenace planning program. The function of planning program is that it calculated the required equipment replenishment based on the return rate. The following paragraphs reflect on the model, the governance for its use and the practical use the tool has for NSM-Planning.

Model introduction The fleet maintenance program calculates the required equipment replenishment per phase based on the return rate. The return rate is put in the dashboard reflected in the past section. The return rate is calculated by the barcode and RFID system based on the difference between the outgoing and ingoing flow (as reflected in Annex C). The following calculations are made: outgoing flow per month, investments per month, yearly replacement and vanish time. The outgoing flow per month provides the amount of items that are send to the network from KCS-Production. This number is calculated using the timetable, the aircraft types and their allotment. The investments per month reflect the lost items. This value is calculated using the return rate (per phase) with the outgoing flow. The amount of lost items is multiplied with the financial value of the equipment. The "yearly replacement" provides the calaculation of the amount of items that is required to put into the loop to maintain the fleetsize. The recommendation is added that this reflects on the situations where demand remains the same. If demand goes up through new destinations, increasing fleetsize, the yearly replacement needs to be recalculated. The "vanish time" reflects the time that it takes



		Total loop						Flow per month	Investment per month					Yearly replacement (number of items)					
	Price	Minimum	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Outflow	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scen
Combo Cup	€ 175,00	714,9427	802,40	716,88	716,88	716,88	805,25	8219,719763	€ 2.876,90	€ 2.445,37	€ 2.013,83	€ 1.438,45	€ 1.438,45	197	168	138	99	99	
Ovenrack	€ 49,28	3710,715	4164,66	3720,79	3720,79	3720,79	4179,42	42807,94907	€ 4.219,15	€ 3.586,28	€ 2.953,41	€ 2.109,58	€ 2.109,58	1027	873	719	514	514	
Oven Skid	€ 3,22	24304,19	27277,44	24370,20	24370,20	24370,20	27374,09	279193,7863	€ 1.798,01	€ 1.528,31	€ 1.258,61	€ 899,00	€ 899,00	6701	5696	4690	3350	3350	
FS Trolley 1/1 Business Clas	€ 400,00	919,8025	1041,52	922,33	922,31	922,31	1041,16	10757,5106	€ 8.606,01	€ 7.315,11	€ 6.024,21	€ 4.303,00	€ 4.303,00	258	219	181	129	129	
HS Trolley 1/2 Business Cla	€ 400,00	521,5358	590,55	522,97	522,96	522,96	590,35	6115,117133	€ 4.892,09	€ 4.158,28	€ 3.424,47	€ 2.446,05	€ 2.446,05	147	125	103	73	73	
Universal Trolley Light Wei	€ 261,91	1683,923	1906,76	1688,54	1688,52	1688,52	1906,10	19490,90445	€ 10.209,73	€ 8.678,27	€ 7.146,81	€ 5.104,86	€ 5.104,86	468	398	327	234	234	
Trolley 1/2 Light Weight Di	€ 377,03	5204,473	5893,20	5218,75	5218,68	5218,68	5891,17	59491,82914	€ 44.860,41	€ 38.131,35	€ 31.402,29	€ 22.430,20	€ 22.430,20	1428	1214	999	714	714	
Square Container	€ 80,67	900,9592	1020,19	903,43	903,42	903,42	1019,83	9284,440931	€ 1.497,95	€ 1.273,26	€ 1.048,57	€ 748,98	€ 748,98	223	189	156	111	111	
Standard Container	€ 106,33	5468,265	6191,91	5483,26	5483,19	5483,19	6189,76	63895,9043	€ 13.588,10	€ 11.549,89	€ 9.511,67	€ 6.794,05	€ 6.794,05	1534	1303	1073	767	767	
Drawer 08cm	€ 16,26	18463,89	20722,66	18514,03	18514,03	18514,03	20796,08	211980,565	€ 6.893,61	€ 5.859,57	€ 4.825,53	€ 3.446,80	€ 3.446,80	5088	4324	3561	2544	2544	
Drawer 11cm	€ 11,41	9726,696	10916,61	9753,11	9753,11	9753,11	10955,29	112339,9428	€ 2.563,60	€ 2.179,06	€ 1.794,52	€ 1.281,80	€ 1.281,80	2696	2292	1887	1348	1348	

Figure D.3: KLM catering equipment fleet maintenance program (Source: Own production)

before the equipment is vanished out of the loop if not maintained. As reflected before, this value can be used to planify the "soft" transition time between an equipment type and its successor. Using this vanish time, there is no financial loss due to obsolete equipment.

The utilization of the model The task applied through the use of the fleet maintenance tool is to planify the required monthly/yearly maintenace required to maintain the fleetsize. The responsible person for the task is the central planner. This is the responsible person since she is responsible for the availability of equipment in KCS-Warehouse. The accountable person is the NSM planning manager since she has final responsibility for the application of the equipment management. The person consultanted is the supply chain specialist within NSM. This person provides functional support for the calculation of this type of action. The persons informed with the required sizes are the project buyers within NSM, the suppliers, the controling department and NSM management. The project buyers are informed since they are required to negotiate prices for the aquisition of the equipment. The controling department is informed since they monitor the budgets for the department. The suppliers are required since they have to prepare the required supply sizes. The NSM management department is informed since they have the final responsibility for the fleet maintenance. The structure is that the fleet maintenance program is revised each six months. The required structure for the organization is proposed to apply each month. It is possible compare the required fleetsize replenishment with the theory for Economic Order Quantity to base the structure of this optimimum acquisition size. The information required to be shared is the return rate (calculated by the barcode + RFID system), the fleetsize, the vanish time, batch size ordered by central planning and delivery time. The rewards for the right application of this task is to be determined by NSM management.

Practical use for NSM There is currently no fleet maintenance (based on return rate) at NSM-Planning. This results in adhoc management of replenishment in case of shortages but no pro-active management based on the return rate. This tool results in suffiient fleet size management. Moreover, the "vanish time" can be used to negotiate the soft implementation time with the product department for the introduction of new products.

THE NETWORK SAFETY STOCK LEVEL CALCULATOR

The safety stock calculation tool, as shown in figure D.4, can be used to calculate the efficiency ratios for the network. The different steps lead from input flows and return rates towards the network efficiency ratios. The first step is to put in the required service levels. The distribution between the service levels in KCS-Warehouse and the OS-WArehouses is made. As indicated, the current service levels are 98% for the KCS-Warehouse and 99,9% for the OS-Warehouses. The required input are the leadtimes towards the outstations (normally 1 day with BBO shipment) or leadtimes from equipment suppliers. The identified leadtime from the suppliers 5 days. The standard deviation from demand is identified as 10%. This is identified based on assumptions on demand variability. Is is easy to adjust the standard deviations of demand and leadtime when additional researh, for example supply chain specialist at CIM, is applied. Based on the indicated service levels, leadtimes and demand, the required service levels in the KCS-Warehouse and the total inventory in the OS-Warehouses is calculated. Based on the fleetsize and the inventories, the efficiency ratios are calculated. It is important to keep the cycle stock in mind. The average inventory is KCS-Warehouse used for the calculations, is the average cycle stock (0,5 times the total cycle stock) + the safety stock. The inventory in the OS-Warehouse is the

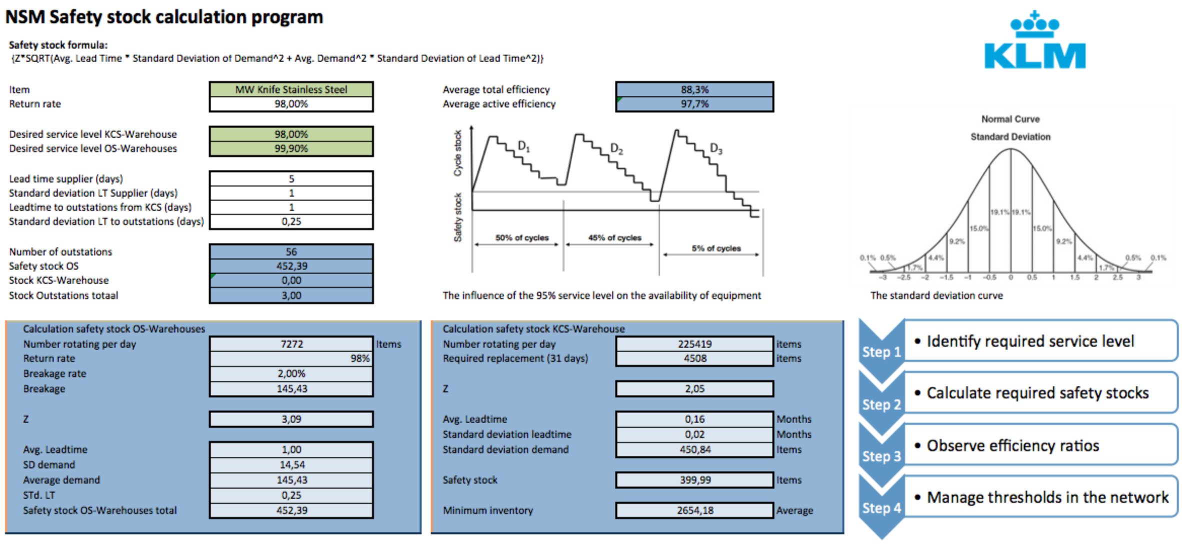


Figure D.4: The dashboard to calculate the efficiency ratios based on the service levels)

safety stock plus the average cycle stock (daily breakage * 0.5). It is up to NSM-Planning to communicate the boundaries to the network and to monitor the compliance. Additional graphs are added to show the impact of the service level and practical examples on the standard deviation.

KCS-Production inventory forecasting tool

This subsection introduces the inventory forecasting tool. The function of the inventory forecast is to reflect on the availability of equipment in the ROA-area in KCS-Production. An impression of the KCS-Production inventory forecasting tool is provided in picture D.5. The inventory is calculated based on the timetable, the aircraft types, their allotment and 3 different production scenarios (A+1 V-8, A+1 V-10, A+1 V-12). The following paragraphs reflect on the model, the governance for its use and the practical use the tool has for NSM-Planning.

Model introduction The model provides the inventory in the "ROA" area in KCS-Production. This area represents the inbound storage where equipment is pushed into the facility when arriving from the inbound flight. The assumption is made that the equipment arrives in KCS-Production within one hour after arrival. The equipment is pulled into production from this area to prepare the departure flights. The amount of hours that the production starts before departure is based on the production scenario. This model compares the inventory fluctuations between three different scenarios (8, 10 and 12 hours before departure). The different graphs show the different characteristics of the operation. The graph "balance incoming/outgoing flights" shows the dynamics of the timetable. This focuses on the balance between the outgoing and incoming flights per day. Monday is characterized by the big number of arriving flights reducing in increasing inventory levels. Tuesday, wednesday and thursday are more or less balanced. However, friday shows an increasing number of arrivals and departure. Since these departures are prepared before the majority of the arriving flights comes in, the inventory levels go down (unless the production scenario is rightly planned). These fluctuations are shown by the 3 inventory fluctuation graphs. The tool enables NSM-Planning to observe the fluctuations per equipment type (possible to change in the field "subject") and per week. Based on the inventory level (the tool provides per production scenario the highest and lowest point of inventory), it is possible to tailor replenishment orders. It is possible to insert the allocation orders per day to see the impact if replenishment is applied.

The utilization of the model The task to be performed is to ensure the availability of equipment for production in KCS-Production. This task is supported by the KCS-Production inventory forecasting tool. The use of the model is to standardize the replenishment procedure. The tool is used by NSM-Planning. Although the current decision making is decentralized, the new control model focuses on centralized decision making by NSM-Planning. The new barcode + RFID system enables NSM-Planning to have an actual insight in the

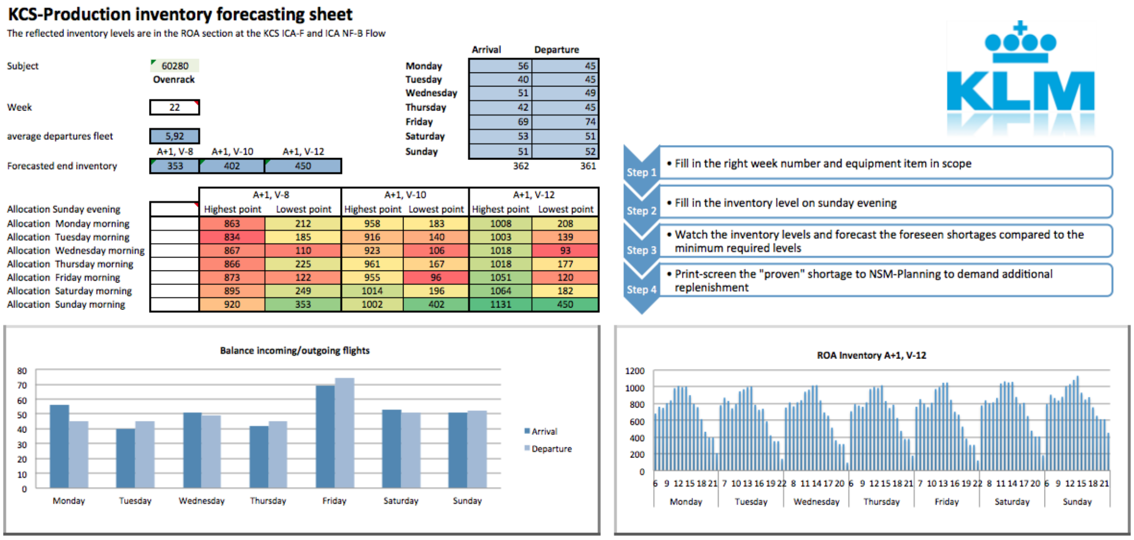


Figure D.5: KCS-Production inventory forecasting planning (Source: Own production)

inventory levels of KCS. Up till the implementation, it is the shift leader that is required to monitor the inventory level each sunday evening to provide the inventory level in the beginning of the week. Based on the inventory fluctuations, it is the central planner that decided for the replenishment. She can calculate the required replenishment based on the production scenarios and the minimum levels per day. Hereby, the focus is to avoid negative levels (shortages) for the production scenario in place. The persons informed with the calculations are the KCS-Warehouse operators since they are responsible for the physical replenishment. The task is required to be performed each monday morning since it is the point in time where the coming week is planned using the calculation of sunday evening. The information to be shared is the replenishment order (with the equipment types in scope and the quantity to deliver).

Practical use for KCS and NSM There is currently no standardized procedure for the replenishment order process within KCS-Production. Nor is there any insight in the expected fluctuations in the inventory levels within KCS-Production. This tool enables KCS-Production and NSM-Planning to have a tangible forecast of the inventory level. This forecast can be used to tailor the replenishment orders. Moreover, the replenishment order procedure is shifted from KCS-Production towards NSM-Planning. The focus is to reduce the amount of rides (orders) between KCS-Production and KCS-Warehouse. The second focus is to use the tool to provide the quantified evidence for KCS-Production that their current production scenario (V-12) results in shortages while the Departure minus 8 hours (V-8) ensures sufficient availability of inventories in KCS-Production (see figure D.6).

THE COST OVERVIEW

This section introduced the cost overview dashboard that provides the financial reflection on the equipment distribution. An impression of the cost overview is provided in picture D.7. Although the dashboard is not really a tool to apply a task, it provides financial reflections on the impact of the chosen parameters for the strategy. The following paragraphs provide back ground information on the information that the dashboard shows and the practical use for NSM.

Model introduction The model provides a financial overview of the equipment distribution per phase. As discussed, the scenario dashboard provides the possibility to put in the target states of the parameters. Based on these parameters, the financial aspects are calculated. The upper section of the table shows the working capital composition per phase. It is easy to observe the difference between the loading equipment share in the working capital compared to the service equipment share. The total working capital reduces per phase since the main strategy is focused on the increased efficiency. This is also shown in the graph "working capital". The second section of the table shows the replacement costs. Th replacement costs show the financial value that is required per month to overcome the losses. These losses are calculated based on the total fleet size and return rates for the loading and service equipment. The third section shows the operational costs.

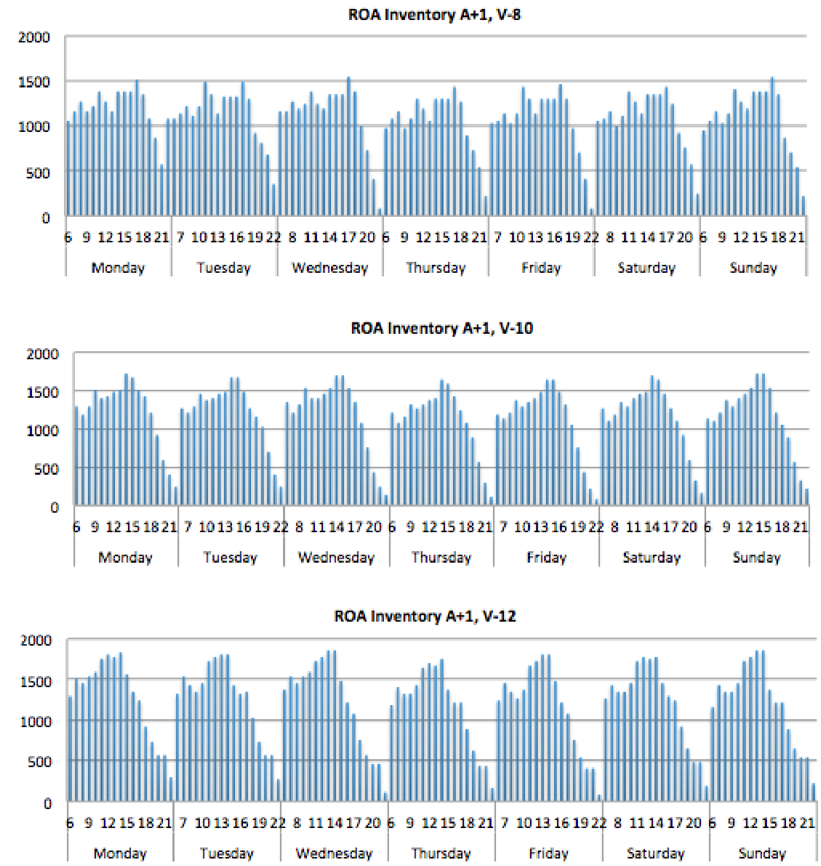


Figure D.6: The different production scenarios and the inventory fluctuations in KCS-Production

NSM-Planning Equipment distribution Cost overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		€ 0,69			
Working Capital					€ 692.483,59
Loading equipment	€ 5.119.106,29	€ 4.962.499,96	€ 4.752.653,80	€ 4.600.546,47	€ 4.452.234,14
Serving equipment	€ 212.819,05	€ 207.918,61	€ 199.475,89	€ 193.471,87	€ 187.207,61
	€ 5.331.925,34	€ 5.170.418,58	€ 4.952.129,68	€ 4.794.018,34	€ 4.639.441,75
Replacement costs per month				10,09%	12,99%
Loading equipment	€ 36.541,06	€ 31.059,90	€ 7.308,21	€ 18.270,53	€ 15.584,76
Serving equipment	€ 82.150,38	€ 73.935,34	€ 61.612,79	€ 41.075,19	€ 35.037,14
	€ 118.691,44	€ 104.995,25	€ 68.921,00	€ 59.345,72	€ 50.621,90
Operational costs					
costs per FTE	2500	2500	2500	3000	3000
FTE	5000	5000	3750	3000	1500
Operational costs system	0	1250	7500	7500	7500
Logistics costs KCS-W and KCS-P	€ 1.818,33	€ 674,79	€ 224,93	€ 204,94	€ 51,24
Reparation Costs	100,00%	80,00%	60,00%	50,00%	30,00%
Reparation per month	25000	20000	15000	12500	7500
	€ 31.818,33	€ 26.924,79	€ 26.474,93	€ 23.204,94	€ 16.551,24
Financial					
Investments	0	1250	110000,00	0	100000,00
Financial costs per month					
Working capital	€ 17.773,08	€ 17.234,73	€ 16.507,10	€ 15.980,06	€ 15.464,81
Replacement costs	€ 395,64	€ 349,98	€ 229,74	€ 197,82	€ 168,74
operational costs	€ 106,06	€ 89,75	€ 88,25	€ 77,35	€ 55,17
	€ 18.274,78	€ 17.674,46	€ 16.825,09	€ 16.255,23	€ 15.688,72
Monthly Costs					
Operational	€ 31.818,33	€ 26.924,79	€ 26.474,93	€ 23.204,94	€ 16.551,24
Financial costs	€ 18.274,78	€ 17.674,46	€ 16.825,09	€ 16.255,23	€ 15.688,72
Replacement costs	€ 118.691,44	€ 104.995,25	€ 68.921,00	€ 59.345,72	€ 50.621,90
Working capital	€ 5.331.925,34	€ 5.170.418,58	€ 4.952.129,68	€ 4.794.018,34	€ 4.639.441,75

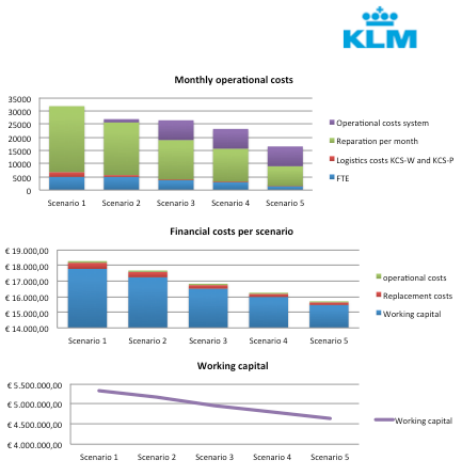


Figure D.7: KLM catering equipment distribution cost overview (Source: Own production)

The operational costs reflect on the costs for personnel, logistics costs and reparation costs. The composition of the costs is shown in the graph "financial costs per scenario". The table shows the reduced reparation costs per month, the reduced logistics costs, the reduced FTE costs but the increased operational costs of the supporting system. The fourth section shows the financial investments. The financial investments reflect the investments required to start the implementation of, for example, barcode + RFID. This is shown by the phase 3 investments. The fifth section reflects on the financial costs. These financial costs reflect on the costs to finance the investments for flet maintenance (replacement costs) the operational costs and the working capital. The values are calculated using the interest rate. As is shown by the table "financial costs per scenario" the financial costs go down. This is maintly because of the reducing working capital, the reducing financial costs and the reduced operational costs. The main driver of the reduced financial costs is the reduced working capital.

Practical use for NSM The analysis in chapter 3 showed that NSM-Planning is currently not monitoring on the aspect "Costs". This quantified reflection on the state of the operation enables NSM-Planning to see the financial impact of their decisions on strategy. These insights can be used to convince actors that efficiency is required and to increase their commitment towards change using the foreseen savings.

Figure D.8: The KLM Catering service in 1935 (Source:klm.com)

E

ANNEX: Reflection

Reflection on process

This reflection describes the different elements of the process. The planning of 6 months has proven to be sufficient. The main driver for this planning is the set of identified research boundaries in the early stage of the process. At first, the subject was solely loading equipment. The decision to expand this later on to equipment in general was taken based on possibility to apply the same approach to both equipment types (loading- and serving equipment).

Although the equipment dashboard is an important element of the proposed solutions, it took me rather long before I decided to build the dashboard. It was something I wanted to put up as a recommendation rather than actually build the tool myself. However, the decision to build the dashboard increased the tangible insights in the equipment distribution dramatically. Another decision that I should have taken earlier is the decision on the push program based on the return rate (as part of the replacement program). Given the theory on closed loop logistics, it is very important to implement active management of the return rate. This is something I also postponed to the last stage of the distribution. A third element that I should have put up earlier is the connection between the service level and the efficiency ratios. In the early stage of the process, I proposed to have NSM-Planning themselves should decide on the strategy. However, the questions about the required efficiency ratios were proposed during the green-light meeting. This showed that I had to find a theoretic base for the efficiency ratios. The service levels (and its translation into required spare stock levels), proposed the solution to this question. Looking back, I can summarize that the process was complete and well planned. However, I could have implemented the solutions from the theory in an earlier stage of the process. This would have increased the pace of the progress and would have enabled more time for training in the final stage of the process.

Reflection on results

The reflection on the results provides the reflection on different elements of the project. The first aspect discusses in a reflection on the thesis itself. The second aspect is the reflection on the control model. The third aspect discussed is the reflection on the equipment dashboard.

Reflection on thesis My intention for this thesis was to keep it structured and straight forwards. Moreover, I was looking for a combination between theory and a practical translation of the impact on the shop floor. Examples of this combination are the benchmark sections used to reflect on the different possible decisions for return rate, efficiency and control approaches. The evidence-based decision-making is another example of something I tried to apply for every decision I made in the thesis. For example, the amount of items in scope for the barcode scanning (compared with the feasibility on the working floor), the influence the service level has on the amount of out of stocks and the efficiency ratios. Another aspect is the decision to work with a standardized return rate for serving and loading equipment. Different analyzed equipment types during the research showed a big variability in return rates. Another aspect that could be handled differently is the description of the system design. The thesis is lacking theoretical background on the actual technical aspects of system design. This makes the description rather vague since actual functions aren't indicated with their technical names. Moreover, the results would be more valuable is the practical use of the equipment dashboard was expanded with more practical descriptions on how to adjust the dashboard. This is something that is transferred to KLM employees during several workshops but not well described in the thesis. However, the general approach for the system design is clear. The collaboration with Air-France and the different possibilities to merge the equipment fleets is another aspect that lacks in the thesis. Although I tried from the beginning, it failed to establish collaboration with Air France. Even if the practical collaboration with Air France was lacking, I could have provided a theoretical approach for the merging possibilities and economies of scale for combined equipment management for the two airlines. This is something I would recommend to future researchers to implement it in the

Reflection on control model The new control model contains the different aspects required based on analysis and research performed. These required aspects were identified based on the difference between the requirements by KLM for equipment distribution and the current application of equipment control. However, only the requirements by KLM were input for the control model. Literature didn't proposed similar cases so the control model is only based on KLM criteria. This makes it questionable if the model is generic enough to implement at other airlines. However, I think that the model is generic enough to be both implemented at other companies (both within as outside) the airline industry. This because all the aspects of the control panel for performance measurement are scalable to other companies. This conclusion is drawn based on personal experience during internships within RPM management at Heineken and case descriptions [38]. The sole difference is the application of the efficiency measurement. I decided that it was very important to attach efficiency to inventory levels. That is a different approach compared to the efficiency indicator proposed by the RPM management model [38]. This model proposes the measurement of efficiency based on return rate. So if someone tries to apply the model, it is to be decided what the best efficiency parameter is for the specific subject. Hereby, the recommendation is made that if specific inventory control is attached to efficiency, to use the efficiency set-up as described in this thesis. Another aspect drawback of this control model is the strong connection it has with the implementation of barcode + RFID. The strong connection sometimes might suggest that the implementation of the barcode + RFID is a prerequisitie for the feasibility of the model. Although it is possible to implement the control model with the barcode+RFID system, the setup of the replacement program and safety stocks is possible without this data colleciton method. However, the impact of improved data reliability is significant and since small deviations of, for example, the return rate has big impact, it is recommended to implement the measurement method. This is also because automated return rate, inventory monitoring and loss deployment is generated by the system without interference of human labor (only for the scanning).

Reflection on equipment dashboard The equipment dashboard is a valuable tool that is provides the possibility to calculate different required items for equipment distribution. It is based on the input of allotment, timetable and outstation allotment and different decision and behavioural inputs for the equipment distribution (return rate). However, it is currently a dashboard based on average allotments and average return rates. Therefore, it is only suitable to provide more or less an approach for the identified numbers. Moreover, collegues of KLM indicated that allotment varies per destination. Another items that require an update in future versions are the implementation timeline. Currently it is not possible to change the implementation timeline very easily. This is recommended to change. Another recommendation is focuses on the maintenance of the dashboard. For the current equipment dashboard, the maintenance (data updates) is destributed between different KLM actors (Supply chain specialists, Loading & Ordering, NSM-Planning). It is recommended to implement centralized update or verification of the data to verify the right input. This is something that is currently not implemented. I also think that I could have provided additional training on the use of the dashboard. The dashboard was mainly constructed in the last two months of the internship and the time to provide training to the NSM-Planning operators was rather short. In the end, I think the equipment dashboard is a sufficient tool that provides a structured approach for equipment distribution planning. If the maturity of equipment within KLM increases, together with the degree of automation, the dashboard structure could be used to design the system infrastructure.

Collaboration within KLM

The collaboration within KLM is something important to mention for this reflection. The two types of collaboration described in this reflection is the collaboration within CIM and the collaboration with KCS. It is described since it has been a very important aspect of the research. Looking back, it can be stated that the focus on increasing collaboration was essential to increase the possibilities for shared equipment management. The start of the pilot project between KCS and KLM is the confirmation that the collaboration has improved.

Collaboration within CIM Within CIM, equipment management and planning hasn't been a big issue or an item of interest. During the project, there haven't been many actors within CIM, outstide the NSM-Planning team, that showed big interest in the project. Although I tried to raise interest for the subject among the supply chain specialists, it remained a challenge. The difference in this approach was reached at the final stage of the research after the visit with a supply chain specialist to the production plant of LSG Skychefs in Frankfurt. I should have put more effort in involving the supply chain specialist from an early stage. This is important because in the end, they are the persons responsible for the different calculations that are the output of the equipment dashboard. The collaboration within the NSM-Planning team was very good and the managers have been very supportive. Also the collaboration with the planners was good although their attitude towards improvement is sometimes not very clear. I could have improved this by organizing workshops in the beginning of the project. Although I think I definitely gained their trust, it took a while. Based on my experience from my internship in the Democratic Republic of Congo, I could have gained trust to active assistance in the design of reporting techniques and dashboards. However, there was not sufficient time to focus upon this activity. This could have increased the involvement of the planners within NSM-Planning.

Collaboration with KLM Catering Services Something that has been a very learnfull experience for me is the role as mediator between KCS and NSM-Planinng. In the beginning of the project, their relation was not good and frustration an (frequent) occuring phenomenon. The fact that the pilot project uses a combined project team (with people from KCS and NSM) and that someone is hired as a specific equipment planner shows the raized devotion of KCS to support NSM-Planning in the equipment distribution control. I think my approach, to start working once a week at KCS, together with an "open" attitude to listen to their problems combined with a focus on shared solution, has been very constructive.

F

ANNEX: FIELD STUDY IMAGES

Figure F.1: The loading of catering equipment, by KCS, for an outbound flight (Source: KLM.com)

Figure F.2: The storage operations in the galley by KCS (Source: NSM-Planning)

Figure F.3: The inbound ramp in KCS-Production (Source: Own production)

Figure F.4: The outbound ramp in KCS-Production (Source: Own production)

Figure F.5: The storage of spare equipment in KCS-Warehouse (Source: Own production)

Figure F.6: The storage of broken equipment in KCS-Warehouse (Source: Own production)

Figure F.7: Visiting the LSG Skyschefs production plant in Frankfurt(Source: Own production)

Figure F.8: Visiting the Do&CO production plant in Istanbul (Source: Own production)

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