Improving the baggage connection process using the lean six sigma approach

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Abstract**—** This case study is a practical implementation of the Lean Six Sigma (LSS) method to improve on-time performance and specifically, reduce connecting baggage related delays at Kenya Airways. The project contributes significantly to the financial bottom and top lines as flight delays impact (1) direct ground handling operating costs, (2) passenger compensation costs and (3) so-called ñsoftò costs or lost revenue opportunities due to brand damage. Using the Define ï Measure ï Analyze ï Improve and Control (DMAIC) continuous improvement cycle the connecting baggage handling was identified as the main contributor to aircraft turnaround delays. The required data was then collected, tested and used to determine the process baseline performance. In a deep dive analysis, the root causes for process variation were identified, resulting in three main improvement areas: (1) out-station loading sequence determination, (2) baggage off-loading and (3) baggage loading. Three pilot cases studies are currently being executed to test solutions to (1) address the out-station loading sequence determination, (2) redesign the narrow body turnaround process to eliminate waste and (3) improve team work between baggage handling and ramp teams by aligning key performance indicators. Using the LSS improvement approach, Kenya-Airways has redesigned its baggage handling process to be better in line with it business model, serving a majority of connecting passengers. Delay costs analysis indicate that continuously improving the baggage handling process can save up to 7.5% of Kenya-Airwaysô delay-related costs.

Index Terms**—Lean Six Sigma, Baggage Handling, Airline Operations**

I. INTRODUCTION

The airline industry is extremely competitive, with notoriously small profit margins. Therefore, the industry requires to continuously improve its operations and reach for operational excellence. The LSS continuous improvement cycle is an excellent tool that enables airlines to control the right inputs to drive process improvements. This article provides a practical case study on how the Kenya Airwaysô ground services department applied the Lean Six Sigma continuous improvement cycle to improve on-time performance and reduce baggage connectivity delays at Jomo Kenyatta International Airport. The project is carried out using Define ï Measure ï Analyze ï Improve ï Control (DMAIC) improvement cycle. This article provides a detailed overview of the steps taken, the decisions made and full results of the project for the five phases of the DMAIC cycle.

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II. Define Baggage Handling Improvement Project

The starting point of the case study is twofold, namely the creation of customer value and the reduction of operational and opportunity costs. The project goal is defined during the Define phase and is the result of (1) the user satisfaction statement and (2) the operations delay cost analysis.

A. Defining Customer Value

The user satisfaction statement is used to determine what is Critical To Quality (CTQôs) for Kenya Airways (KQ) guests. This analysis includes three elements: (1) a *user needs* assessment, (2) an analysis of *opportunities to improve* and (3) an *industry benchmark* analysis.

From the user needs assessment shown in Figure 1, Kenya Airwaysô three main user needs are: (1) on-time performance, (2) a seamless guest experience, (3) a smooth and correct delivery of the check-in luggage.

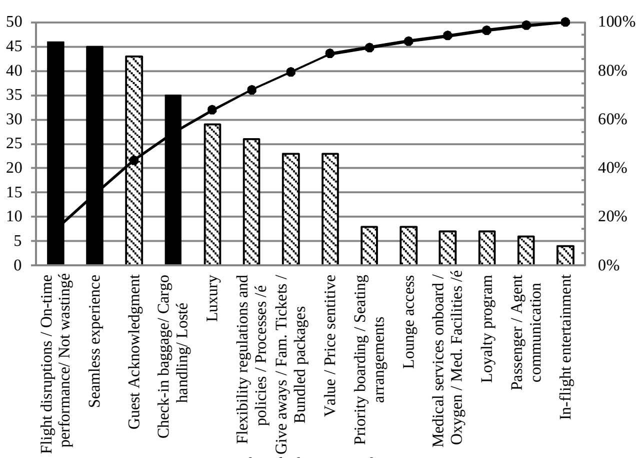

Fig. 1. User needs assessment. This Pareto analysis chart shows the score points of the Kenya Airways passenger needs. Solid bars are user needs addressed in this research. [1]

From the opportunities to improve analysis given in Figure 2, it is found that baggage handling is the most important area as it is the largest contributor (64%) to user complaints.

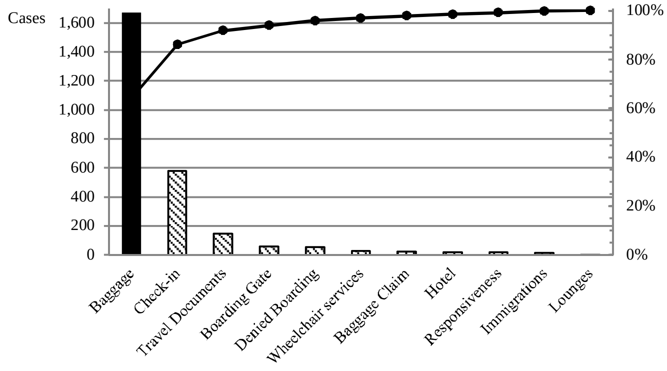

Fig. 2. Opportunities to improve analysis. This Pareto analysis of user complaints shows the main areas to improve from a customer perspective 11[2]

From the Skyteam service benchmark given in Figure 3 it is clear that Service Recovery process dealing with flight disruptions and missed connections as well as the Arrivals process where passengers are reconciled with their baggage are the two customer touch points where Kenya Airways achieve relatively the lowest scores of the Skyteam group.

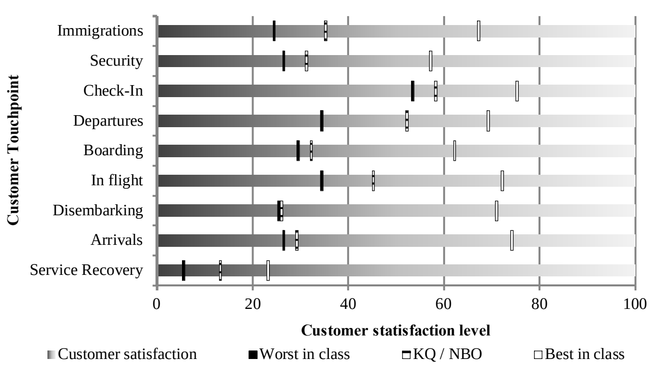

Fig. 3. Summary customer satisfaction benchmark airlines with the Skyteam group. This chart shows how Kenya Airways (KQ) and Nairobi (NBO) airport perform at each for all customer touchpoints in the passenger journey compared to the worst and best performer in the Skyteam group. [3].

From this customer value analysis, it can be concluded that both on-time performance and baggage performance are critical to quality for Kenya Airways guests.

B. *Defining business value*

Using a delay costs analysis based on the work of Omondi, 2012 [4] using the method described by Cook, 2012 [5] to ñevaluate the true cost to airlines of one minute é delayò, the cost-saving potential of continuous improvement of the related primary and reactionary baggage delays is 2.1 million USD. The cost-saving potential is calculated based on the actual endured delay minutes for the financial year 2015-16. This estimation includes: (1) delay related operational costs, (2) passenger compensation costs and (3) so-called ñsoftò costs, i.e. brand loyalty and lost opportunity costs. The total delay costs for Kenya Airways are estimated to be 28.1 million USD. Aircraft turnaround related processes represent 61% or 17.3 million USD of the total delay costs. Within this group, the highly related primary and reactionary baggage delays are the biggest contributors, which account for 0.5 million USD and 1.6 million USD respectively. When combined they represent 7.5 % of the total delay costs.

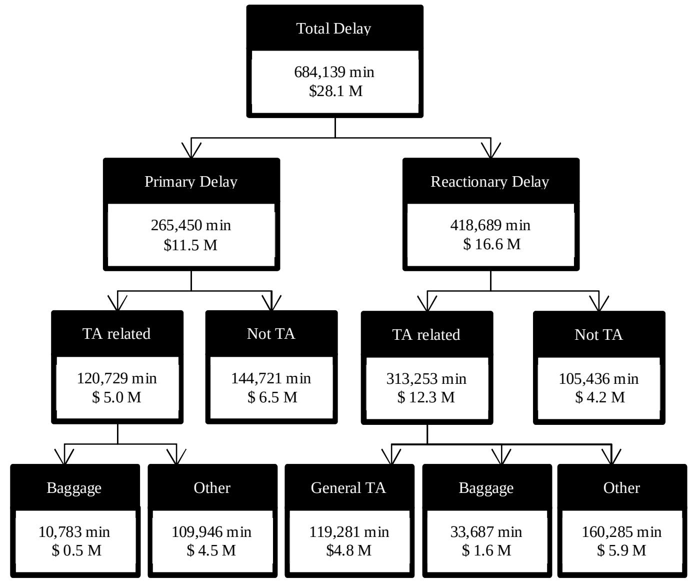

Fig. 4. Primary and reactionary delay cost breakdown while drilling down to aircraft Turnaround related and baggage related delays.

C. *Definition project goal*

From both the business and customer value perspectives, implementing a LSS continuous improvement method for baggage handling in order to improve the airlineĝs on-time performance makes strategic sense.

The project goal is defined as ñoptimizing the baggage connection process to significantly improve the financial performance of Kenya Airways by improving the airlineĝs on-time performance and reducing baggage related connectivity delays while improving the airline product to the customerò.

D. *Project Risks*

As major risks to the project planning, (1) scope changes, (2) data quality and (3) difficulties to implement solutions were identified. Until now, the poor data quality of the Flight Turnaround Application (FTA) and inaccessibility to the BRS time-stamp data required several mitigating actions. Both risks occurrences also reduced the initial 90% improvement target to 60%.

III. MEASURE: THE PROCESS BASELINE PERFORMANCE

During the Measure phase of the DMAIC cycle, required data is collected and tested on accuracy and stability in order to determine the current baseline performance of the baggage connectivity process.

A. *Data accessibility and quality*

Three main data sources are used to determine the baseline performance for OTP and baggage (off-) loading duration, namely: (1) the flight delay data provided via Sabre Movement Control, (2) measurement of the aircraft (off-) loading duration provided through timestamps records using the Flight

Turnaround Application, and (3) automated baggage processing timestamp data, which is measured automatically when bags pass through scanning points within the baggage sorting system. This data is provided through the Baggage Reconciliation System (BRS). Unfortunately, despite several attempts to acquire the BRS data, it remained inaccessible during the project without disproportional efforts by the project team and/or disproportional costs charged by third party data suppliers.

Concerning data quality, only the flight delay data achieve a first time pass for the accuracy and stability tests and is therefore qualified data to be used in statistical analysis and base the baseline performance upon. The FTA data however turned out to be of extremely poor quality. Both the accuracy and the stability tests were not passed for the unfiltered raw data. The human error and user-unfriendliness of the FTA handheld PDA measuring devices are the root causes of inaccurate measurements done by the turnaround coordinators. It is found that 10% of all measurements of the off- and loading activity had values between 0 and 5 minutes, which physically is clearly impossible for E190, B737 and B787 aircraft. To improve the FTA data quality a Data Quality Improvement Kaizen event was organized. This resulted in a 30% reduction of less than 5 minute measurements for the B787 and E190 fleets and 30% increase in less than 5 minute measurements for the B737 fleet. Additional statistical tests during the Kaizen event allowed filtering out the data taken by turnaround coordinators that consistently measure incorrectly. This allowed the project team to continue using the data and establish the baseline performance. However, it must be noted that the FTA data quality is extremely poor and is a major risk when used by ground services and network planning analysts if no proper data tests, data filtering or other data cleaning techniques are applied.

B. Current baseline performance

After the required data from the 2015-16 financial year has been gathered and tested on its accuracy and stability, the baseline performance for the project output was established. The project output is measured on two levels. The first high level project output is measured using the On-Time Performance Achievement metric, the number of days per year that the 0-minute and 15-minute OTP targets of 75% and 85 % are achieved. The OTP is translated in a second lower level metric, the number of delays, as a correlation exists between the number of primary/reactionary delays and the 15-min OTP (Figure 5).

TABLE I
OTP ACHIEVEMENT BASELINE PERFORMANCE

KPI	Best Performance Oct 2015	Average yearly performance FY 2015-16
Average 0-min OTP[1]	70%	58%
Average 15-min OTP[1]	84%	77%
0-min OTP target daily achievement	11 days, (35.5%)	46 days, (12.6%)
15-min OTP target daily achievement	16 days (51.6%)	91 days (24.8%)

[1]The 0-min and 15-min OTP measures the percentage of flights that departed within 0 and 15 minutes of their scheduled departure time.

Currently the OTP Achievement for the full FY 2015-16 for 0-minute and 15 minute targets, given in Table I, are 13 % (46 days/year) and 25% (91 days/year). The best monthly performance was achieved in October 2015, with 36% (11 days/month) and 52% (16 days/month) for the 0-minute and 15-minute OTP targets.

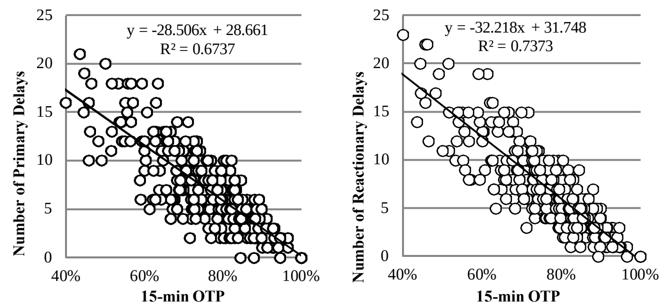

Fig. 5. Regression analysis between number of primary (left) and reactionary (right) delays and the on-time performance (OTP). Based on Kenya airways delay data period FY2015-16. [7].

The baseline performance and specification limits for the off-loading process of quick turnarounds (QT) are given in Table II. The E90 fleet used on domestic routes under QT conditions performs the worst with only 23% of its turnarounds within specification limits (20 minutes for off-loading). The B787 fleet achieved the best performance with 50% of the turnaround within the specification limit of 30 minutes off-loading duration.

TABLE II
AIRCRAFT OFF-LOADING BASELINE PERFORMANCE (FY 2015-16)

A/C	DOMESTIC INTERNAT.	SCHEDULED TA TIME	BASE LINE PERFORMANCE[1]	TARGET OFF-LOADING
E90	Domestic	45	23.4 %	20 min
E90	International	45	38.5 %	25 min
B787	Dom. + Int.	90	29.6 %	35 min
B737	Dom. + Int.	60	50.0%	30 min

[1]The base line performance measures the percentage of aircraft off-loadings which are executed within the target time for off-loading during quick turnaround conditions.

Similar to the off-loading performance, the loading performance under QT conditions is measured in Table III. Although slightly better, the aircraft loading performance ranges between 50% and 57% depending on aircraft type.

TABLE III
AIRCRAFT LOADING BASELINE PERFORMANCE (FY 2015-16)

A/C	DOMESTIC INTERNAT.	SCHEDULED TA TIME	BASE LINE PERFORMANCE[1]	TARGET OFF-LOADING
E90	Dom. + Int.	45	57.0 %	25 min
B737	Dom. + Int.	65	50.0 %	30 min
B787	Dom. + Int.	90	53.4 %	45 min

[1]The base line performance measures the percentage of aircraft off-loadings which are executed within the target time for off-loading during quick turnaround conditions

IV. ANALYZE ROOT CAUSES FOR VARIATION

Using statistical data analysis, field observations and LLS analysis techniques, numerous potential causes and stratification reasons for baggage delays are evaluated in order to find the root causes for variation in the aircraft (off-) loading processes.

A. Aligning baggage strategy with the business model.

From the delay minutesô analysis given in Figure 6 the largest contributor to baggage related aircraft turnaround delays are reactionary load connection delays. Furthermore, positioning of connecting baggage results in twice as many delays minutes than the positioning of departing bags. From this observation together with the knowledge that the largest user need is OTP and the fact that Kenya Airwaysô business model revolves around ñ*connecting Africa to the world and the world to Africa*ò, it becomes apparent that Kenya Airways requires a ñconnectionsò oriented baggage handling strategy. As such the current ñterminatingò baggage strategy, which is focused on the First Bag/Last Bag (FiBAa/LaBa) principle, is a major cause for baggage connection delays and Kenya Airways inability to recover inbound delays in its Nairobi hub. As this case study will point out, this is due to the misalignment of key performance indicators between the Baggage Handling Reconciliation (BRS) and Ramp teams.

B. Analyzing the root causes for delays.

The backbone of the analysis is a deep dive investigation into the delay codes and minutes of the financial year 2015-16, given in Figure 6. The top five delay reasons for baggage related delays at Kenya Airways are: (1) load connection (RL), (2) inadequate turnaround time (SG), (3) late completion of loading (GL), (4) late positioning of connecting bags (BC) and (5) rotation due to baggage related (RL) delays. The top five reasons amount to 42,163 minutes annually and represent 87% of all baggage delays. The single largest contributor is load connection (RL) delays with 32,163 minutes annually or 67% of the total baggage delays. However, it must be noted that the RL delays are affected by both connection baggage as well as passengers. Because of being the largest contributor, the analysis is strongly focused on RL delays although the full spectrum of baggage delays is analyzed.

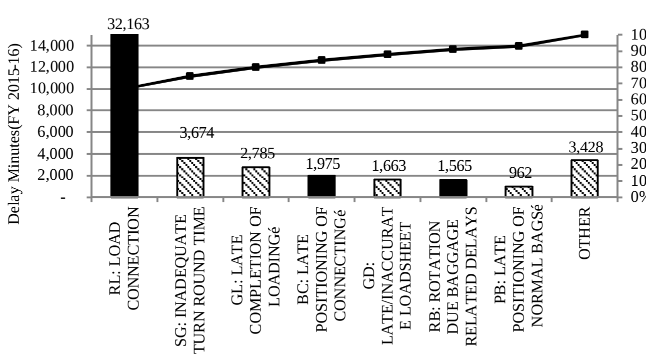

Fig. 6. Pareto analysis of the major contributors to baggage related turnaround delays. [7]

Using a cause and effect diagram in combination with a cause and effect correlation matrix a prioritization (Table IV) of root causes was established which can be mainly classified in four areas four improvement: (1) outstation loading (30%), (2) NBO aircraft off-loading (24%), (3) NBO aircraft loading (23%) and (4) flight planning (11%) as shown in Figure 7.

TABLE IV
ROOT CAUSES PRIORITIZATION

CAUSES	SCORE
No connecting baggage time target (FiCo/LaCo)	251
Inefficient use of Trolleys, Dollies, confined space off-loading	228
MCT information availability to determined loading sequence	227
Late arrival connecting bags	198
Conflict priorities BRS and Ramp team, sorting at AC side	195
Accuracy loading diagram	192
Insufficient use critical flight connections information	188
HotCon/ShoCon baggage position in aircraft	181
Planned ground time to short	170
Number of equipment operators	163
Priority between ShoCon/LongCon and Sky Priority bags	161
Transportation duration	158
Outstation OTP	142
Inefficient use of trolleys, dollies during loading,	139
MCT vs ground handling confidence	117
Planned Quick Turnaround time to short	112
Other	112

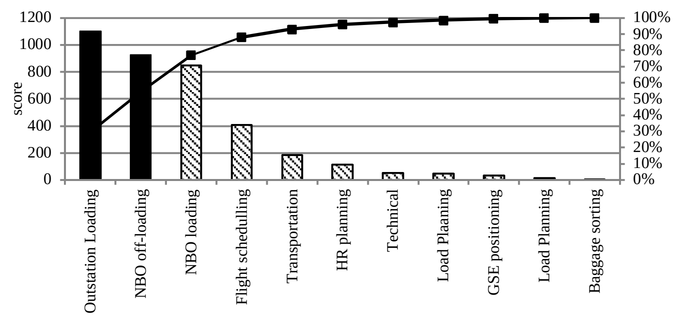

Fig. 7. Root cause categorization per are of improvement. The score is calculated using the cause and effect matrix, where causes are related to the effects (types of delay given in Figure 6). A higher score indicates that the cause has a higher impact. The solid bars represent the focus areas for the lean six sigma case study and pilot case study.

The fact that Kenya Airwaysô baggage handling strategy is not fully oriented towards connections is further illustrated by the impact of the main inbound trader routes typically between Dubai and West-African destinations and between Mumbai and Johannesburg. Currently the four most critical inbound flights, KQ311, KQ205, KQ211 and KQ765, represent 45% (Figure 8) of all load connection delays.

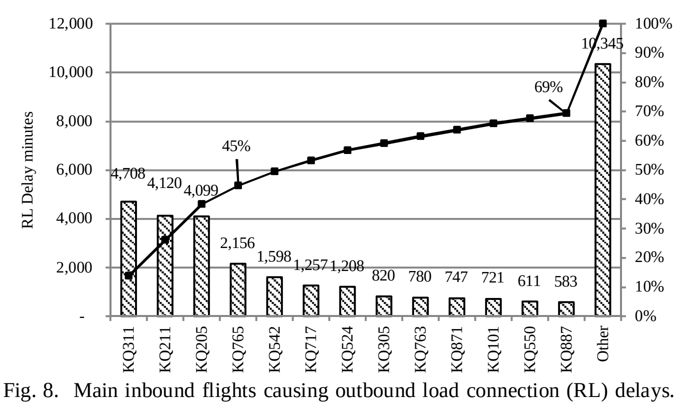

Fig. 8. Main inbound flights causing outbound load connection (RL) delays. The majority al the RL delays is caused on the typical ñtraderò routes.

The 12 most critical inbound flights represent 69% of all load connection delays. Many of these destinations are part of the typical ñtrader routesò between Dubai, Mumbai, West Africa or Johannesburg. Trader passengers typically check-in large amounts of excess luggage, easily up to 100 bags per trader. Due to the large amount of connecting baggage these trader routes are very prone to load connection delays. Currently KQ211 from BOM connecting with KQ764 to JNB experiences delays on 24% of its scheduled connections. Connections from KQ311 (DXB) to KQ542 to West Africa even 31%.

C. Influence of aircraft loading sequence on baggage delays

The out-station loading is the first and most important area of improvement, as it is at this stage in the connection process that the position of the connecting baggage is determined. A connection oriented load plan and loading sequence at the out-station allows Nairobi ground services to off-load connection baggage first, before offloading terminating baggage and gives them the largest potential to recover inbound delays and reduce reactionary delays. Within the out-station loading process the three root causes which determine the position of the connecting baggage are: (1) insufficient use of critical NBO outbound flight information, (2) insufficient use of minimum connection time (MCT) information and (3) a priority conflict between connecting and terminating baggage.

Knowing the critical inbound-outbound flight connections is essential in determining which connections results most often in delays. From the analysis it is found that the (1) relatedness (the amount of connecting bags between inbound and outbound flight) as well as the (2) critically (a measure of the shortness of the MCT) must determine the position of the connecting bags. That the MCT has a critical effect on RL delays is statistically proven to the extent that RL delays are twice more frequent on 50 minutes versus 65 minutes MCT connections, as can be seen in Fig 9. These are essential inputs for flight planning.

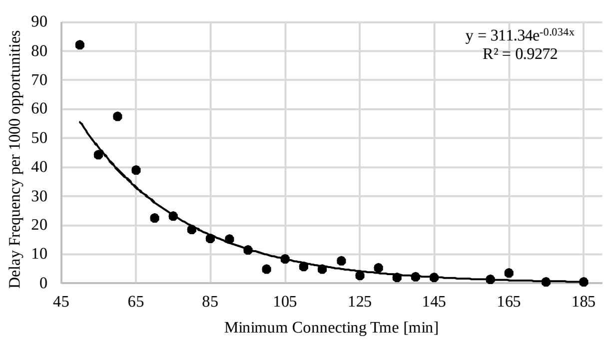

Fig. 9. Relationship between delay frequency and minimum connection time

Currently the heavy loads connections are well monitored and used as guidance for the load plan, as typically connection between Dubai and West Africa as well as the Mumbai and Johannesburg with short to medium connection times make use of pre-sorted hub containers. However, it is often observed that very short MCT connections with lower amounts of connecting bags are also very prone to connecting baggage delays as they are often significantly spread out between different baggage containers (ULD) or spread around the bulk loaded cargo holds.

In addition, a trend is observed between the length of the RL delays, which tends to be longer depending on the position of the connecting baggage in the aircraft as can be seen in figure 10.

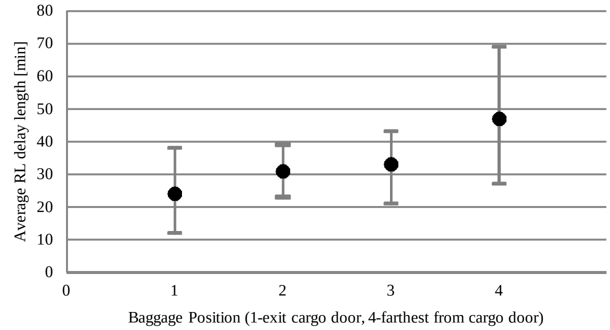

Fig. 10. Relationship average RL delay with baggage position inbound flight (DXB, B787); 95% Confidence interval for the mean

D. BRS and Ramp team target misalignment, non-maximising of manoeuvring space and inefficient use of baggage trolleys impacts NBO off-loading performance.

The second most important area of improvement is the NBO baggage off-loading process. The two main root causes which cause delays during the off-loading process are: (1) the confined space at the forward cargo hold during off-loading and (2) the conflict of KPIôs between BRS and the Ramp teams. The confined off-loading area around the conveyor belt is a major issue, as precious minutes are lost in order to manoeuver baggage trolleys back and forth. This excessive manoeuvring is the result of inefficient positioning of the baggage trolleys and the interference with the catering truck.

Fig. 11. Illustration of the confined space during baggage off-loading which hampers the maneuvering of the baggage trolleys.

The off-loading space is further confined due to the KPI conflict between the BRS team and Ramp team as both teams focus respectively on connection baggage and terminating baggage. Currently the BRS teamôs performance is measured using the Bags Misconnections (BM) target for connecting baggage and the Ramp teamôs performance is measured using the First Bag/Last Bag (FiBa/LaBa) target for terminating baggage. Consequently, both teams are mainly focused on their own target. This results in excessive baggage movement around the conveyor belt, baggage trolleys and the extra BRS van to transport Hot Connection (HotCon) and Short Connection (ShoCon) baggage pieces. This proves that the KPIs for both teams are misaligned. The BM and FiBa/LaBa KPIs cannot be directly compared to each other as they measure different things in different units. A so called First

Connecting/ Last Connecting bag (FiCo/LaCo) on the sorter belt can solve the misalignment as it measures the connecting baggage performance in a similar manner to the FiBa/LaBa. As such setting targets for FiBa/LaBa and FiCo/LaCo should be set in line with a connection oriented ñbaggage connectionò strategy. The BM KPI should instead be used as a result indicator whether the connections are actually achieved.

Fig. 12. Waste due to excessive movement of bags due to conflicting key performance indicators between Ramp and BRS teams resulting in unnecessary baggage sorting at the aircraft stand.

E. Late positioning of connecting baggage main driver loading delays

The third area of improvement is the NBO loading process. The main root causes identified affecting the loading process are: (1) late arrival of connecting bags, (2) no time target for connecting baggage (FiCo/LaCo) and (3) inefficient use of trolleys during loading. As the loading process is the last process in the row for connecting baggage between flights, it comes as no surprise that root causes related to the ñconnection baggageò strategy boil down to the loading of the aircraft in the form of late positioning of connecting baggage. Statistics show that ópositioning of connecting baggageô delays result in about double the amount of delay minutes than delays due to positioning of normal ódeparting baggageô. Obviously the terminating NBO baggage is not causing any connecting delays anymore. This again highlights the need to align connection and terminating baggage priorities to reduce baggage related delays in order to improve OTP.

F. Ground time confidence enables robust flight planning

The last area of improvement regarding the baggage related delays involves flight planning. From the regression analysis between MCT and RL delay frequency shown in Figure 9, it is clear that increasing the MCT lowers the amount of RL delays, especially for connections with an MCT below 55 minutes. This observation in combination with the low baseline performance for the (off) loading activities, makes it questionable whether the flight planning department is sufficiently using the ground time confidence. Similar to the block time confidence, the ground time confidence is an important metric for flight planning purposes, as they both drive the aircraft utilization and airline profitability. However, as the MCT analysis proves, planning shorter MCT times has an exponentially negative impact on connection delays.

V. Improve The Baggage Handling Process

Once the root causes for variation in the baggage (off-) loading processes are determined Kenya Airways is able to develop improvement strategies to align the baggage handling strategy to its business model. Finding these improvements is the focus of the Improve Phase, during which the LSS team defined the strategy to tackle the first two main areas of improvement: (1) out-station loading and (2) NBO off-loading. A pilot case is executed focussing on the two of most critical flights, KQ311, and KQ305, both originating from Dubai.

A. Generating and benchmarking potential solutions

Using several solution generation techniques, a total of 13 potential solutions were generated and evaluated against 7 criteria weighted using the analytical hierarchical process (AHP) matrix given in Table V.

TABLE V
ANALYTICAL HIERARCHICAL PROCESS SOLUTION EVALUATION CRITERIA

	Speed	Costs	Technical ease	No additional techniquesé	Potential safety risks	Acceptance of solution	Impact on CTQ	Relative weight	Weight calculation
Speed	1	6	1/6	9	9	1/7	1/9	1.3	5
Costs	1/6	1	1/5	6	1/9	1/7	1/9	0.3	1
Technical ease	6	5	1	3	1/9	1/6	1/9	0.5	2
No additional techniques /data required	1/9	1/6	1/3	1	1/9	1/6	1/9	0.1	1
safety risks	9	9	9	9	1	3	3	2.1	9
Acceptance	7	7	6	6	1/3	1	1/6	0.9	4
Impact on CTQ	9	9	9	9	1/3	6	1	1.9	8
	32	37	25	43	11	10	4.6	7	30

[1] The analytical hierarchical process is used to determine the pilot evaluation criteria against each other.

Through the benchmarking the solution against each other using the PUGH, 1990 [10] method, a prioritised solution list is established as given in Table VI. Several solutions were combined in three different pilot cases shortly outlined in Table VI.

TABLE VI
SOLUTION PRIORITIZATION

Priority	Solution
Priority 1	Redefine BRS RAMP team priority during off-loading
Priority 2	Loading communication via BMS
Priority 3	Compliance loading sequence outstation
Priority 4	BRS monitoring load diagram and give feedback on loading plan
Priority 5	Dedicated non-trader (Shocon lighter connections)
Priority 6	Implement FiCo LaCo
Priority 7	Ground time confidence assistant
Priority 8	K1 to Expedite HotCon Shocon trolley to sorter
Priority 9	Loading sequence calculator
Priority 10	Optimizing trolley positioning during off-loading
Priority 11	Transportation time targets
Priority 12	Trolley positioning instructions (loading)
Priority 13	Catering starts at rear left door

[1] A all solutions are benchmarked against each other using the Pugh method [10].

B. Pilot 1: Improve out station loading sequence.

The goal of pilot 1 is to optimize the loading at out-station based on MCT and critical connections and improve the loading diagram compliance, accuracy and the correct communication of information between out-station and hub.

By implementing the newly preferred loading sequence as shown in figure 6 the following root causes were addressed: (1) preferred loading sequence compliance, (2) correct use loading diagram (bags place in right hold/ULD), (3) loading sequence communication between outstation and hub, (4) use the critical flights connections and MCT knowledge in NBO, (5) interchange baggage Priority 1 to connecting bags and Priority 2 for terminating baggage and (6) Hotcon & ChoCon bags spreading over the aircraft holds.

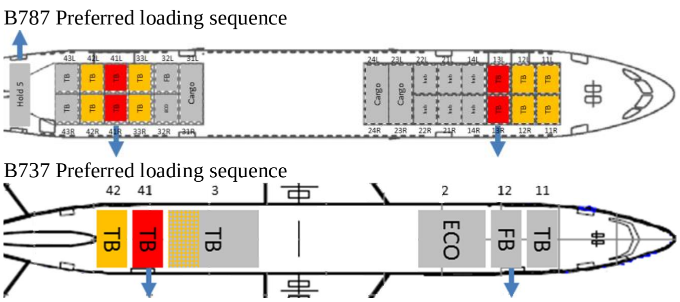

Fig. 13. Preferred Loading Sequence during pilot phase where HotCon and ShoCon baggage are given priority over terminating local baggage in order to be off-loaded first. (red TB: HotCon bags, MCT<50 min; orange TB: ShoCon bags, 50 min < MCT < 80 min, TB, Transfer bags MCT > 80 min; HUB Transfer bags for one dedicated flight; ECO terminating economy bags; FB, terminating business class and Sky Priority bags. Amended Figures Boeing [8],[9]

C. *Pilot 2: Improvement of NBO confined off-loading space.*

The goal of pilot 2 is to eliminate excessive manoeuvring of trolleys around the conveyor belts to speed up off-loading of connecting baggage. This pilot addresses the following root causes: (1) excessive manoeuvring of baggage trolleys and (2) conflict with catering truck at forward hold during critical off-loading phase. The pilot redesigned the off-loading process for the B737 fleet as can be seen in figures 14 and 15 for the old and new situations.

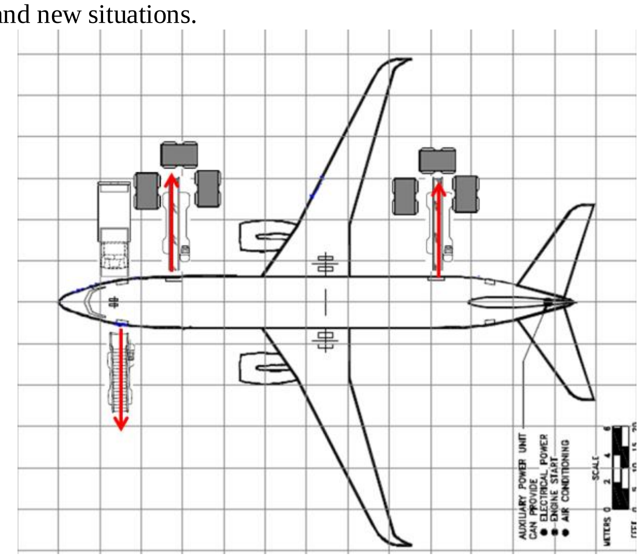

Fig. 14. Old situation B737 off-loading Amended Figure Boeing [8]

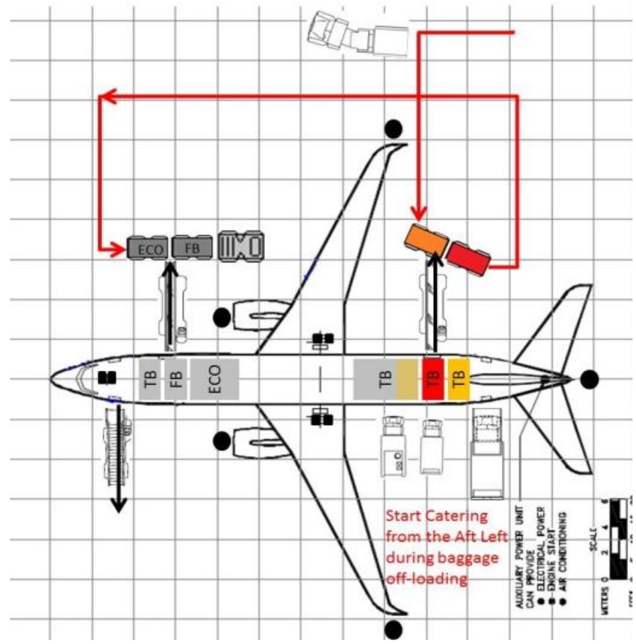

Fig. 15. B737 New off-loading process. Amended Figure Boeing [8]

D. *Pilot 3 Improvement of the BRS and Ramp teamwork:*

The goal of pilot 3 is to avoid excessive baggage movement during the aircraft off-loading process by aligning the KPIȍs of both teams to focus on connecting baggage before terminating baggage. This is achieved during the pilot case through new guidelines to prioritize the off-loading of HotCon and ShoCon connecting bags over the terminating sky priority and economy baggage in combination with temporarily removing the FiBA/LaBa and baggage connectivity targets. The combination of these new guidelines combined with the relaxation of KPIȍs resulted in improved teamwork during the B737 off-loading process. Figure 8 is a clear example of the improved teamwork and reduced baggage movement waste, which contrasts significantly with figure 5 as the need for baggage sorting at the aircraft side is eliminated during the pilot case.

Fig. 16. Improved teamwork during B737 off-loading and trolley positioning

E. *Reduction of Baggage Connectivity Delays*

All three pilot cases are tested simultaneously on flights KQ311 (B787) and KQ305 (B737) originating from Dubai. The results of the Dubai pilot implementation are given in Table VII which show a statistically significant overall RL delays reduction of 65%. Even when taking into account the improvement of 24% achieved in the control group (Table IX), the result of the Dubai case remains significant.

TABLE VII
CASE STUDY RESULTS: CONNECTIVITY DELAYS REDUCTION

	CBA CONFORMITY	BEFORE [RL DELAYS PER WEEK]	AFTER [RL DELAYS PER WEEK]	CHANGE [%]
All DXB flights	77%	6.7	2.3	-65%
KQ311,	79%	5.7	2.3	-59%
KQ305,	75%	0.9	0	-100%
Control Group[1]	NA	18.3	13.7	-24%

[1] The Control group exist of all other flights with the exception of BOM flights KQ211 and 205 as during the pilot period the ground handler was replaced in Mumbai.

From Figure 17 and the process statistics in Table VIII it can be seen that the improved process achieved a statistically significant reduction in RL delays while at the same time the trend is observed that also the variation reduces.

TABLE VIII
CASE STUDY RESULTS: REDUCTION OF RL DELAYS KQ311

KQ311			
STATISTICS (KQ311)	BEFORE	AFTER	CHANGE
Mean (delays/week)	5.65	2.25	-60%
StDev(overall)	3.55	1.25	-2.29
ACTUAL CAPABILITY	BEFORE	AFTER	CHANGE
Z.Bench	-0.13	1.75	1.88
% Out of Spec	55.08	3.99	-51.08
DPMO[1]	550,756	39,934	-510,822
HYPOTHESIS		P-VALUE	ANSWER
H_0 = Did the process mean change?		0.003 < 0.05	YES
H0 = Was the process standard deviation reduced?		0.059 < 0.1	TREND

[1] Defects per million opportunities

TABLE IX
CASE STUDY RESULTS: REDUCTION OF RL DELAYS CONTROL GROUP[2]

CONTROL GROUP[2]			
STATISTICS (KQ311)	BEFORE	AFTER	CHANGE
Mean (delays/week)	18.06	13.75	-23.8%
StDev(overall)	9.24	3.59	-5.64
ACTUAL CAPABILITY	BEFORE	AFTER	CHANGE
Z.Bench	-1.51	-2.24	-.073
% Out of Spec	93.48	98.75	5.27
DPMO[1]	934,821	987,515	+5.6%
HYPOTHESIS		P-VALUE	ANSWER
H_0 = Did the process mean change?		0.108 > 0.05	NO
H0 = Was the process standard deviation reduced?		0.087 < 0.1	TREND

[1] Defects per million opportunities
[2] Control group includes all flight exclusive KQ311 and KQ305

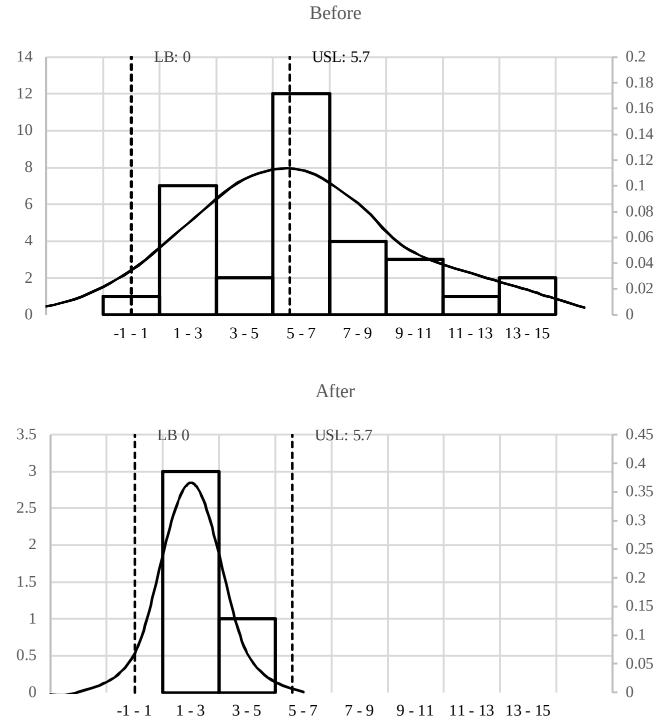

Fig 17. RL delay per week distribution before and after pilot implementation reduction related to flight KQ311.

When further taking into consideration the current level of Connecting Baggage Accessibility (CBA) Conformity, or with other words the level in which the out station loading sequence is executed in conformity with the new loading instruction to ñLoad HotCon ShoCon at door areaò, the full potential of the improved connecting loading sequence becomes apparent as shown in Figure 18. A 100% CBA Conformity corresponded during the pilot phase to a RL delay reduction of 83% for KQ311 using the B787 aircraft.

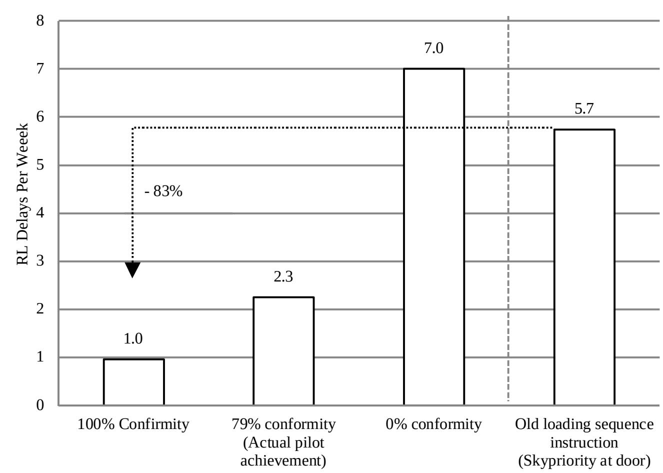

Fig 18. Average RL delays per week (KQ311, B787); full bars: "HotCon ShoCon at door"; shaded bars " Sky Priority at door". The breakdown of the pilot results for KQ311, the average number of RL delays per week is calculated based on whether the loading sequence was executed conform the new Connecting Baggage Accessibility instructions.

F. On-time Performance Improvement

As the number of delays decreased during the pilot case, also the on-time performance of the HotCon and ShoCon connections related to flight KQ311 improved as shown in Table X and Figure 19. The p value of the process mean change, which is less than 0.05, proves that the process improvement is statistically significant.

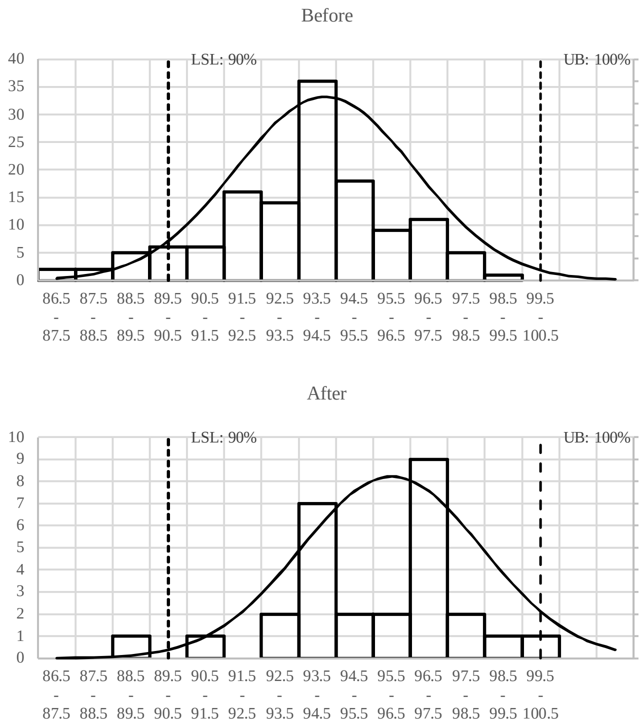

Fig 19. Daily on-time performance distribution HotCon ShoCon Connections related to flight KQ311. A shift in mean after pilot implementation indicates a 1.78% improvement.

TABLE X
CASE STUDY RESULTS: ON-TIME PERFORMANCE IMPROVEMENT

STATISTICS	BEFORE	AFTER	CHANGE
Mean	93.71%	95.49%	1.78%
StDev(overall)	2.41	2.47	0.06
ACTUAL CAPABILITY	BEFORE	AFTER	CHANGE
Z.Bench	1.49	1.67	0.11
% Out of Spec	6.82%	4.73%	-2.09%
DPMO[1]	67,174	47,272	-20,902
HYPOTHESIS		P-VALUE	ANSWER
H_0 = Did the process mean change?		0.001 < 0.05	YES
H_0 = Was the process standard deviation reduced?		0.555 > 0.05	NO

[1] Defects per million opportunities

G. Impact on First Bag Last Bag Terminating Baggage

From the results it can be seen that the ñconnecting baggage strategyò had no statistically significant impact on both FiBa and LaBa for Sky Priority Bags. The connecting baggage strategy does slightly increase the FiBa for economy passengers. This result is in line with a similar deterioration for the FiBa for the control group. Furthermore, taking into account the average waiting time at immigrations of 12.3 min, Goethem 2012, [6] at Jomo Kenyatta International Airport, this increase represents a marginal deterioration of the actual baggage waiting time for economy passengers. Interesting is that the LaBa for economy passengers shows an improvement trend of about 7 minutes, whereas the control group did not show any significant change in LaBa for economy passengers. Therefore, it can be concluded that the new ñconnecting baggage strategyò has no significant impact on the Sky Priority FiBa/LaBa, but it does achieve an Improvement trend for Economy passengers. The improvement is a clear result that the BRS and Ramp teamwork is more synchronized after the pilot than before.

TABLE XI
CASE STUDY RESULTS: IMPACT ON FIBA/LABA[1] TERMINATING BAGGAGE

GROUP	BEFORE	AFTER	DIF.	SIGNIFICANT CHANGE[2]
DXB FIBA Sky priority	17.6	22.1	4.5	**NO 0.106** > 0.05
Control FIBA Sky priority	15.9	16.7	0.8	**YES 0.031** < 0.05
DXB LABA Sky priority	31.2	31.1	-0.1	**NO 0.977** > 0.05
Control LABA Sky priority	19.8	19.7	-0.1	**NO 0.869** > 0.05
DXB FIBA Eco	16.0	21.5	6.4	**YES 0.015** < 0.05
Control FIBA Eco	16.2	16.8	0.6	**YES 0.048** < 0.05
DXB LABA Eco	41.0	34.0	-7	**TREND 0.1** <=0.1
Control LABA Eco	23.5	23.5	0.0	**NO 0.904** > 0.05

[1] First bag / last bag arriving on the arrival belt of terminating passengers in Jomo Kenyatta International Airport
[2] P-value Hypothesis H_0 = Did the process mean change?

VI. CONTROL THE BAGGAGE HANDLING PROCESS

The last phase in the DMAIC improvement cycle is to control the improved process by setting up a control plan to sustain the improvement and to share best practices network wide. As a LSS project is a continuous cycle a discussion is provided in this section which points out new process input for future monitoring.

A. Setting up a control plan

The proposed control plan to monitor the improved process is given in Table XI and includes four vital input (Xôs) factors and three output (Yôs) measures. In the improved process the two main input factors are the Connecting Baggage Accessibility (CBA) compliance and the Loading Sequence Communication compliance. By using the control mechanisms mentioned in Table X, it now becomes possible for Kenya Airways to keep the number of baggage connectivity delays under control as shown in Figure 20 and increase the airlineôs on-time performance.

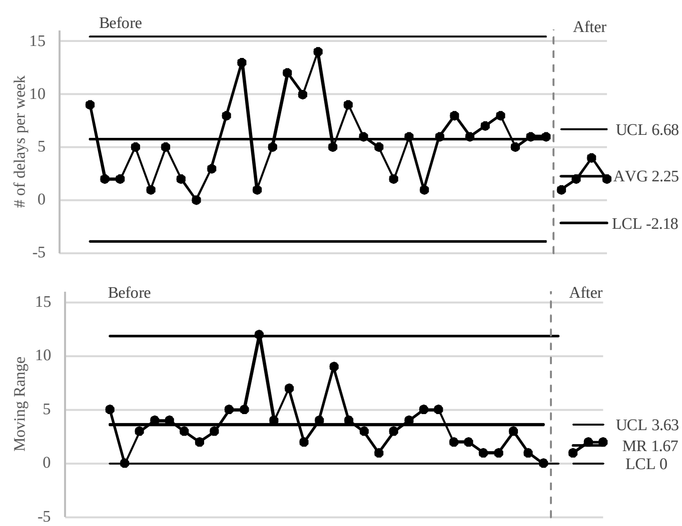

Fig. 20. KQ311 Control chart for number of RL delay before and after

TABLE XI

CONTROL PLAN

WHAT MUST BE CONTROLLED?	DEPARTMENT / INDIVIDUAL	PROJECT Y OR X	REQUIREMENTS (SPECS)	ONGOING CONTROL MECHANISMS
15-min OTP:	Performance Monitoring Department	Y1	85%-100%	1. Control Charts
# RL delays per flight	Performance Monitoring Department	Y2	KQ311: 0-2.25 KQ305: 0-1	1. Control Chart
Bags Misconnection	BRS Team	Y2	<0.05%	1. Control Chart
CBA compliance:	Outstation team	X	80%-100%: Target: >90%	1. Confirm outstation officer roles and responsibilities 2. Use control charts to communicate achievement to team 3. Document new preferred loading sequence visually in Ramp Handling Manual
LSC compliance:	Outstation team	X	90%-100% Target 95%	1. Confirm outstation officer roles and responsibilities 2. Use control charts to communicate achievement to team
FiBa Sky priority Economy LaBa Sky priority Economy	Ramp Team	X	 15 min 25 min 20 min 35 min	1. Align FiBa/LaBa and FiCo/LaCo targets to determine "connecting" or "terminating" baggage strategy 2 Document targets in Ramp Handling manual in line with strategy. 3. Use control charts to communicate achievement to team
FiCo (New) Sky priority Economy LaCo (New) Sky priority Economy	BRS Team	X	 10 min 20 min 10 min 20 min	1. Align FiBa/LaBa and FiCo/LaCo targets to determine "connecting" or "terminating" baggage strategy 2 Document targets in Ramp Handling manual in line with strategy. 3. Use control charts to communicate achievement to team

It is important to note that the improvement of the baggage handling connectivity was achieved during the pilot mainly because the teamwork between the BRS and Ramp teams improved. Teamwork was improved by temporarily relaxing their respective KPIs for; (1) Bags Misconnections and (2) the FiBa/LaBa This allowed to work as one team on first off-loading the HotCon and ShoCon bags before any terminating baggage. This clearly shows that a need exists to align the teams performance indicators such that they work together on one target at a time. Therefore, it is proposed, when the automated baggage timestamp data (BRS data) becomes accessible, to introduce the FiCo/LaCo input metric in order to control the BRS teamꞌs performance, in line with the FiBa/LaBa to control the ramp teamꞌs performance. By balancing both targets for FiBa/LaBa and FiCo/LaCo the right balance can be made between applying a strategy focused on connecting baggage and one focusing more on terminating baggage. Future research is proposed to investigate what the adequate target settings need to be.

VII. CONCLUSIONS

In this case study the Lean Six Sigma (LSS) method is used to improve the on-time performance by improving the baggage connectivity through significantly reducing reactionary load connection delays. The case study proves that a systematic focused continuous improvement method is able to find root causes for large interdepartmental problems.

The main take-away from the case study and the LSS framework is that it helps airlines to drill down starting from the critical to customer quality metrics (CTQ) the desired project outputs (Yꞌs), the process inputs (process Xꞌs) to the vital process inputs (input Xꞌs). As such, Kenya Airways has been able to improve its customer value by reducing its flight disruptions (CTQ) by improving its on-time performance (Y1) and baggage connection delays (Y2). This is achieved by improving the outstation loading and NBO off-loading processes (Process Xꞌs). Kenya Airways is now able to control the connecting baggage process though the monitoring the Connecting Baggage Accessibility and Loading Sequence Communication Compliance, the Input Xꞌs).

Using the LSS framework it was possible to determine the main root causes resulting in baggage connectivity delays. For the specific case of Kenya Airways, the largest root cause was the misalignment of Key Performance Indicators (KPI) between the Ramp and Baggage Reconciliation teams. The Ramp team being responsible for baggage off-loading is appraised using the ñFirst Bag Last Bag arrival on the airport arrival beltò principle. Whereas the Baggage Reconciliation team is appraised using the Bags Misconnections KPI. This leads to two teams fighting each other to achieve their KPI with a significant process waste as a result, in terms of excessive baggage movements, trolley maneuvering and baggage sorting in the confined space around the aircraft cargo holds. This process waste was even augmented through loading sequence miscommunication and an ambiguous out-station baggage loading sequence as Nairobi Hub teams were both requesting to have Sky Priority and Hot and Short Connection bags to be placed close to the cargo door for quick off-loading.

The three proposed pilot cases to (1) improve outstation loading sequence compliance and communication, (2) improve the Nairobi off-loading process and (3) improve the Ramp and Baggage Reconciliation teamwork, were implemented and evaluated for inbound flights from Dubai. The results are positive and show a 65% reduction of load connection delays. However, if the Connecting Baggage Accessibility compliance was further improved an improvement potential of 83% can be achieved. The reduction in RL delays corresponded with a statistically significant increase of 1.8% in on-time performance for Hot and Short Connections. Furthermore, the results show that the improved connecting baggage strategy and team work benefitted terminating economy passengers as an improved trend is observed for the time it takes for the last bag to arrive on the arrival belt.

This case study is the first step in the continuous improvement effort for baggage connectivity. It is now important for Kenya Airways to make decisions based on the results of the case study to strike the right balance between a connecting and terminating baggage strategy aligned with its hub and spokes business model. The new Connecting Baggage Accessibility metric can be used to control the process. However, it is proposed for further improvement to investigate the introduction of a First Connecting Bag, Last Connecting Bag (FiCo/LaCo) on the sorter to further align key performance indicators with the correct baggage strategy matching Kenya Airwaysô business model.

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