PRACTICE PAPERS

Air cargo overbooking based on the shipment information record

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Abstract

KEYWORDS: industries, air cargo, revenue management, transportation-shipping, overbooking

Overbooking is one of the most important processes of Air Cargo Revenue Management (ACRM). Airlines can improve their capacity utilisation and increase revenue and profitability. Overbooking, however, can on the other hand lead to offloads and suffering service quality. Current overbooking methods usually work on the flight event level and forecast shows up ratios based on historical flight events. These methods were derived from passenger airline overbooking models and imply various problems as the business requirements of air cargo differ significantly from the passenger business. This paper suggests a new approach for ACRM using certain parameters of the Shipment Information Record (SIR) to forecast the show up behaviour of a shipment. As this methodology is again derived from the so-called Passenger Name Record (PNR)-based overbooking of the passenger business, this paper focuses on the analysis whether it is reasonable to adapt the PNR-based method for air cargo. Some basic definitions that are necessary for future research are provided and the results of an expert survey that was processed to identify the parameters that significantly determine the shipment show up behaviour are presented. The aim is to provide the necessary foundations for further research on SIR-based overbooking.

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INTRODUCTION

Air Cargo Revenue Management (ACRM) is a revenue management application that was developed based on the success of revenue management methods and processes on the passenger airline side. Becker and Kasilingam (2008) outline the major ACRM processes, which show parallels to the passenger airline revenue management. Thus, many ACRM methods were derived from methods that have been applied successfully in the passenger revenue management. This is also true for the currently used overbooking methods that are based on passenger revenue management experiences.

The aim of overbooking is to offset no-shows and late cancellations by virtually increasing the physically available capacity to be able to accept more shipments. The amount of this virtual capacity is referred to as overbooking and is calculated based on a forecast of the show up probability of the shipments that are booked on the respective flight event (a flight event is defined as a single departure of a flight number at a specified day).

Whereas the first passenger overbooking methods, as for example stated in Shlifer and Vardi (1975), were introduced in 1970, the research work on cargo overbooking started only about 20 years later with Hendricks and Kasilingam (1992) as one of the first ACRM research papers. The practical application of air cargo overbooking has developed simultaneously: for many years the reservation teams of the cargo airlines have accepted more shipments than available capacity using manual processes based on experience of the staff and without a structured method or workflow support. Lufthansa Cargo was one of the first airlines that introduced a standardised, IT-supported overbooking workflow approximately a decade ago. More and more cargo airlines or combination carriers since then have introduced similar workflows and methods. The methods used in the current IT tools overbook on the flight event level. Those aggregated overbooking methods have added value for the carriers that have used it. It became, however, evident that those models have their limitations and cannot materialise the full revenue potential of overbooking.

A new approach is the overbooking based on the detailed shipment information rather than on the flight event level. The concept is derived from the passenger overbooking research where models have been developed that work on the Passenger Name Record (PNR) information level. The SIR-based approach overcomes methodology as well as the business process and user friendliness shortcomings of the traditional cargo overbooking models.

After an introduction to air cargo overbooking, the weaknesses of current methods are outlined before the new approach is introduced and evaluated. This is followed by a presentation of the results of an expert survey on overbooking. The paper is completed with a conclusion and outlook on avenues for further research.

WEAKNESSES OF CURRENT OVERBOOKING APPROACHES

The overbooking process is divided into show up forecasts for certain reading days (a reading day (RD) is defined as a specific day before departure within the booking period) and overbooking values that are calculated based on the show up forecasts using several optimisation techniques (eg cost minimising) and further constraints (eg service level). Figure 1 outlines the overbooking process with its two major steps: no-show forecast and overbooking.

Historical booked and tendered departure data are used to calculate a historical show up distribution as well as a show up forecast in a second step. The overbooking value is derived from the show up forecast using various optimisation algorithms, as described below.

Popescu *et al.* (2006) define a show up as the percentage of cargo that is tendered to the airline at the origin until the latest possible acceptance time for the flight it is booked on, from the total booked weight and volume at the respective RD. A similar definition is used by Luo *et al.* (2005a). Another way to define a no-show is to compare the booked against the flown values. With this approach the shipments

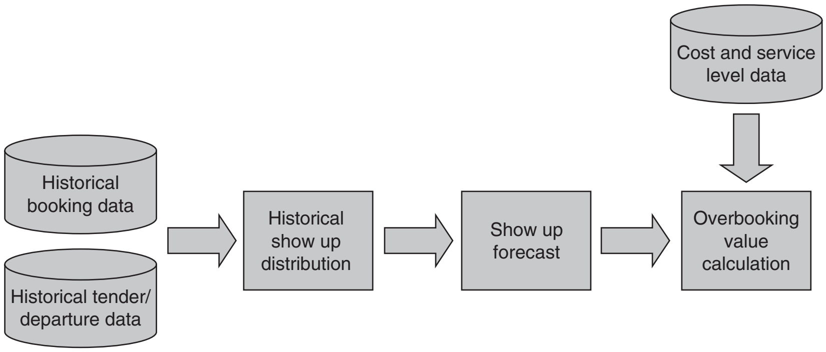

Figure 1: The overbooking amount is calculated based on no-show forecasts

that were booked on a flight segment are compared with the shipments that flew on the same segment. The major difference between these two approaches is that the latter takes routing modifications after the acceptance of the shipments by the airlines (that are usually not based on customer requirements) into consideration.

Today's air cargo overbooking methods analyse historical show up rates aggregated on flight event level and forecast a show up behaviour for the actual controlled flight event (usually assuming the normal distribution). Based on this show up rate, an overbooking value will be calculated using a cost minimisation algorithm. This algorithm seeks to solve the trade off between offload costs (additional handling, warehousing and bad will costs) on the one hand and opportunity costs of flying empty (missed revenues) on the other by searching for the overbooking value that minimises the overall costs (as the sum of opportunity and offload costs). Kasilingam (1996) developed one of the first cargo overbooking models that was enhanced later, for example by Cakanyildirim *et al.* (2005). Figure 2 illustrates the trade off based on the two cost curves.

The overbooking value therefore depends on the amount of offload and opportunity costs. This calculation can lead to major overbooking amounts if the offload costs are much lower than the opportunity costs. To

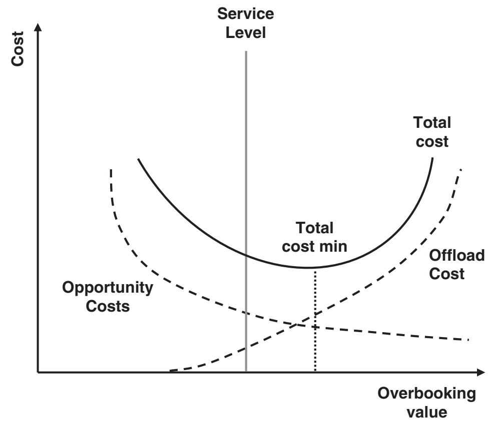

Figure 2: The optimum of offload and opportunity costs is the minimum of both curves

avoid massive offloads due to overbooking in those cases, a service level can be introduced that restricts the overbooking in order to ensure a certain service quality. This method is widely used and generates additional revenue for the cargo airlines as well as an additional capacity offer for the shippers and forwarders, especially valuable on the high demand routes. For example, Cakanyildirim *et al.* (2005) and Popescu *et al.* (2006) state that it has some shortcomings and leaves some improvement potential:

- The normal distribution is suitable for passenger overbooking, but not for cargo. This is because a single passenger utilises only a minor part of the available capacity (eg ~0.3 per cent for a 747 passenger aircraft). A single shipment can utilise 20 per cent or more capacity of a cargo flight. This range of cargo booking sizes and numbers per flight event together with other, business complexity drivers, lead to show up patterns that are not normally distributed. Becker and Dill (2007) provide a detailed analysis of the complexity drivers in ACRM compared to other revenue management applications.

- The no-show based on flight events is not intuitive for the ACRM staff as no-shows do not happen on the flight, but rather on the shipment level. Even if a large shipment is cancelled, increasing the actual show up rate beyond the show up forecast on one flight this show up forecast will not change in the aggregated model as only historical data are considered.
- The flight event-based overbooking generates an artificial problem: the ACRM team has to decide which capacity segments to overbook. Usually the ACRM processes differentiate between the allocated (eg for certain products or customers) and the nonallocated capacity that is sold during the booking period. A decision has to be made which capacity to overbook. The different capacity segments then need different overbooking models as their show up behaviour will be different (eg for normal bookings compared to bookings into a customer allotment with a guaranteed capacity access).
- The aggregated flight event based overbooking model implicitly assumes that the same shipments (or at least shipments with the same show up behaviour) are on the actual flight as they were on the historical flights that are used for the show up rate calculation. As — except for certain special businesses as flowers or annual wine distributions — the shipments are not the same for each flight event of a certain flight number, this assumption must lead to an inaccuracy. Furthermore, irregularly repeated events (such as major sport events) on different destinations can hardly be covered by the aggregated forecast as the historical data are not available for the flight events.
- The flight event-based overbooking is leg and not segment or even O&D based. If a shipment is travelling over more than one segment, its no-show behaviour cannot be forecasted on its origin and destination. The flight legs that belong to the shipment itinerary are forecasted independent of each other.

Those methodology flaws have led to further research regarding new overbooking techniques. Popescu *et al.* (2006) developed an aggregated show up forecast using histogram estimators instead of parametric distributions to overcome the shortcomings of the normal distribution and achieved a significantly improved performance compared to normal distribution-based algorithms. Luo *et al.* (2005b) tested the common distribution on real-world data. Furthermore, Luo *et al.* (2005a) as well as Cakanyildirim *et al.* (2005) and Luo and Cakanyildirim (2004) developed several cost minimising approaches, focusing on single leg flights and taking weight and volume into consideration separately. One contribution of these approaches is the possibility of not considering actual booking request for the overbooking calculation which helps airlines that do not capture booking and tendered data in a sufficient quality and quantity, which still is a widespread problem within the air cargo business. Cakanyildirim and Moussawi (2005) further enhanced these approaches by focusing on profit maximisation with nonlinear profit and offload costs rather than purely minimising offload and opportunity costs.

One up to now not considered approach is the adaptation of the PNR-based overbooking method that is used within major passenger airline revenue management systems since about five years. The concept is to find parameters of a shipment that affect its individual show up probability. For the

PNR-based overbooking those parameters are, for example, booking class, transport origin or the ordering of special meals. In order to adapt this approach for air cargo, the appropriate definition of a PNR must be found for a shipment before analysing the relevant data. Furthermore, the success factors of PNR-based overbooking must be validated for air cargo overbooking and differences must be evaluated.

INTRODUCTION TO SIR-BASED OVERBOOKING

A shipment can be defined as an object that comprises all lifecycle status of a business contact between a cargo airline and its customer regarding a single business event (no long-term contracts, etc). Figure 3 illustrates this shipment-object and its typical lifecycle. For the purpose of simplicity, the paper does not take the various irregularities into consideration that can occur during the lifecycle.

The lifecycle of a shipment starts with the initial booking (status 'booking made'). The customer contacts the airline and requests a booking with certain parameters (such as weight, volume, etc) on a certain routing within the airlines network with a defined drop off and delivery time. At this point not too many attributes describing the shipment are mandatory: customer, origin, destination, flights in routing, weight, volume and commodity (additional special information based on the commodity, eg if dangerous goods are booked). The question whether an attribute is mandatory at this point of time can vary based on the policy of the airline. For many airlines, products or rates are also mandatory for the initial booking.

This initial booking in the air cargo business is usually a rough plan that will be updated several times from now on until departure. With this initial booking, the Shipment Information Record (SIR) is created and the provided booking information is stored. With later booking updates more shipment details are provided (eg number and dimensions of pieces) as well as existing details are updated (eg weight or departure date).

The Air Waybill (AWB) as the next lifecycle status is the actual transportation contract between the agent and the airline. Some agents provide an electronic AWB, the so-called Freight Waybill (FWB) additionally. The FWB is an electronic message that is sent by the agent at the time the AWB is issued, which usually happens several days before the goods arrive at the airline whereas the AWB document itself is provided together with the goods. Therefore, by receiving and processing the FWB, the airline can increase its reservation data quality within the last three to four days before departure, where the most demand is expected.

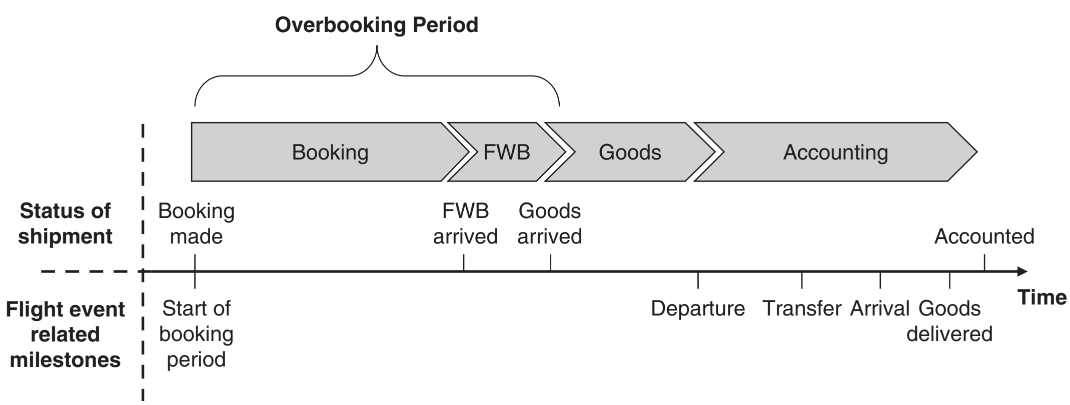

Figure 3: The lifecycle of a shipment from the initial booking until accounting

The Goods Acceptance (GAC) is the process milestone when the actual shipment is tendered to the airline and therefore is the last status of the booking lifecycle that is used for the show up forecast. Once the shipment is tendered, the actual shipment values as well as the desired routing are evident to the airline.

The later processes (such as accounting) are not relevant for the show up rate and overbooking calculation and will therefore be neglected in this paper. The SIR is continuously getting updated with new information on the shipment from booking updates, FWB, AWB and goods. Figure 4 illustrates the number of data fields that are describing a shipment within its different status as well as the overall SIR data quality that increases over time with every update of the SIR until all data are available in a sufficient quality. The detailed quality improvement depends on the individual shipment and the involved agent and shipper and cannot be represented in a numeric and universally valid way.

The major part of the information can already be available at the time of booking. The problem is that many data fields are optional at that time and that even the provided information often is of low quality — especially regarding exact weight, volume and dimensional figures. This is because even the booking agent does not exactly know the details of the shipment at the time of booking.

With every booking update this data quality should increase. If an FWB is provided, a major step regarding data quantity and quality can be made. All product-related information (booked product, rate, etc) should now be available in approximately 80 per cent accuracy, relative to the actual shipment data as it becomes evident only at the time the acceptance of goods and the AWB documents has been made. The information that can still be modified with the GAC is directly related to the goods (pieces, weight, volume, dimensions). It can happen that the FWB and AWB data again differ from the goods itself if the shipment has changed on short notice. For the show up rate calculation this is a very relevant part of the SIR. Furthermore, practical experience shows that the AWB data differ from the data provided with the FWB. As the AWB is the formal transportation contract between the airline and

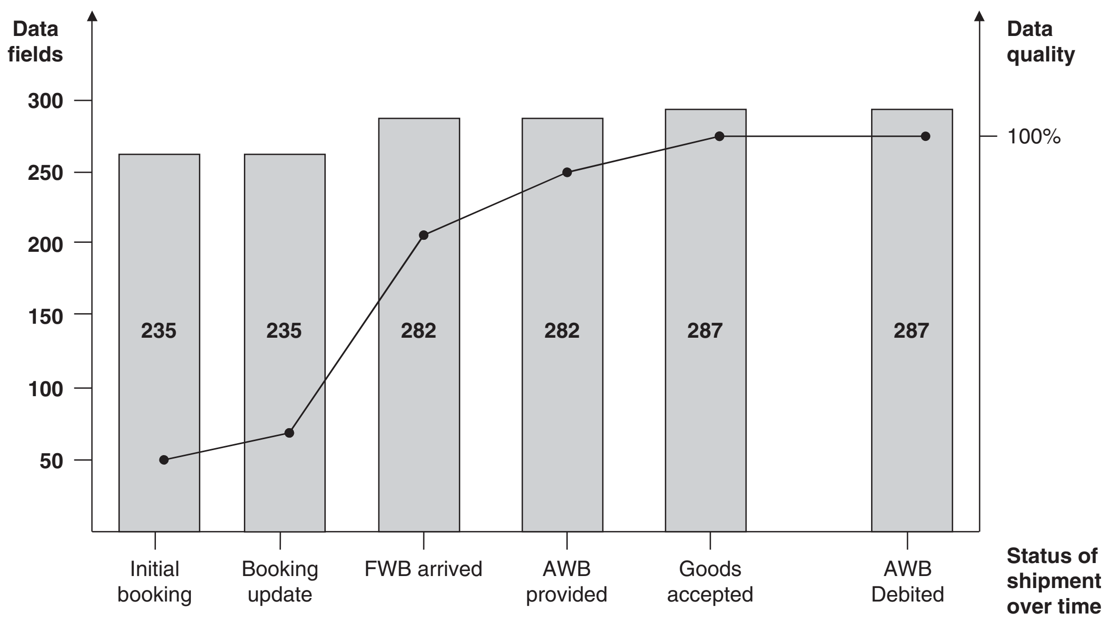

Figure 4: The data fields and data quality of the SIR increase over time

its customer, the AWB data will always overrule different FWB information. At the time of GAC the maximum data quality is achieved as the contract as well as the goods are available.

PNR- VERSUS SIR-BASED OVERBOOKING

The PNR-based overbooking method has been researched for about ten years. The first implementations have been introduced by several passenger airlines since the year 2000 (see eg Weber and Kalka, 2000). Neuling *et al.* (2004) calculated the forecast improvement potential compared to a classical overbooking at 3.5–10 per cent. Also Gorin *et al.* (2006), who developed a blended cost- and PNR-based approach, calculated a revenue gain of up to 10 per cent per available seat mile compared to classical no-show forecasts. Wishlinski (2006) states that PNR-based approaches gain a total revenue increase of 0.5 per cent to over 1 per cent, whereas Lawrence *et al.* (2003) proved that their PNR-based, cabin-level overbooking model improves the total revenue between 0.4 and 3.2 per cent compared to conventional models.

Taking those numbers as a basis for the SIR improvement potential, a total revenue increase of 0.4 per cent up to 3.2 per cent due to this new overbooking method would almost fully contribute to the airline profit, as only short-term variable costs are generated with those additionally accepted shipments. Even if the net profit calculation approach of Suzuki (2006) is taken into account, that on average decreases the measured benefits from overbooking by taking the network effects on nonoverbooked flights into consideration, the overall profitability contribution potential is by far high enough to encourage further analysis.

To analyse whether it is feasible to adapt the concept of PNR-based overbooking to the air cargo overbooking, the structure of the two businesses and data models have to be compared and it has to be clarified whether the success factors for the PNR-based overbooking are also valid for SIR. Neuling *et al.* (2004) and Gorin *et al.* (2006) list advantages and success criteria for PNR-based forecasting that can be analysed regarding their validity for the SIR-based overbooking approach.

- PNR-based forecasts are truly O&D based, always using the latest booking information, whereas traditional, leg-based no-show forecasts are only using historical booking data. This is also the case for SIR-based forecasts. Leg-based methods use the historical booked and tendered data, consolidated for a flight leg. The SIR-based forecast works on O&D level, taking historical but also always the latest shipment information (eg number of booking updates) into account.
- Separate PNR-forecasting models can be developed for special passenger groups. Also for the cargo processes it is possible to develop different algorithms tailored to the different no-show behaviours of the shipments. One could think of having a different forecast model for an allotment booking compared to free sale bookings.
- Seasonal and event influences can be forecasted on O&D level based on where they originate on PNR- as well as SIR-based approaches. This would solve a major problem of today's overbooking models that cannot forecast those influences at all as their effect on the network is not transparent when forecasting on leg level.

Furthermore, the concept of PNR and SIR is comparable, as the lifecycle of a PNR is comparable to the lifecycle of a SIR. Both are initiated with a booking, followed by several booking updates. The AWB/FWB is comparable to the ticket issuing, followed by the actual show up of the passenger or goods. Furthermore, comparable to the PNR, the SIR contains data fields that seem to provide information for the show up estimation (eg booking class versus cargo product). Not only the data fields itself, but also the object status (eg number of booking updates or ticket issued versus FWB provided) allows conclusions on the show up behaviour.

The structure of a shipment, however, is more complex compared to the passenger. It has two independent dimensions (weight and volume) as well as continuous show up rates in both dimensions. As Becker and Dill (2007) point out, those complexities are one of the major reasons why methods from the passenger revenue management cannot simply be adapted to the air cargo processes. Regarding overbooking, both methods — the SIR based as well as the classical leg based — have to manage this complexity. The SIR-based method does not solve the complexity challenges but also has no methodology disadvantages compared to leg-based approaches.

Lawrence *et al.* (2003) mention a disadvantage of the pure PNR-based overbooking: at an early time in the booking process, when only a few bookings have been made, the PNR-based approach cannot calculate reasonable overbooking levels as the PNR database is not sufficient. The authors suggest a weighted average of the conventional and PNR-based forecasts as an approximation for this time in the booking process. For the cargo business and a SIR-based overbooking approach, this is not a valid problem as no reliable overbooking value is necessary as long as no or only a few bookings are accepted for a flight event. The overbooking starts adding value as soon as the flight has reached a critical utilisation (eg 80 per cent), because even if an overbooking method provides additional virtual capacity, there is no economic effect for the airline as long as this capacity is not utilised with reservations. With a utilisation of less than 80 per cent, one additional booking will most probably not reach the physical capacity limit and use the virtual capacity generated from the overbooking model.

In this situation, there should be enough bookings available to be able to calculate an overbooking value with the SIR-based method.

Another challenge is derived out of the special characteristics of the air cargo business. It may happen that only a few shipments utilise the whole capacity of a flight (eg big shipments on continental feeder flights). In this case, an inaccurate no-show forecast for even only one of these shipments will lead to a wrong overbooking of the complete flight. This problem is a challenge for every overbooking model; today's leg-based models are not able to solve this situation sufficiently as they do not even recognise the situation because they only work with historical data. The SIR-based approach can improve this situation by analysing the actual booking data. A sufficient solution of this problem, however, can only be found by providing an efficient overbooking and no-show monitoring workflow that is supported by the SIR-based overbooking method.

As it seems to be feasible to derive the SIR-based method from the PNR-based concept, the success criteria regarding the research process can be analysed. Neuling *et al.* (2004) group the PNR attributes determining the no-show behaviour of a passenger in the categories flight attributes (eg O&D), airport attributes (eg intensity of traffic for the feeder to a flight), seasonal aspects and passenger attributes (eg special meal). Such an attribute cluster can also be used for shipments. A different attribute cluster, however, was developed for the SIR-based approach (see the section 'Expert survey' of this paper for details). The number of PNR parameters determining the show up behaviour must be reasonably small. Gorin *et al.* (2006) use only three parameters in their model. Neuling *et al.* (2004) also preselected the 200 PNR parameters with the help of expert knowledge. Both used expert evaluations as well as statistical and data mining techniques to find out the most important parameters. Also Cherrier (2000) points out that one of the important aspects of PNR-based overbooking is the validation of the captured PNR data with other sources such as expert knowledge.

Menich and Prinz (2006) processed a first step towards an SIR-based overbooking by analysing Continental Airlines Cargo Shipment data, trying to identify predictors for 'severe undertendering' (SUT). They defined SUT as shipments that are tendered with max 50 per cent of the booked value. The focus of this work was on the comparison of different data mining techniques to analyse the available shipment data. For this analysis, the decision tree-based algorithm worked best — a method that has also been used for the analysis of PNR data. The analysis does not provide any information on the potential of their approach compared to leg-based overbooking methods; also a clear definition of booked and tendered is missing. The work, however, is a very valuable starting point for future research on the SIR-based overbooking and further strengthens the theoretical potential of this approach.

After the general feasibility of the SIR-based approach has been analysed, the first step to find out about possible significant attributes for the show up behaviour as well as about the general assessment of the new method was an expert survey. This survey and its results are presented in the sequel of this paper.

EXPERT SURVEY

The aim of the expert survey was to find out the assessment of selected ACRM experts regarding the concept itself and the effect of selected SIR attributes on the show up behaviour of the respective shipment. To achieve this, the experts were asked to evaluate the show up determination of totally 42 attributes of the SIR, grouped into five clusters: customer, general shipment, shipment dimensions, rate and process/time-related attributes. The clusters were deduced from the attribute structure with the aim to frame attributes that describe the same business object. Furthermore, general questions about the attitude regarding cargo overbooking were asked and in a sixth cluster the survey participant was able to name additional attributes or attribute combinations.

The survey was processed on all identified attributes without any statistical data analysis in advance. Another approach was to first analyse the selected attributes and then ask the experts about their opinion on the analysis results. The advantage of the chosen approach is that the expert opinion is not influenced by the results of the data analysis. This is especially important as the quality of the reservation and tender data is not always perfect. Furthermore, the analysis of the difference between the expert evaluation and the data analysis can gain additional, valuable information, for example for the later workflow design. The 42 attributes were selected from the 287 attributes of the SIR by filtering out those attributes that definitively do not have any effect on the show up behaviour, such as technical control attributes.

The participating experts are employees and managers of cargo airline revenue management and IT departments as well as ACRM software providers. All experts are either members of related research groups (such as AGIFORS Cargo Study Group) or had a related profession that ensures a well founded knowledge. They were able to choose within a Likert-scale per attribute whether its show up determination is evaluated as 'none' (1), 'weak' (2), 'strong' (3), 'very strong' (4) and 'don't know'. Between evaluation (1) and (4) the scale was chosen to be as equidistant as possible in order to be able to evaluate basic metric indicators, such as average and standard deviation.

In total, 168 participants were addressed by e-mail between 7th April and 14th May, 2007. The response rate was 28.79 per cent within that time-frame.

SURVEY RESULTS

The questionnaire started with two general questions regarding the satisfaction with currently used overbooking processes and methods as well as current improvement activities. In all, 36.11 per cent of the participants were satisfied with their current overbooking methods, 50 per cent were not satisfied and another 13.89 per cent were not satisfied at all. Nobody answered that he/she was very satisfied. Seventy-five per cent of the survey participants are currently working on improvements of their overbooking methods.

There is a significant difference between the evaluations of the software providers and the airline employees regarding these questions: whereas 85.71 per cent of the questioned software provider employees answered that they are satisfied (14.29 per cent are not satisfied, none are very satisfied or not satisfied at all), the Airline employees answered the same question with 0 per cent very satisfied, 24.14 per cent satisfied, 58.62 per cent not satisfied and 17.24 per cent not satisfied at all. Whereas 79.31 per cent of the airline participants are currently working on improvements, only 57.14 per cent of the software vendors answered accordingly.

The mean[1] of the five different attribute clusters was rated 2.38 (shipment dimension), 2.63 (customer), 2.74 (rate), 2.83 (process) and 2.84 (general); no significant differences were rated on this aggregated level. On the attribute level, ten attributes can be identified that are evaluated by the participants to have a determination on the shipment show up behaviour that is between strong (3) and very strong (4). Figure 5 shows the evaluated determination of those ten attributes and their corresponding standard deviation.

According to the survey results, the show up ratio of a shipment mostly depends on the shipper (3.30, Customer cluster). As the shipper is the participant of the transportation chain who starts the process by ordering the transportation (mostly at the agent, very rarely at the carrier directly), it seems to be meaningful that this attribute has a strong determination on the show up behaviour of a shipment. The same is valid for the 'agent', rated 3.05. The attribute rated second ('AWB provided', 3.24, Process cluster) means that the agent has provided the Air Waybill (AWB), the transportation contract, to the carrier. As the AWB is issued by the agent when the goods are prepared for the air transportation, the weight and volume information on the AWB is usually of a high quality. The 'nature of goods' (3.16) and the 'product' (3.22) are both related to the general cluster.

Out of the ten attributes that are ranked highest, four are from the process cluster, three from the general cluster, two from the customer cluster, one from the rate cluster and zero from the dimension cluster. The average standard deviation of those ten attributes is 0.83. On the other end, three attributes

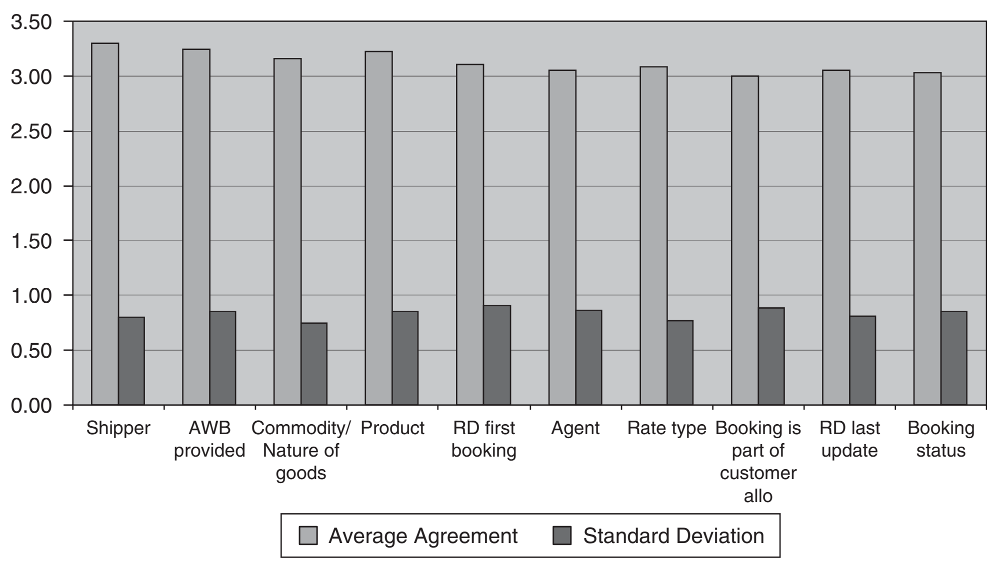

Figure 5: The ten attributes with the strongest evaluated determination on shipment show up

can be identified that have an evaluation of two (weak) or lower. Those attributes are the 'amount of dry ice weight' used for the shipment (1.96), the 'used volume per ULD' (1.81) and the 'contour code of the ULD' (1.75), all belonging to the dimensions cluster. The average standard deviation of those three attributes is 0.87.

For the further consideration of an attribute, not only the potential impact on the show up determination have to be considered, but also the value of the information within the overbooking process. For example, the attribute 'AWB provided' was ranked second highest with an evaluation of 3.24 (standard deviation 0.85). This information, however, is only available together with the goods and therefore too late. It is not adding value in the process compared to the actual tendered goods information, as it is not available to the overbooking process earlier. Even if an attribute is available in the process earlier, its quality has to be taken into consideration. Some information is provided early in the process, but only with a low quality and gets updated frequently. For example, the FWB is usually available up to four days before departure, which would be early enough to add value in the process. Mostly, the quality of the provided information is not sufficient and can hardly be taken for further processing (eg reservation and booking update). As stated at IATA (2007), there are currently activities within the IATA e-freight working group to enhance the quality and quantity of all electronic messages.

In Figure 6, all attributes are arranged using the dimensions 'determination on show up rate' from the survey results and 'process value of the information'. The process value can be 'high', 'medium', 'low' or 'very low' depending on the time of availability within the process as well as expected quality of the data (all attributes are evaluated with these two criteria; the overall process value is the mean of these two numbers). The earlier the information available in process and the more reliable this information, the higher the evaluation of the process value in the illustration below. The evaluation of the process value was not part of the survey. The data were enhanced with this criterion afterwards, based on the experience of the authors.

According to these enhanced survey results, the SIR-based overbooking should focus on the attributes in sector 1 as well as some attributes in sector 2 that have more than a medium process value and at least a show up determination that is above 2.00 (the total average of all attributes is 2.64). The sectors 3 and 4 should be neglected as the attributes neither do have a huge impact on the show up behaviour nor are available in a reasonable quality at a point of time that is not sufficient for the process. This reduces the attributes to the list shown in Table 1.

Out of these 21 attributes, the major part comes from the process cluster (8), followed by

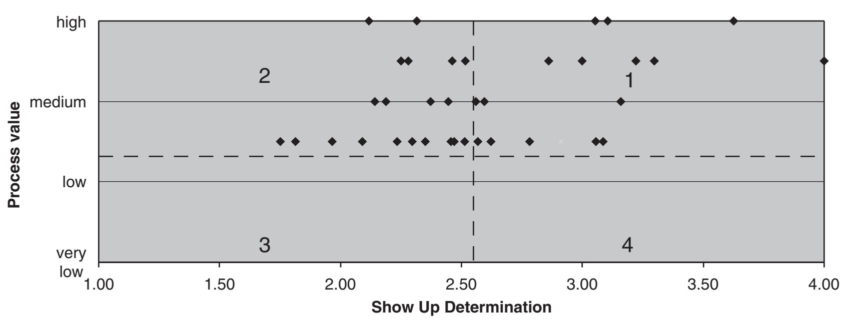

Figure 6: Attributes arranged by determination and process-related value

Table 1: The relevant attributes

Customer	*Shipment dimensions*	*General shipment*	*Process/time*	*Rate*
Shipper	Detailed weight/volume provided	Intensity of competition to destination	Reading day of first booking	Rate contract number
Agent	Total volume Total weight	Product Commodity/nature of goods Booking is part of customer allotment Origin SPL codes	Booking is a prebooking FWB has been provided Booking is own sales Booking is DGR Number updates made Booking is internal service/employee cargo Reading day last update	Rate type

the general (6) and shipment dimension (3). Customer (2) and rate (2) have the fewest attributes in the list. Two attributes from the list of ten with the highest evaluated show up determination (AWB provided and booking status) are not in the final list any more.

In summary, the following key aspects can be extracted from the survey: process and customer-related attributes play a major role for the show up determination followed by the commodity of the shipment as well as the booked product that are also evaluated as important. In contrast, rate-related attributes are not evaluated as valuable for the analysis. Taking the process value of the attributes into consideration, the number of attributes that are worth a further analysis can be reduced to 21.

CONCLUDING EVALUATION OF THE SIR-BASED APPROACH

The analysis showed that the concept as well as the success factors of the PNR-based overbooking can be transferred to the concept of SIR-based overbooking in the cargo environment. The SIR-based approach improves some flaws from the traditional, leg-based approach currently used by air cargo overbooking processes:

- The SIR-based no-show forecast is origin and destination, not leg based.
- It solves the problem of different capacity segments to overbook by focusing on the shipment rather than the different capacity segments. The question whether the booking is part of a certain capacity segment (eg allotment) is a parameter in the model.
- The forecast on shipment level is more intuitive and can also be used for monitoring processes beyond overbooking. A workflow could be defined that monitors all shipments that have a very low show up forecast. At a defined critical RD the sales staff can, based on this monitoring, contact the respective customers and actively ask whether the shipment will show up or not.

The revenue and forecast accuracy improvement potential of SIR-based overbooking compared to traditional cost-based approaches seem to be comparable to the PNR-based improvement on purely cost-based overbooking methods in the passenger overbooking. The validity of this assumption as well as the capability of the SIR-based approach to handle the ACRM complexities better than leg-based approaches have to be proven with real data experiments. Furthermore, the problem of finding the appropriate distribution for the show up behaviour description is not automatically solved with the SIR-based approach. The shipment level show up forecast, however, provides new possibilities to find an appropriate distribution that have to be analysed in regard to their improvement potential.

The SIR-based approach, however, still has some challenges to face, especially regarding the general complexities of ACRM. It will not be able to solve those problems but will handle the complexities at least as good as leg-based approaches. During the prototyping of a related workflow, it will turn out that the users have to think completely out of the box compared to current approaches. Steering with a leg-based approach that comes from a shipment-level forecast can increase the workflow complexity, especially when it comes to the override of certain values and their effect on the overall overbooking level.

SUMMARY AND OUTLOOK

Based on a comparison with the PNR success factors and the expert assessments, this paper showed that the SIR-based overbooking is a promising approach for new ACRM overbooking models. A definition of a shipment as well as of the SIR has been provided as a basis for future research and the theoretical parallels and differences to the PNR-based forecasting have been outlined. Furthermore, the results of an expert survey were presented that also underline the improvement potential of this new approach.

Further research is necessary to analyse real-world data with statistical and data mining methods in order to verify the parameter assessment of the expert survey. This must be followed by the evidence of the theoretical improvement potential with a prototype. Furthermore, the impact of the new approach on the workflow within the ACRM-overbooking process has to be analysed.

NOTE

1. Even if original Likert scales had been designed for ordinal measurement, treating Likert-like scale responses as interval data is well-established, especially in social sciences (see for example Sarantakos (2005)).

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