Summary

KLM Cargo is home based at Amsterdam Airport Schiphol (AAS). With several buildings the hub function in the hub-and-spoke transportation concept is being fulfilled. The hub is a link in many different transportation chains and here the reorganization of goods take place. From 2012 the premises of KLM Cargo has got to make place for the expansion of the passenger capacity of AAS. The movement to the 'other side' of the runway is a good opportunity to revise the current process. Plans have been developed and the decision has been made that the automated storage/transportation system for standardized airplane loading devices (ULD's) as it is being used in the current process will not move with. In this investigation is concluded that this Pallet Control Handling System (PCHS) has another function besides transporting and storing the ULD's. This function is monitoring the locations of all present ULD's. Also in the process after the movement this function needs to be realized with a Location System (LS). This LS should qualitatively contribute to the transformation process of products. Transformation here means that the goods change in location (from the entrance of the hub to the exit) within the planned throughput time and change in position relative to each other (combined on or in ULD's) as planned preserving the necessary environmental conditions.

The main goal of the LS is generating location data of the ULD's present at the hub. The users of these data have several requirements. In the current process the user of the location data is the same as the supplier of the data, integrated in the PCHS. In the new process the moving of ULD's will be the responsibility of human employees, for which they have manual operated vehicles (ULD-transporters) available. To move a specific ULD, the employee at least needs to know (besides some other information) where to find this unit. Therefore this employee becomes the user of the location data generated by the LS. After investigating the consequences of incorrect data, the human being is found to be too unreliable to be the supplier of location data. The user from the data realized by the LS must therefore be separated from the supplier. The research question rises: How can the location data of every ULD at the hub objectively be made available for central use?

Despite the fact that the section ULD-Transport does not yet exist, some requirements on the location data of ULD's has been listed. The generated location data must at all times correspond with the real location (within certain accuracy and time limits); 100 % reliability. Besides that the 'target' must be easily identified when arriving at the generated location.

To be able to make a choice for a final concept, in this investigation an overview is provided in the possible methods to localize a ULD. The chosen method automatically provides some different functions to fulfill and therefore possible existing technologies are explained. This ends up in four possible solutions; scenario's which make localization of ULD's possible at the hub. From these four solutions the final concept is chosen by assessing the 'extra' benefits and the required expenses. Before describing the final concept there needs to be told that Air France and KLM have initiated a project together (project "Freight 70") with the goal to have all ULD's in their property provided with passive RFID-tag by the year 2010. With these tags ULD's can be automatically and wireless (up to a few meters) identified. This project is aimed for to fasten and simplify the handing over from one link to another in the supply chain but the use of this technology is available for side applications like the LS.

The final concept consists of two subsystems. Subsystem 1 detects which ULD and which ULD-carrier (a ULD is always dependent on different kinds of resources; ULD-carriers. These can be static or mobile) get combined. For this detection RFID-readers, assembled on the ULD-transporter, are used. These devices read the ULD and the ULD-carrier when they get combined (the ULD-carrier is also provided with a RFID-tag). The achieved data get checked by the driver of the vehicle before sending them wireless to a central computer. This subsystem provides information about which ULD is combined with which ULD-carrier. This subsystem demands that at the entrance of the hub every ULD gets assigned to the ULD-carrier it remains on. Technology specifications of this subsystem still lack as it depends on project Freight 70.
Parallel to subsystem 1 subsystem 2 contributes to the LS by localizing the mobile ULD-carrier present at the hub. Every ULD-carrier is provided with two RF-transponders which emit radio signals every 10 minutes. Installed antennas receive the signals and with different techniques a location can be assigned to the transponder. With this technology the localization of the ULD-carrier takes place with an expected accuracy of 1,1 m with a probability of 95 %. This subsystem gives insight in the whereabouts of every ULD-carrier present on the hub. It demands that at the entrance and exit points of the hub detection gates register all incoming and outgoing transponders.
The combination of both subsystems together foresees in the location data of every single ULD. Because the ULD location is coupled to the location of the ULD-carrier the driver of a ULD-transporter can identify the ULD by identifying the accompanying ULD-carrier. These devices take part of a closed circuit at Schiphol and therefore number plates can be attached to make them visual identifiable. The driver can easily recognize the ULD-carrier he is looking for when arriving at the location generated by the LS. The expected accuracy ($\varepsilon < 2{,}4$ m with a probability of

99,99 %) satisfies the requirements. The reliability of the system is found 99,9 % for movements of ULD's provided with RFID-tags.

The developed LS gives an answer to the question how to collect location data of ULD's at the hub. The theoretical reliability isn't 100 % as required but this number is expected to increase when investing in technology and techniques. Partly for this reason it is required for KLM Cargo to start soon with researching and developing to have the knowledge and skills necessary at the time of implementation. The investments will be significant and besides that the LS will have considerable impact on the process. It should be considered though that a 'cheap' LS can only be achieved when accepting the human being as a sufficient reliable supplier for location data. And with this should be accepted the accompanying losses in quality of the process and many 'side' applications.
Reinstalling the process of the hub without the PCHS and without losing control in the process is possible only when a LS is installed which provides location data automatically as does the LS described in this investigation.

To contribute positively to the transformation of a product, the least thing to know is the present state of this product! The transformation process at the hub Schiphol is explained in paragraph 1 of this summary and consists mainly of changing locations and positions of individual goods and goods combined on ULD's. Therefore the locations of goods and ULD's should be clear at moments that movements will take place. The LS provides in reliable location data of ULD's and increases the controllability of the process!