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Musculoskeletal ill-health risks for airport baggage handlers

Report on a stakeholder project at East Midlands Airport

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Research Report

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Report on a stakeholder project at East Midlands Airport

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In Great Britain the majority of baggage handling is contracted out from the airline to ground handlers and is often viewed as a 'stand alone' part of the aircraft turnround process. Little consideration has been given to the design and working of the interface between the aircraft (airline carrier), airport (operator), handling equipment (supplier/manufacturer) and those persons undertaking the baggage handling work (ground handlers). Unless these factors are dealt with at an early stage, there is often little or no opportunity for the ground handler to address and reduce the risks. Fully effective risk reduction during the baggage handling activity will only be achieved if all the parties involved actively work together.

This report describes the work undertaken to gather further information on the musculoskeletal ill-health risks associated with baggage handling operations and to appraise the efficacy of new Extending Belt Loader (EBL) technology. The GB aviation sector health and safety steering group (Revitalising Health and Safety in Air Transport - RHSAT), which includes the HSE, identified the requirement for a working partnership. Staff from the HSE, HSL, East Midlands Airport (EMA), Menzies Aviation, Servisair, EasyJet, BMI Baby and the Civil Aviation Authority (CAA) formed a collaborative working group to take this work forward. The evidence presented in this report, and other studies including previous work by the HSE (Tapley & Riley, 2005 and Riley, 2008) provide a strong case for this task to be re-designed or mechanised to reduce the risk of injury.

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EXECUTIVE SUMMARY

In Great Britain the majority of baggage handling is contracted out from the airline to ground handlers and is often viewed as a ‘stand alone’ part of the aircraft turnround process. Little consideration has been given to the design of the interface between the aircraft (airline carrier), airport (operator), handling equipment (supplier/manufacturer) and those persons undertaking the baggage handling work (ground handlers). Unless these factors are dealt with at an early stage, there is often little or no opportunity for the ground handler to address and reduce the risks. Fully effective risk reduction during the baggage handling activity will only be achieved if all the parties involved actively work together.

This report describes the work undertaken to gather further information on the musculoskeletal ill-health risks associated with baggage handling operations and to appraise the efficacy of new Extending Belt Loader (EBL) technology. The GB aviation sector health and safety steering group (Revitalising Health and Safety in Air Transport - RHSAT), which includes the HSE, identified the requirement for a working partnership. Staff from the HSE, HSL, East Midlands Airport (EMA), Menzies Aviation, Servisair, EasyJet, BMI Baby and the Civil Aviation Authority (CAA) formed a collaborative working group to take this work forward. The evidence presented in this report, and other studies including previous work by the HSE (Tapley & Riley, 2005 and Riley, 2008) provide a strong case for this task to be re-designed to reduce the risk of injury.

OBJECTIVES

1. Agree a definition for the narrow-bodied aircraft of concern;

2. Collect and record weight/frequency data of the baggage handled;

3. Review current handling methods and assess associated levels of risk of injury;

4. Evaluate new extending belt technologies.

MAIN FINDINGS

Baggage handling methods risk comparison

The assessment of the current baggage handling methods identifies a number of manual handling related factors, which expose a significant proportion of the working population to the risk of injury. This includes the vertical height and distance of the lift, the horizontal distance of the hands from the lower back, trunk twisting and sideways bending, postural constraints and the grip on the load (HSE, 2004). The potentially high load weights combined with the frequency of handling also contribute to the risk of injury.

A comparison of the risk ratings of five different baggage handling methods indicates the following hierarchy of risk, starting with the lowest:

1. ***EBL type technology*** – There is a risk reduction for the external worker in terms of postural improvement for an EBL with a height adjusting and extending belt, however, for other EBLs without this capability the risk is the same as that for a conventional belt loader. There is a considerable risk reduction for the internal worker through the automation of the transfer of the bags down the hold, the reduction in lifting required, and the posture when lifting.

2. ***Beltloader*** – The vertical lift region when using a belt loader generally remains above knee and below shoulder level. When poorly set up the there may be an increased

tendency for trunk twisting and/or sideways bending. Compared to the EBL, there is an additional need to manually move items along the hold. This function needs to be performed by an extra worker positioned within the hold doorway for on-loads, and by the un-stacking worker during off-loads. For the internal stacking and un-stacking workers, the risks are the same as for the Mallaghan LBT90 and direct to hold methods.

3. ***Mallaghan LBT90*** – The change in risk associated with the Mallaghan LBT90 is only for the external workers using it. The vertical lift region is similar to that observed when using a belt loader, and reach distances to grasp and place items are generally improved compared to using a beltloader. There is a risk that the hand distance from the lower back is increased if the belt mechanism fails or jams temporarily. Also, if workers then have to stand on the belt to move the bags there is a risk of slipping. The external handler will generally have the additional risk associated with transferring the bags down the hold to the in-hold stacker. Due to the relative position of the stack and the hold, there is considered to be an increased tendency for trunk twisting, but in our observations the proportion of time spent in these postures was small. The platform surface has the potential to be slippery. For these reasons the risk is ranked slightly higher than for belt loader use. However, there are no baggage carts required, avoiding the possibility that they might be moved manually.
4. ***Direct to hold from ground level*** – The vertical lift region can be between cart and above head height depending on the sill height of the hold door. There is also the additional risk associated with reaching to the opposite side of the cart compared to the Mallaghan LBT90. The external handler will generally transfer the bags down the hold to the in-hold stacker.
5. ***Direct to hold using a flatbed truck*** – The vertical lift region occurs between close to floor level and shoulder level. Depending on the headroom, the hold doorway can restrict the external handlers' posture. There is also a tendency for both trunk twisting and sideways bending for the external worker at the hold doorway. There is an increased risk of a fall from low height due to working on an open platform that has the potential to be slippery. The need for the external worker to transfer bags down the hold remains. For these reasons the risk is considered to be greater than when loading direct to hold from ground level.

It is important to note that other approaches, such as the moving hold floor technology of the Sliding Carpet Loading System (SCLS) when used in combination with advanced belt loaders such as the RTT Longreach (Telair International AB) are considered to offer similar risk control advantages to the EBL technology (Riley, 2008).

The EBL technology trialled in this project reduces the risk of injury primarily through the mechanisation of the transfer of bags down the hold and the use of height adjustable belts. The outcome of the trial is that this type of technology can significantly reduce the risk of injury, particularly to the internal stacker. The following comments apply to any EBL that has similar operational features to that studied. Further observations relating to the use of the EBL include:

1. The external adjustable element of the EBL studied can reduce lifting during on-load operations when used. Consequently there is no vertical lift distance, almost no twisting between the cart and EBL, and a reduced effect on the body of the hand distance from the lower back. For other EBLs that do not have this capability the risk is the same as that for a conventional belt loader.

2. The internal adjustable element of the EBL can reduce lifting and the vertical lift distance when used effectively. It also appears to reduce the need to twist (through up to 45 degrees) either side.

Musculoskeletal symptom reports

The HSE musculoskeletal symptom questionnaire results provide further evidence that the current baggage handling methods are physically demanding with 73% of handlers reporting trouble with their lower back in the past 3-months, 51% reporting trouble in their knees and 43% reporting trouble in their shoulders. Compared to other (Nordic Musculoskeletal Questionniare - NMQ) data from physically demanding tasks, baggage handling produced the highest prevalence rates for trouble experienced in the last three months/year. The results of the EMA survey also compare favourably with other NMQ data from baggage handlers, which also report a high prevalence of trouble in the lower back, knees, shoulder and neck.

Manual movement of ground support equipment

As well as baggage handling, ground handling staff are often exposed to a high level of risk during the routine manual pushing and pulling of ground support equipment (GSE) such as baggage carts, belt loaders and aircraft passenger steps.

There are a range of reasonably practicable ways, which are commercially available, that will eliminate the need to manually move GSE including:

- Pedestrian controlled tugs;
- Pedestrian controlled powered GSE, such as the aircraft steps in use at Amsterdam Schipol;
- Driveable GSE.

Other observations

Other observations made include the falls from height risk associated with direct to hold on-loading and off-loading, since there is no equipment present to assist with access to, or egress from the aircraft. Belt-loaders, EBLs and Mallaghan LBT90s provide a means for workers to access and egress the hold. Baggage carts and flatbed trucks are often used to gain access/egress, however since these are typically not designed as a means of access, there are likely to be associated fall risks. Similarly, where staff are working on flatbed trucks (which have no edge protection), and within the hold at the hold door there is also the risk of a serious injury resulting from a fall.

RECOMMENDATIONS

- This study shows that EBL type technology significantly reduces musculoskeletal risks through the mechanisation of the transfer of bags down the hold and improvements in posture and lifting. Therefore the GB aviation industry should consider using such technologies as a way to partly mechanise the task of handling baggage within the hold of the aircraft (NB: in-hold systems when used in combination with advanced belt loaders are considered to offer similar risk control benefits).
- For the external on and off-load of bags the vertical level and lift distance of the bags is more favourable when using a belt loader or Mallaghan LBT90 compared to direct to hold loading from the ramp. A mechanical means should therefore be used in place of direct to hold loading wherever appropriate.
- It is considered that workers loading bags with the Mallaghan LBT90 may be likely to twist the trunk due to the location of the bags being parallel to the hold, however,

postural analysis suggests that the proportion of time spent in these postures is small. Because of the relatively small sample of workers observed using this equipment, it is recommended that its use be assessed further.

- The high risk manual movement of GSE, including aircraft steps, should be avoided and the following methods of mechanisation should be explored: pedestrian controlled tugs; pedestrian controlled powered GSE; and driveable GSE.

- Means of risk reduction and control should also be explored for the other ancillary manual handling operations that handlers perform. For example, the baggage cart positioning, and the placement and collection of cones around the aircraft. Where some form of mechanical assistance is already in place, ensure that it is used. Further training and supervision may be required to achieve this.

- A suitable means of access and egress to the aircraft for baggage handlers should be identified and provided, both in terms of safety from of falls from height and enabling effective working postures. For example for staff working on flatbed lorries there is no edge protection and there is restricted headroom and footing, which leads to more twisting and sideways bending when handling.

1 INTRODUCTION

In Great Britain the majority of baggage handling is contracted out from the airline to ground handlers and is often viewed as a 'stand alone' part of the aircraft turnround process. Little consideration has been given to the design of the interface between the aircraft (airline carrier), airport (operator), handling equipment (supplier/manufacturer) and those persons undertaking the baggage handling work (ground handlers). Communication, co-operation and co-ordination between parties has, in the past, been less than effective with few joined-up interventions at a strategic level to reduce risks to those undertaking the baggage handling. This is now starting to improve with examples of partnership working becoming apparent. Fully effective risk reduction during the baggage handling activity will only be achieved if all the parties involved actively work together.

Any organisation contracting out parts of its operation or having control over a common place of work, still retains some responsibility for the health and safety of activities carried out by their contractors or those using their site. What these organisations do, will to a large degree directly influence the safety aspects of the final activity, such as baggage handling. For example, the carrier may decide to install in-hold handling systems in their aircraft fleet, thus reducing the in-hold handling risks, or an airport operator designs and constructs a baggage reclaim/sort hall that ensures there is suitable access for the ground support equipment (GSE) used on the ramp. Unless these factors are dealt with at an early stage, there is often little or no opportunity for the ground handler to address and reduce the risks.

The GB aviation sector health and safety steering group (Revitalising Health and Safety in Air Transport - RHSAT), which includes the HSE, identified the requirement for a working partnership to gather further information on the musculoskeletal ill-health risks associated with baggage handling operations. This was needed to expand the range of aircraft that had previously been considered, as well as the range of baggage handling approaches (Tapley and Riley, 2005). This earlier work was directed by the need to prioritise on the area where there was perceived to be the greatest problem (risk of injury to handlers) and on the most typical aircraft types. This was predominantly in the low cost sector of the GB market, and where aircraft such as the Boeing 737 series and Airbus A319/320/321 are routinely bulk (or loose) loaded. These aircraft fall within what can be defined as (commercial) *narrow-bodied* aircraft (Dell, 2007). However, any findings relating to manual bulk loading will be likely to be relevant wherever this occurs, and this may include larger aircraft.

A comprehensive literature review was undertaken to update the previous work by the HSE (Tapley & Riley, 2005). The updated review is presented in a separate report (Riley, 2008).

Staff from HSE, HSL, East Midlands Airport (EMA), Menzies Aviation, Servisair, EasyJet, BMI Baby and the Civil Aviation Authority (CAA) formed a collaborative working group to take this work forward.

The initial project objectives were to:

1. Define and group types of aerodrome.
2. Agree a definition for the narrow bodied aircraft of concern.
3. Collect weight/frequency data.
4. Review current handling methods and assess associated levels of risk of injury.
5. Evaluate new extending belt technologies.
6. Investigate the efficacy of wearing knee protection whilst handling inside the aircraft.

7. Trial a different way of internal bag stacking to assess handler effort and opinion.

This report covers the objectives 2 to 5. It was decided against completing the first objective after the group decided that this was too problematic and appeared to be of limited practical value in helping to understand where and why certain baggage handling approaches are adopted.

Objectives 6 and 7 could not be achieved within the timescale of this project. However, these objectives were discussed and agreed within the working group, so there is potential for these to be taken these forward in the future at EMA, either with HSE/L involvement, or independently.

2 RAMP HANDLING OPERATIONS AT THREE GB AIRPORTS

2.1 BACKGROUND: MANUAL HANDLING – THE RISK FACTORS

MSDs continue to account for approximately 50% of the personal injury incidents reported to HSE from UK airports. The majority of these incidents occur during ground handling activities, in particular the baggage handling operations (HSE Air Transport Web pages, 2008).

Companies continue to reduce the risks to staff with the use of new equipment and changes in work practice. However, in the UK there is still perceived to be a lack of robust and clear guidance on the risks and possible risk reduction measures.

Ergonomics and medical research has helped to clarify the main risks of back disorder associated with manual handling. Physical activities associated with an increased risk of back disorder are: heavy physical work; lifting and handling of loads; and awkward postures (e.g., bending and twisting) (Bernard, 1997; De Beeck and Hermans, 2000). The use of objective measures of the extent of physical loading to the lower back (e.g. spinal loading) during manual handling has contributed to the strength of these associations (De Beeck and Hermans, 2000).
The specific factors (HSE, 2004) that modify the extent of the loading to the lower back are broadly as follows:

- The load - The mass of the load, its size, shape, stability and grip characteristics.
- The task - The postures adopted (twisting, stooping and reaching), hand distance from lower back, vertical reach and lift distance, repetition, duration of the activity and carrying distance.
- The environment - The space available to move, floor conditions, changes in level, lighting, noise and weather conditions.
- The individual - The operator's individual capability and characteristics, their level of knowledge and experience, or underlying health problems should not be overlooked.

Psychosocial factors may also influence the health of workers, for example, aspects of work design such as how much control people have in their jobs and the support they receive from supervisors and co-workers. These factors can act in combination to make the risk greater; for instance, a repetitive lifting task undertaken in a non-ideal posture will present an increased risk.

2.2 THE JOB OF THE BAGGAGE HANDLER

While the focus of this report is on the musculoskeletal health risks associated with manual baggage handling activities taking place on the ramp, these risks need to be considered in relation to the whole job of the typical Ground Handler operating in this sector, who may fulfil a range of activities depending on their contracts. There are a large number of variables at play and influencing the overall risk of musculoskeletal ill-health problems arising. If we consider the variety of functions that might be performed by the staff referred to as baggage handlers (Ground Handlers), we will see that other manual handling activities are being performed. Dell's (2007) description illustrates that the roles performed by baggage handlers are very consistent around the world.

The activities performed by a 'ground handling' team in GB can typically include:

- Marshalling the aircraft to stand
- Placing aircraft and GSE wheel chocks
- Placing marker cones
- Deploying and connecting power cables
- Manually moving passenger steps, baggage carts and towable belt-loaders between tugs and close to the aircraft
- Manual moving of baggage carts in the make-up area
- The baggage handling activity, off-load and then on-load
- Manual moving of baggage carts in the baggage arrivals area
- Providing assistance to non-ambulant passengers.
- Manually moving passenger steps, baggage carts and towable belt-loaders away from the aircraft to connect to tugs
- Manually connecting the pushback tow-bar
- Collection of marker cones
- Removal of chocks
- Disconnecting and stowing power cables
- Marshalling off stand

(This list is not exhaustive)

While the focus of this report is on the most hazardous and repetitive handling activity, that of bulk unloading and loading of passenger baggage, there are clearly other significant manual handling operations contributing to the overall level of risk to an individual.

The organisation of the work varies with ground handling companies. In some, the handlers are in fixed teams, with a designated team leader making decisions about the handling methods, in others the team structure is more flexible, and without any leadership or supervisory role assigned within the team.

The level of exposure to manual baggage handling activities for any single individual will depend on the frequency and duration of the activities, such as the number of aircraft turnrounds performed by that team on that shift, the type of aircraft, the destinations, the time of year, and any rotation to different tasks within the team. In addition to this there are the other hazardous manual activities to consider, as described above.

Clearly the amount of variability makes it impractical to consider every eventuality and the risks associated with each in this report.

2.3 DESCRIPTION OF BAGGAGE HANDLING WORKING METHODS

There are two main approaches to the bulk (or loose) loading of aircraft:

- *Direct to hold*, where the baggage items are manually transferred between carts and the hold door, and;
- *Mechanically assisted* using belt-loaders and other equipment.

The method used can be dictated by the aircraft type, but not exclusively so. Within the various methods there are important differences between ground handling companies and locations in terms of the number of people involved and how they are managed.

Larger (hold door above convenient reach) narrow bodied aircraft such as the Boeing 737 family and above, are typically handled in a fairly consistent way between handling companies and locations in GB (and elsewhere, Dell, 2007). However, from 2 to 5 staff may be involved in the baggage handling activity.

Handling methods for the diverse group of smaller ‘regional’ jet and turboprop aircraft such as the Bombardier/de Havilland Dash8, Embraer ERJ 145, McDonnel Douglas MD80/90/95 series, BAE Jetstream J41, Fokker F70/F100, Saab 2000, etc., are more varied, but a team of two baggage handlers typically handle these. A sub-set of these aircraft, including the BAe J41, Embraer ERJ145 aircraft, can be classified as having a single hold area at the rear of the fuselage. The doorway is often located at the left side of the aircraft, relatively high up. On some of this group, the hold access is in close proximity to the engines. These aircraft are generally dealt with by a team of two handlers, accessing the hold door either from a baggage cart or a flatbed vehicle. One will climb inside, where there is usually room to stand upright or stooped, and pass baggage items to the outside worker standing on the flatbed or cart platform. These aircraft are generally not operated on routes where there is a lot of heavy baggage. They are typically operated on domestic and international business routes.

Intermediate sized aircraft such as the Fokker F70, 90, 100 can have a similar baggage hold layout to larger narrow bodied jets (Boeing 737, Airbus 319). They have hold openings on the right hand side of the aircraft, front and rear. Access is made either directly at ground level for the front hold, or from a cart or flatbed for the rear (or occasionally directly from ground level, but the sill height can mean an extreme reach at the rear hold). Only one worker will be deployed into each hold.

For larger aircraft (Boeing 737 200 to 900 series, 757, Airbus 319 to 321 series) direct to hold bulk handling is of greatest interest as these are ubiquitous in the low cost sector, and are therefore, where risk reduction measures will be most applicable and will have greatest impact.

2.4 DIRECT TO HOLD (FULLY MANUAL) HANDLING

On-load and off-load have to be described separately as there are important differences in the operations, especially relating to the occupational health risks to workers performing specific functions. Off-load will be described first, as this is usually the first operation.

2.4.1 Off-load

An in-hold worker accesses the hold (there are no means to assist with this) and starts to extract items from the stack. They may either pass them directly to an external worker – and probably will do in the first instance if the baggage is stacked right up to the hold door area, as there will be little room for a colleague until space is cleared. Load restraint netting may need to be unfastened.

One or two external workers will then handle the items between the hold sill and the baggage carts. The far side of the baggage cart will typically be filled first. This involves reaching across half of the width of the cart.

If enough staff are available, and there is a need, for example if the hold is long, a second in-hold worker will enter the hold and position him or herself at the hold doorway. They will receive bags from the unstacking worker and pass them to the external worker(s).

The unstacking worker will either push (if the distance is short) or 'propel' (if it is long) items from their location towards the hold door.

The external workers will need to pull other carts into place as they are filled. This may be done using the tug, or manually by one or both workers.

2.4.2 On-load

The train of baggage carts will be drawn up from which baggage can be on-loaded. Carts will be located close to hold doorways.

One or more workers handle baggage directly from the cart to the aircraft hold. Depending upon the size of the hold, there may or may not be a worker positioned just inside the hold door to receive the items. If the hold is short, or, if insufficient staff are available, then the external worker(s) may have to propel the bags along the length of the hold to the stacking face. This will be through either a propelling action in through the door, or a push once the item is placed on the sill. Items may be oriented to suit the in-hold worker.

The in-hold stacking worker lifts the bags from the hold floor and forms a stack, starting from the bulkhead and working back towards the door. Load restraint netting may need to be fastened.

2.5 MECHANICALLY ASSISTED HANDLING

The following methods of mechanically assisted baggage handling between the aircraft and the ramp include varying degrees of mechanical assistance. Only those observed directly in GB are described below. Other devices such as the Sliding Carpet Loading System (SCLS) and Telescopic Bin System (TBS) exist, and are described in Riley (2008). They are not within the scope of this report.

2.5.1 Belt loaders

A belt-loader is a piece of ground handling equipment. It is an inclined powered conveyor.

2.5.1.1 Offload

The belt-loader is positioned at the hold doorway (with the end just below and outside the sill). One or two workers will access the hold using it. Netting may need to be unfastened. A worker will begin to clear the door area by pulling bags from the stack and pushing them out on to the belt-loader. As space is cleared, the second worker can be brought into operation. They will be located at the doorway, and will receive bags from the unstacking worker and place them onto the conveyor of the belt-loader.

As the distance increases inside the hold, the unstacking worker will increasingly need to exert more force in propelling the bags across the distance to the co-worker.

If the hold is short, it may be possible for a single worker to be able to remove baggage items from the stack and to push them out of the doorway and onto the belt.

Outside, at the bottom end of the belt-loader, there will be one or two workers transferring bags from the belt and into a stack on the baggage cart. Depending upon how the cart has been positioned relative to the belt, they may be able to work at either side of the belt and fill a single cart, before moving another into place, or they may choose to position two carts, and fill one each. The carts are usually positioned so that the workers do not need to step between the belt and the carts.

2.5.1.2 On-load

The belt loader is repositioned so that the belt is slightly inside the hold doorway, and above the sill, such that baggage items will drop onto the hold floor. Otherwise, this is essentially the reverse of the off-load operation, except that the worker at the hold doorway (if present) will now need to provide the effort to propel the items along the length of the hold. As described previously, if the hold is short either side of the door, then a single worker may be able to perform the operation alone in the hold.

2.5.2 Flatbed trucks

Off-loading is when flatbed trucks are most likely to be used. At some airports they appear to be used more routinely than at others for dealing with aircraft in the Boeing 737 and Airbus A320 families.

Flatbed vehicles are also used to assist with the baggage handling for smaller and more variable aircraft, particularly those with only a single baggage hold side door at the rear of the fuselage, where a belt-loader may not be used due to the number of bags, or access difficulties.

2.5.2.1 Off-load

The vehicle is reversed up to the aircraft until it is close enough for a worker standing at the very rear of the bed to reach into the hold easily. Once parked, the workers will mount the flatbed (there is often no purpose designed means of access) and one, or possibly two, will enter the hold. One or two workers may remain on the flatbed. The operation is then conducted in a similar fashion to direct to hold as described above, with the exception of the worker(s) remaining on the flatbed. If there is one worker in the hold unstacking they will propel the bags to the hold door. A worker on the flatbed will then lift the bag out of the hold and walk to behind the cab of the flatbed to form a stack of bags. Exactly where they start the stack will depend on how many bags they know they have to handle. If it is a small load, they will generally start the stack a lot closer to the rear of the flatbed. For the worker on the flatbed, the task is therefore one of lifting from around waist level, carrying, and placing a load somewhere between floor level and the top of the stack. The stack does not typically extend above waist/chest level.

Depending on the aircraft, and its door configuration, access to the hold may be hindered by a lack of headroom.

2.5.2.2 On-load

Flatbed vehicles are understood to be used far less routinely for on-loading. For aircraft in the Boeing 737 and Airbus A320 families, the following methods generally apply.

The flatbed based worker(s) will perform the reverse of the operation described above for off-loading, transferring baggage items from a stack on the flatbed, requiring handling at below knee level for the base of the stack, and into the hold doorway. Here they may either propel the baggage items to the stacking worker, or an in-hold worker located inside the doorway may perform this function. An alternative operation is for a flatbed based worker to remain stood in the hold doorway, usually stooped due the headroom, and for them to pass bags down into the in-hold worker. This worker will be supplied with bags, placed on the flatbed (at floor level) next to them by a co-worker walking up and down transferring baggage items from the stack.

2.5.3 The Mallaghan LBT90

2.5.3.1 Offload

The Mallaghan LBT90 (referred to colloquially as a Mallaghan) is a unique device that replaces the use of the baggage carts and their tug, as well as belt-loader. One or two workers can stand on its platform and handle items between the Mallaghan's conveyor bed and the hold doorway. It therefore reduces the vertical height and lift distance of handling direct to hold that is normally overcome through the use of a belt loader. It is not an approach that suits all aircraft, and there are also important requirements of the airport baggage system infrastructure that need to be in place to get the most from this device.

The Mallaghan LBT90 will approach the aircraft hold doorway, the worker(s) will access the platform and raise it to a suitable height. They will gain access to the hold. A worker will move into the hold and start passing bags out to the worker stood on the Mallaghan platform. This worker will form a stack of baggage on the Mallaghan conveyor bed. Once the stack is formed it can be moved backwards away from the worker, creating another space in front of the worker. They then proceed to fill this until the Mallaghan is full or the hold is empty. The internal worker will work in a conventional way, unstacking items and propelling them the length of the hold to the doorway. A third worker could be present here to assist, but this is not usual. Two workers could be present on the platform. Two workers usually operate the method.

2.5.3.2 On-load

This is essentially the reverse of the above. The loaded Mallaghan will approach the hold doorway and one or two workers will access the platform and raise the unit to the appropriate level. The in-hold worker will still be present in the hold from the off-load. The Mallaghan worker(s) will unstack baggage items from the conveyor bed and transfer them onto the hold floor. As with direct to hold loading from a cart, they will now have to propel the items deeper into the hold to the stacking worker. It is possible to have another in-hold worker located inside the doorway to perform this function, but this is not usual.

2.5.4 Extending belt loader technology

This equipment includes devices such as the RampsnakeTM, the PowerstowTM and the MongooseTM. There are significant differences between these devices, but functionally they are similar.

2.5.4.1 Off-load

The device approaches the hold doorway, the door is opened and the extending element is located just onto the hold door sill. The worker(s) can now access the hold using the belt. It is intended that a two-person team operate all of these devices. The internal worker will deploy the extending section of conveyor as far as is required. There may be no need to deploy it at all until baggage has been cleared from the hold door area. They will do this in the conventional manner, by pulling items from the stack and placing them or dragging them onto the belt. As space is cleared the extending section can be deployed into the hold. Here it can be used to full effect, by using its height adjustment. The unstacking worker will adjust the conveyor head position and level and pull items onto the belt. There should be relatively little lifting required. They will progress into the hold as the stack is removed, extending the conveyor as they go.

Externally, there are differences between the three devices currently available in that not all EBLs may have an extending and height adjustable section for use in loading and unloading the baggage carts.

One or two external workers can work with any of the three devices, but the intention is that only one worker will be necessary. The Powerstow and Mongoose will be operated in exactly the same way as for a belt-loader; however, the RampsnakeTM warrants further description.

The cart loading worker operates the height adjustment, position, and extendable tail conveyor section. This can be used to direct baggage items where they are required, with little lifting of the whole item required. There will be some pushing necessary to get items into final position on the cart. Typically the worker will work with one hand controlling and positioning the tail conveyor, and the other pushing and directing the baggage items off it and onto the cart. Alternatively, the worker can locate the tail conveyor conveniently and use both hands to push and/or lift the baggage items.

2.5.4.2 On-load

This is the reverse of the above. The worker operating the tail conveyor of the EBL can position it close to the cart and drag items onto it without having to lift their entire weight. This can be a single or two-handed operation.

For those EBLs without this function, the operation is identical to that described for using a belt-loader.

2.6 SUMMARY

The broad definition of the term narrow-bodied aircraft has been established, that includes the range of aircraft that are bulk loaded, and is representative of the low-cost sector.

The job of a baggage handler, or ground handling worker, includes a range of strenuous manual activities additional to the handling of baggage. These have been outlined. These tasks need to be considered in making an overall assessment of musculoskeletal ill-health risks presented to workers, but the extent to which they contribute to the overall risk to any one individual worker will vary according to a range of factors.

There are a wide variety of methods used for handling baggage between carts or flatbed trucks and these narrow bodied aircraft. There is variability associated with the aircraft types, the staff available, the equipment available and the number of passengers and bags to be handled.

Mechanical assistance in the baggage handling operation has the potential to reduce risks significantly.

3 RAMP HANDLING OPERATIONS– MUSCULOSKELETAL RISKS

To investigate the MSD risks of current baggage handling methods, data were collected from three separate site visits to East Midlands Airport (20th/21st August 2007), Bristol Airport (25th October 2007) and Stansted Airport (25th September 2007). These visits were facilitated through the members of the project group at EMA. These visits provided additional data to that collected previously (Tapley & Riley, 2005) in order to cover a broader range of aircraft and handling methods. The range of aircraft and methods covered in this work should be considered as indicative of that at other regional airports and for ground handling companies servicing the low cost sector, rather than definitive.

3.1 APPROACH

Video footage and information from individual baggage handlers was collected on live operations on what could be described as a ‘targeted opportunity sample’ basis. We prioritised access to aircraft and handling method combinations that had not been previously studied (Tapley and Riley, 2005). Video recordings were made using Sony mini DV cameras. Where possible two researchers recorded both the internal hold and the external cart operations simultaneously. The workers were only video recorded handling bags around the aircraft and at the baggage reclaim belt. No video data were captured of the baggage handlers between these times. The aim was to capture a complete aircraft turnround, i.e. off-load then on-load, wherever possible. Despite the best efforts of our project team escorts, this was occasionally hampered due to the need to be escorted at all times, the need for the handlers to complete some turnrounds within 25 minutes, getting into a suitable location to film, and physically moving between aircraft stands in time to observe the operations we needed to see. With only a finite number of days in which to gather the data, some activities were inevitably missed.

A summary of the observation data collected from the three separate site visits is shown in Table 26 in the Appendices. The data collected for the trial of the mechanical aid is shown in Table 37.

Five analytical approaches were employed in the study:

1. Assessment of the common risk factors in handling – the load, the individual, the environment and the task. This was based upon information gathered during site visits, from handlers and from observation of video recordings of their working practices.

2. Assessment of postures adopted by baggage handlers using video recording and the Ovako Working posture Assessment System (OWAS) posture classification tool. This would indicate whether, and to what extent, the postures adopted are hazardous.

3. Assessment of perceived exertion using the BORG CR10 scale. This would determine how hard a handler perceives that they have to work when handling bags. This was intended for use as an indicator only, and may be useful to compare methods.

4. Comparison of sill heights, where bags are loaded direct to hold, against the 5th, 50th and 95th percentile anthropometric dimensions of male and female British adults. This would illustrate the postural requirements of loading at these levels.

5. Consideration of measured forces associated with manually moving passenger steps and baggage carts that had been obtained during previous work at other airports.

These methods and approaches are discussed in more detail below.

3.1.1 Manual Handling Assessment

A manual handling assessment was undertaken that covered the same risk factors included in the Manual Handling Assessment Charts (MAC, HSE 2004). This includes the load and frequency of handling, the hand distance from the lower back, the vertical lift region, trunk twisting and sideways bending, postural constraints, and the grip on the load. The MAC was developed, using ergonomics and medical research, to make an initial assessment of the physical risk factors for manual handling injuries (Monnington et al. 2003, Tapley 2002). Colour bands are used to illustrate the associated level of risk. The risk level descriptors for the colour bands are shown in Table 1.

Video recording was used as the primary means of assessing the physical risk factors of baggage handling. For the load/frequency assessment for handling whilst kneeling a load reduction of 15% was applied (Boocock 1997). This method was used in the previous study of baggage handling (Tapley & Riley, 2005). Each section of video for on and off load operations for a range of aircraft was analysed and the risk factors identified and recorded (observations are provided in the Appendices).

Table 1 MAC colour bands and associated level of risk

Colour Band	***Risk Level***
G= Green	Low level of risk (The vulnerability of special risk groups such as young workers should be considered where appropriate).
A = Amber	Medium Level of risk Examine tasks closely
R= Red	High level of risk Prompt action needed – This may expose a significant proportion of the working population to risk of injury

3.1.2 Postural analysis

Video was used as the primary means of recording posture data and work rates. Working posture was broken down into the categories provided by the OVAKO Working Posture Analysis System (OWAS) (Karhu *et al.*, 1977, 1981). The first part of the analysis coded changes in the back, arms, and leg postures adopted, and the loads being handled. The second part used these data to examine the frequency, relative times and mean durations of particular postures.

The coding of the video was done using the Observer Pro video (V4.0) analysis system (Noldus Information Technology BV, Wageningen, The Netherlands). This provides precise control of the video recordings (Carey and Gallwey, 1998) while postures were being coded. The video was digitised to MPEG-1 format and the digitised file was played back through the Observer software.

The Observer software was set up for ‘Focal Sampling’. This is a real time method of coding with defined events being coded at the point of their occurrence. It is therefore possible to measure the duration of a particular action and identify if sequences of events recur. Four

Behavioural Classes were defined corresponding to the three body parts and the force level category that are classified in the OWAS system.

Only the video taken of external operations for baggage handling was analysed. Three different methods were assessed:

1. Using a belt loader to on and off load the aircraft.

2. Loading and off loading the bags directly from the hold.

3. Using a Mallaghan LBT90 to on and off load the aircraft.

Subjects were defined to correspond to each handler being videoed for the tasks outlined above. Within each Behavioural Class, Elements were defined corresponding to each of the postures for the corresponding body part. A 'no entry' element was also defined for each body part. This combination of Subjects, Behavioural Classes and Elements allowed each of the subjects being observed to be coded separately for the duration of the video. The Behavioural Classes and Elements are listed in Table 2 below.

Table 2 Assignment of postures to Behavioural Classes / Elements

Behavioural Class	Element	Definition	
Back	Straight	Trunk upright and not rotated	Default
	Bent	Trunk bent forwards or backwards	
	Twisted	Twisted or bent sideways trunk	
	B&TW	Trunk bent and twisted or bent forward and sideways	
	No Back	Trunk not visible	
Arms	2 Below	Both arms below shoulders	Default
	1 Above	One arm above shoulders	
	2 Above	Both arms above shoulders	
	No Arms	Arms not visible	

OWAS can be used to assign Action Categories using the percentage of time that a person spends with a body part in a particular posture (Wilson & Corlett, 2005). This allows different degrees of severity to be assigned to the same posture, depending on the proportion of the time that is spent in that posture. The meanings of the different Action Categories are shown in Table 3. The postures, percentages of time and associated Action Categories are listed in Table 4.

Table 3 OWAS Action Categories

Action Category	Meaning	Action required
AC 1	Normal posture	No action required
AC 2	Slightly harmful posture	Action required in the near future
AC 3	Distinctly harmful posture	Action required as soon as possible
AC 4	Extremely harmful posture	Action required immediately

Table 4 Percentages of time in a posture and OWAS assignments to Action Categories

Body part	Posture	AC 1	AC 2	AC 3	AC 4
Back	Straight	0-100%			
	Bent	0-30%	30-80%	80-100%	
	Twisted	0-20%	20-50%	50-100%	
	Bent and Twisted	0-5%	5%-30%	30-70%	70-100%
Arms	Both below shoulder	0-100%			
	One below shoulder	0-30%	30-80%	80-100%	
	Both above shoulder	0-20%	20-70%	70-100%	

3.1.3 Rating of perceived exertion

The Rating of Perceived Exertion CR10 scale created by Borg (1998) was used to obtain a rating of workers' perceptions of how strenuous they found loading and unloading baggage handling for each of the different job roles outlined in sections 2.4 and 2.5. The CR10 scale was used to enable comparison of individuals' ratings. It can be inferred that a worker who reports a value twice as high as a co-worker is probably working twice as hard.

3.1.4 Anthropometric comparisons to sill heights

The sill heights of each of the aircrafts' holds were measured using a standard tape measure and were recorded in a notebook (some measurements from previous work were used also). These sill heights were compared with those shown in the 'ramp handling manuals' of the baggage handling organisations for accuracy. The measured sill heights were then compared to the shoulder and head heights of a short (5^{th} percentile, i.e. only 5 per cent are shorter) British adult aged between 16-65, and a tall (95^{th} percentile, i.e. only 5 percent are taller) British adult. The comparison was done using a 3D virtual human software package called 'JACK' (v5.1, UGS Corp, http://www.ugs.com). The statures used for the male and female British adults were adjusted manually and taken from the PeopleSize licensed software (Open Ergonomics Ltd, 2001).

3.1.5 Force measurements

Forces required to move two types of typical steps used for Boeing 737 series ground handling operations were measured at a GB airport using experienced handlers. Measurements were made during for two handling methods that are typically used:

Method 1: Both handlers pulling using the tow bar.

Method 2: One worker pulling using the tow bar and the other pushing with a wide grip using the handrails of the steps.

3.2 RESULTS

These results are consistent with those presented in the report by Tapley & Riley (2005). Some information included in the first report has been repeated here for the purpose of clarification and ease of reference.

3.2.1 The load

Individual baggage item weights were obtained for seven outbound low-cost sector flights from EMA (see Figure 1). The weights were recorded at the check-in desk by the check-in staff for all hold baggage items being checked in.

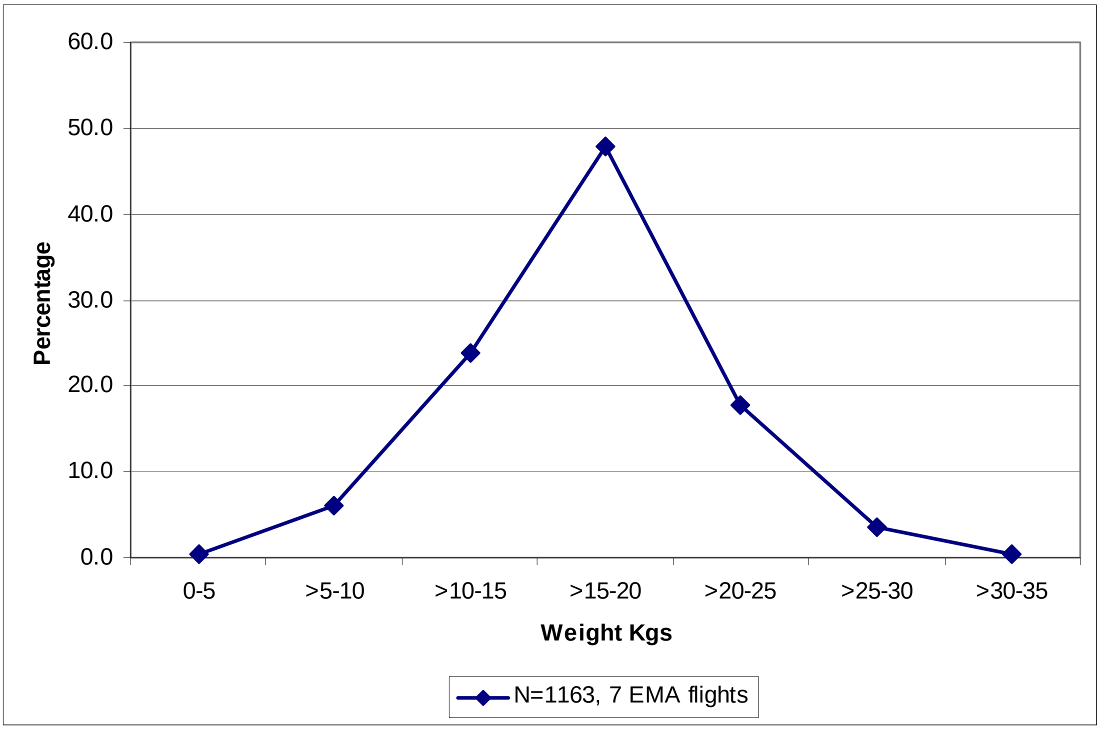


Figure 1 Distribution of bag weights collected from seven separate outbound low-cost sector flights.

The average bag weight of the seven flights was 17.4 kg (SD= 4.4, N=1163), and the heaviest bag weight recorded was 32 kg. For all flights 40-50% of the bags weighed between 15-20 kg. The baggage handlers commented that one of the heaviest items they have to handle into the hold is an electrically powered wheelchair. These can weigh in the region of 54 kg (Cochrane & Wilshere, 1988), mainly due to the battery. It is important to remember that alongside the handling of bags, baggage handlers may also push and pull baggage carts, and passenger steps during every turnround.

The frequency of baggage handling will vary depending on the flight destination, time of year, and number of passengers. The speed at which the bags have to be loaded also varies with the requirements of the airline. Typically, low cost airlines operate on short turnround times, as low as 25 minutes, for an off and an on-load of all baggage as well as the other turnround functions.

The MAC has been used to allocate a level of risk for handling bags at various weights and frequencies outside the aircraft. This is set out in Table 5 below. An additional load/frequency scoring chart with a load reduction of 15% (Boocock, 1997) has also been used to allocate a level of risk for handling bags while kneeling on one or both knees. This is shown in Table 6 below.

Table 5 MAC load/frequency scoring for a single operator outside the hold

Bag weight	One lift every			
	5 seconds	**9 seconds**	**14 seconds**	**60 seconds**
Less than 10kg	Green	Green	Green	Green
10 kg	Amber	Green	Green	Green
15 kg	Amber	Amber	Amber	Amber
20 kg	Red	Red	Amber	Amber
25 kg	Purple	Red	Red	Amber
32kg (IATA max)	Purple	Purple	Red	Red

Table 6 MAC load/frequency scoring for a single operator inside the hold

Bag weight	One lift every			
	5 seconds	**9 seconds**	**14 seconds**	**60 seconds**
Less than 10kg	Amber	Green	Green	Green
10 kg	Amber	Amber	Green	Green
15 kg	Red	Amber	Amber	Amber
20 kg	Red	Red	Red	Amber
25 kg	Purple	Red	Red	Amber
32kg (IATA max)	Purple	Purple	Purple	Red

Colour coding:
Green: low level of risk
Amber: Medium level of risk, task should be examined closely
Red: High level of risk, prompt action needed
Purple: Very high level of risk

The Liberty Mutual Manual Materials Handling Guidelines (2004) indicate the percentage of the population that a given task would be acceptable to (based on psychophysical data), taking account of a range of other known risk factors alongside the load weight and handling frequency. At a lift distance of 76 cm (handling from the base of the cart to above shoulder height), a lift weight of 15 kg, and a hand distance of 31 cm (handling towards the rear of the cart) with a handling rate of 1 lift every 15 seconds[1] (lowest frequency provided in the Tables, which is based on handling over an 8-hour period) this task is acceptable to approximately 43% of the male work population. The aim is to design manual tasks for greater than 75% of the

[1] *Observations of baggage handlers show that bags can be handled at a frequency of 1 lift every 4 seconds (one person handling). The total number of bags on each flight varies; however the maximum number of bags handled for an on or off-load is approximately 180-200.*

female work population to offer the best protection from injury for the general working population. The parameters used above illustrate a typical scenario that could occur during a period of baggage handling, with the exception of the frequency and duration. However, even if a lift of this nature were required once in an 8hr period, it would be acceptable to less than 10% of the female work population.

3.2.2 Postural analysis

The OWAS postural analysis method was used to assess the percentage of time workers spent with their trunk and arms in non-ideal postures when transferring bags into the aircraft hold. The range of trunk postures includes straight, twisted, bent forwards, backwards or sideways or a combination of twisted and bent. The range of arm postures includes two hands below shoulder height, one or two hands above shoulder height. A limitation of the trunk categorisation is that there is no consideration of the actual joint angle of the trunk, i.e. is the trunk 20 degrees from neutral or 60 degrees, and is 5 degrees bent or straight. The further from neutral the trunk is, the greater the potential moment at the low back. The angle of the trunk has not been accounted for in this analysis; however, when the trunk was observed to be only slightly bent or twisted (up to approximately 5 degrees) the posture was classified as 'straight'.

The duration and frequency of the different postures can be affected by:

- The location of the cart relative to the aircraft/belt;
- If the worker is handling on their own or with a colleague;
- If it is an on or off-load;
- Individual differences in handling style.

Each of these variables will influence the number and duration of harmful postures during baggage handling on and off the aircraft. As the data were collected in a limited time while observing real operatives it has not been possible to control for each of these variables.

For the analysis, only video footage of on/off loads of full carts with no time delays was used. This controlled for, in part, the height of the stack on the cart. The video was positioned at the start of an on/off load of a cart and coding began from this point. Where necessary, the file was stepped through frame by frame.

The Observer software was used to record the total duration in a given posture for the observation period. The individual observations for a given handling method were combined to give an overall total duration in a given posture. The percentage of time spent in a given posture and a 95% confidence interval were calculated for the different handling methods for the back and arm postures. In total 1775 seconds of video was observed for belt loading, 603 seconds for direct to hold loading and 582 seconds for the use of the Mallaghan LBT90.

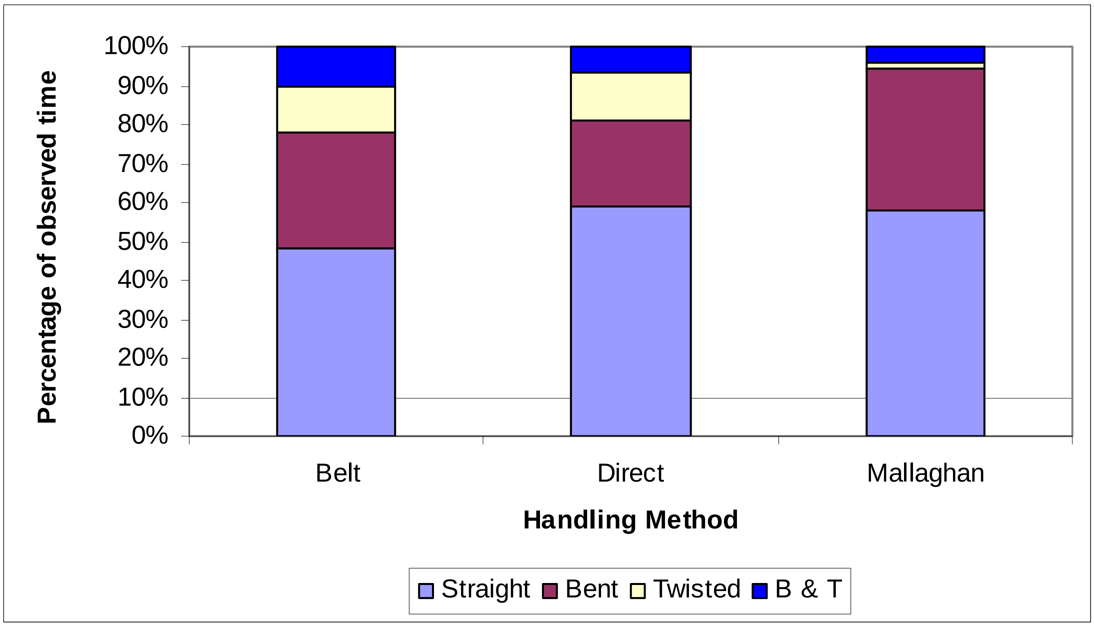


Figure 2. Posture of trunk (percentage of observed time)

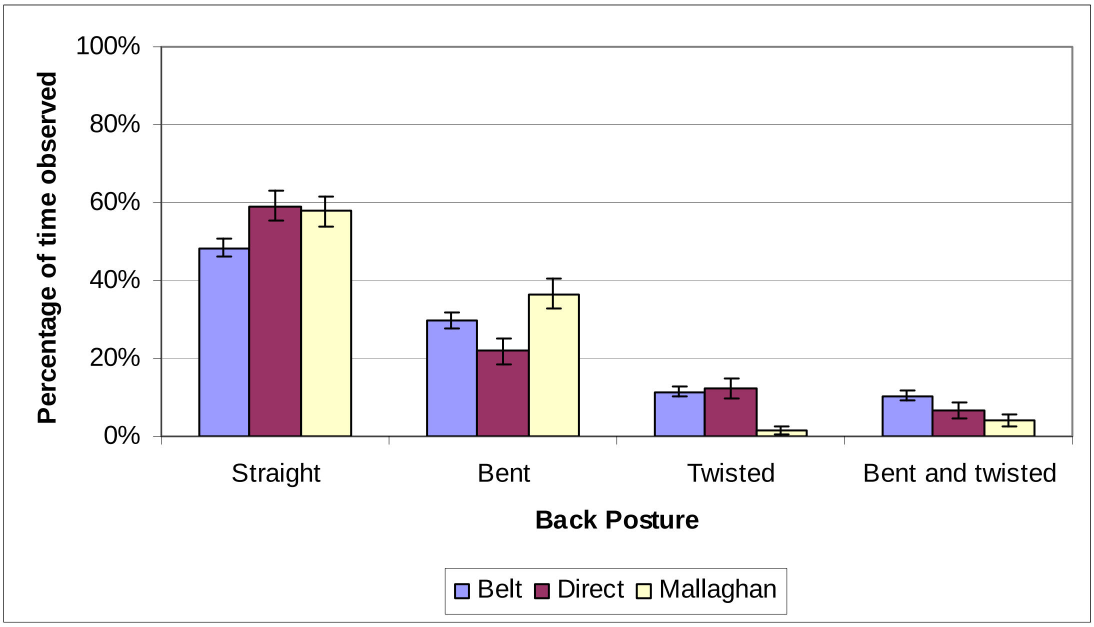


Figure 3. 95% confidence intervals for the posture of the trunk

Figure 2 shows how the total percentage of observed time in different back postures varied across the three different handling methods. The total percentage of time spent in non-ideal postures when using the belt loader was 52%, for direct to hold it was 41% and for the Mallaghan LBT90 it was 42%. The confidence intervals illustrated in Figure 3 show there was significantly less time spent with the back straight using the belt compared with direct to hold and the Mallaghan LBT90.

When comparing the individual observations of different workers there was a great amount of variability in the trunk posture durations. For the belt loader 6 different workers were observed and this amounted to a difference of 60% between the lowest percentage of time with the back straight (20%) and the highest (80%). Compare this with Direct to hold where 3 different workers were observed, there was only a 16% difference between the lowest percentage of time with the back straight (62%) and the highest (78%). A further consideration is that to place or retrieve a bag from the hold the handler will be stood straight.

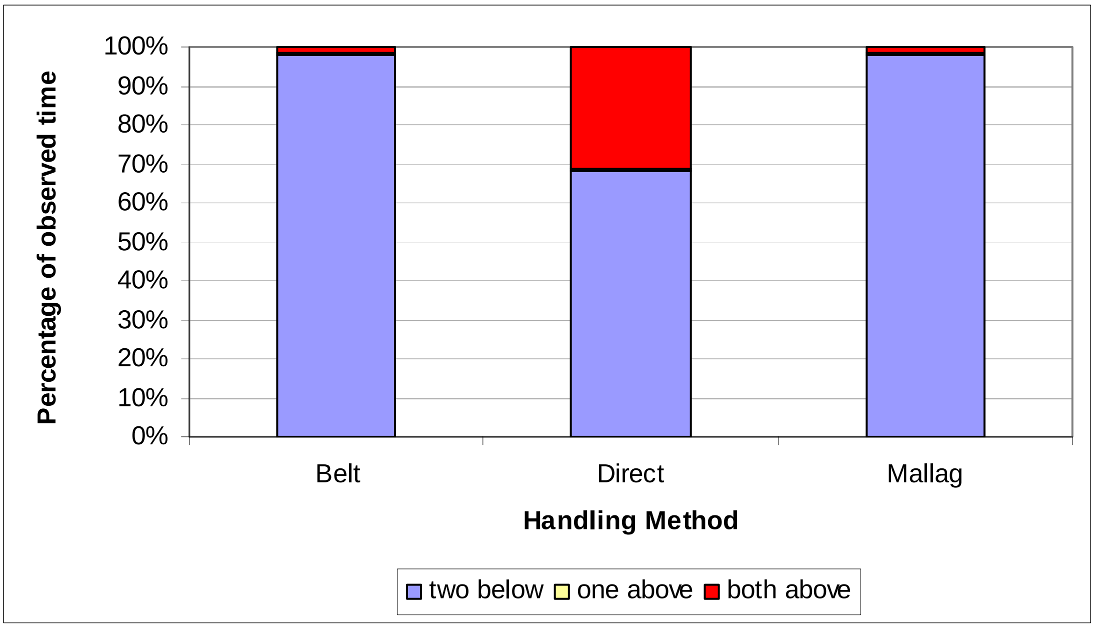


Figure 4 Position of hands relative to shoulders (percentage of observed time)

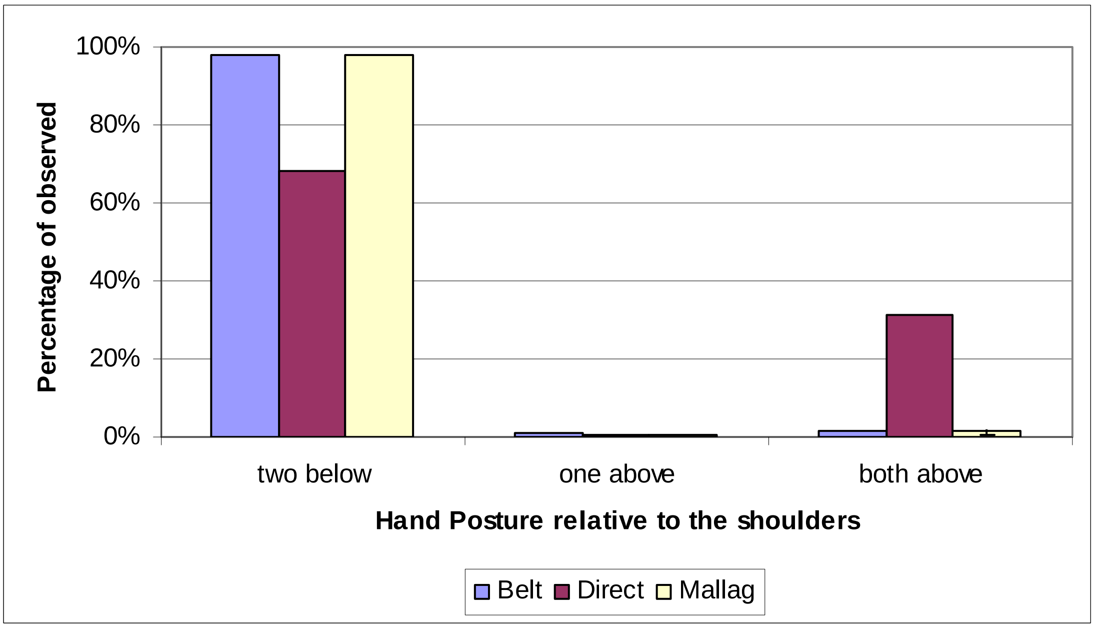


Figure 5 95% confidence intervals for the position of hands relative to shoulders

Figure 4 shows the total percentage of observed time when either one or two hands were above shoulder height. With direct to hold loading, nearly a third of observed time was spent with both hands above the shoulders. In some instances this would occur for a short duration, to deliver the bag into the hold, while in others the time would be extended due to the need to push the bag down the hold to the in-hold stacker. The action of frequently lifting the arm above shoulder height and high velocity arm motions such as propelling/pushing items down the hold are factors that can increase the risk of injury, particularly to the shoulders (Chaffin et al. 2006). Furthermore the strength of the lifting action falls off steeply when handling above shoulder height (Pheasant, 1991). Propelling items is also considered to be physically stressful and such tasks should be considered for redesign (Liberty Mutual, 2004). Figure 5 shows a significant difference between the time spent with the hands above shoulder height between direct to hold and the belt loader and Mallaghan LBT90. Indeed the hands were below shoulder height almost 100% of the time when using the belt loader and Mallaghan LBT90.

Table 7 shows the Action Categories assigned to the percentages of time in Figures 2 and 4 using the boundaries described in Table 4. The amount of combined bent and twisted postures when using the belt loader and direct to hold methods fell into AC2 (action required in the near future). The amount of bent forwards or backwards postures using the Mallaghan LBT90 also fell into AC2. The amount of time spent with both hands above shoulder height fell into AC2 for direct to hold only.

Table 7 OWAS Action Categories applied to the percentage of observed time

	Belt Loader	***Direct to hold***	***Mallaghan***
Straight trunk	AC1	AC1	AC1
Twisted or bent sideways trunk	AC1	AC1	AC1
Bent forwards or backwards trunk	AC1	AC1	***AC2***
Bent and twisted or bent forward and sideways	***AC2***	***AC2***	AC1
2 hands below shoulder height	AC1	AC1	AC1
1 hand above shoulder height	AC1	AC1	AC1
2 hands above shoulder height	AC1	***AC2***	AC1

OWAS is a useful tool to define the different postures and compare the percentage of time spent in a given posture with the pre-defined Action Categories; however, it does not differentiate the degree of bending or twisting or take into account the weight of the load. There are also uncertainties of the OWAS Action Categories so the justification of intervention based solely on this categorisation is limited. However, the analysis has highlighted that a baggage handler could collectively spend approximately 50% of their time handling bags with their backs in non-ideal postures, using any of the three methods considered. When loading direct to hold they could also spend approximately a third of the time with their hands above shoulder height.

3.2.3 Cart location and number of handlers

When there are two handlers loading/unloading items, each handler tends to stand to either side of the belt with the cart positioned at right angles to the belt a short distance away. The cart tends to be positioned further away when there is only one handler so that they can move between the cart and the belt loader (see Photograph 1). A cart set at right angles to the belt loader can increase the tendency for workers to twist. This is perhaps more so when there is only one handler as they effectively have double the workload and it is ‘easier’ and quicker to twist to transfer the bags between the two locations than to move the feet. The structure of the spine is such that rotation of the lumbar spine is accomplished through the deformation of the discs that sit between the vertebrae, which puts them at risk of damage. When the rotation is coupled with flexion, for example when lifting a bag off the cart, the risk of injury is increased (Pheasant, 1991). A cart set at a 45-degree angle to the belt loader can help reduce the requirement to twist (OSHA, Jan 2008).

Photograph 1 *One and two handler's loading bags onto a belt loader*

Handlers will also twist to transfer bags when loading direct to hold (see Photograph 2). This may be more the exception than the rule given that when loading directly into the hold handlers can be required to push the bag down the hold to the in-hold stacker. Furthermore in cases where there are two handlers they would have the time available to go at a slower rate.

Photograph 2 *Single worker rotating the trunk to propel bags into the hold*

The space available to the handler using a Mallaghan LBT90 is pre-determined by its design. The method of transfer appears similar to that of direct to hold, i.e. if the handler is not required to push the bags down the hold they may twist and propel the bags into the hold. This situation is less likely to occur for an off-load due to the need to stack the bags.

3.2.4 Physical dimensions of equipment and aircraft hold (external)

The hold sill height, location of the hold door and the dimensions of the aircraft hold doorway, the carts and belt loaders can force handlers into non-ideal postures.

Figure 6 illustrates a range of example hold sill heights against the body sizes of workers in the general population of British workers, small female (5^{th} percentile, stature = 1540mm) and large male (95^{th} percentile, stature = 1895 mm). This shows that for the small female, only the Boeing 737 200, Dash 8 and BAe 146 sill heights are below shoulder level. For the small male, sill heights of 136 cm or less are below shoulder height.

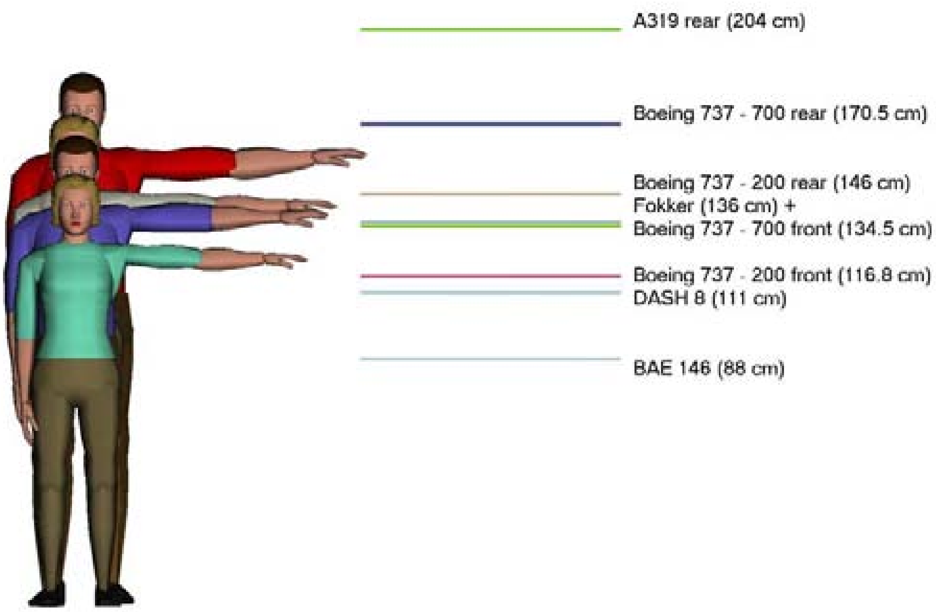
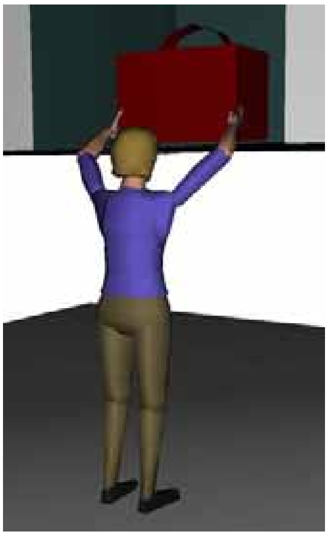


Figure 6 Anthropometric comparisons of 5^{th} and 95^{th} percentile female and male British workers in relation to a selection of aircraft sill heights (measured).

Human computer models of a small and large (5^{th} and 95^{th} percentile) female and male figure handling a bag into an aircraft hold with a sill height of 146 cm (measured height of rear hold for Boeing 737-200) were created. This sill height was chosen, as it is the highest at which direct to hold loading was observed at EMA. The models shown in Figures 7 & 8 illustrate that for both the tall male and female figure the sill is either at or just below shoulder height.

In reality, due to the dimensions of the baggage items, the position of the hands (which is the critical factor) will typically be lifted considerably higher than the sill in order for the baggage item to be placed on it. Therefore the handling (the application point of the hand forces) is actually above shoulder height. Photograph 3, illustrates this for two different sill heights, and for two different sized workers. Both workers are lifting and propelling items into the hold with one hand higher than the other. The upper hand is typically at or above head level and is supporting the load. The lower hand is supporting and pushing the item onto the sill.

5th percentile female handling a load up to a 146cm sill



95th percentile female handling a load up to a 146cm sill

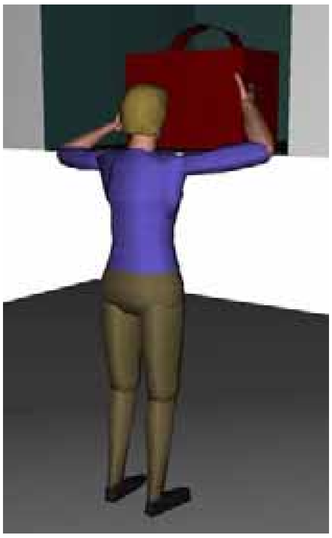
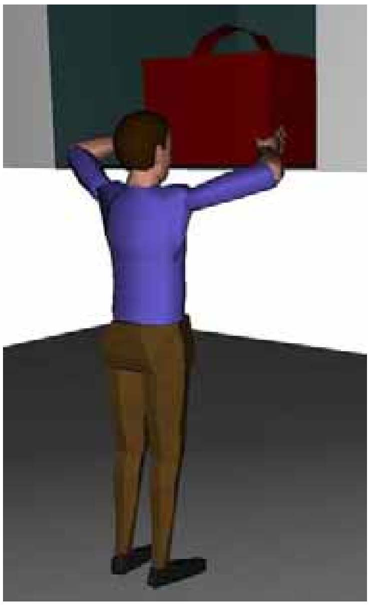


Figure 7 Anthropometric comparisons of a 5th and 95th percentile female British worker in relation to a sill height of 146cm (Boeing 737-200 rear: measured)

5th percentile male handling a load up to a 146cm sill



95th percentile male handling a load up to a 146cm sill

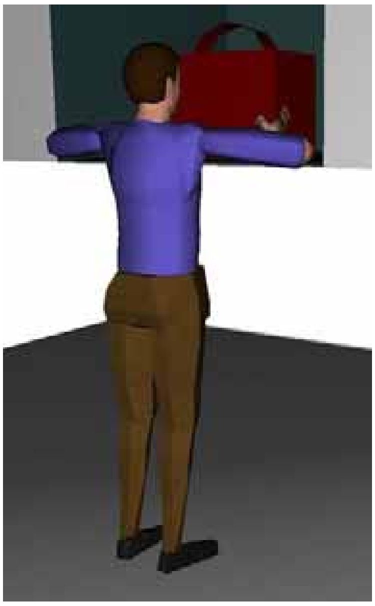


Figure 8 Anthropometric comparisons of a 5th and 95th percentile male British worker in relation to a sill height of 146cm (Boeing 737-200 rear: measured)

B737 – 300 rear hold (approx. sill height 1460 mm)	B737 – 500 rear hold (approx. sill height 1370 mm)
	

Photograph 3 *In reality bags will be lifted higher than the sill height to load bags into the aircraft hold*

In terms of ergonomics, the sill height of the hold door is an important factor. Lifting items above shoulder level is known to present an increased risk of musculoskeletal injury and ill-health. Clearly the point at which the load is raised above shoulder level is an individual factor, based on a person's stature.

Photograph 4 illustrates the hazards of handling above shoulder height. In this instance the handler has leant backward (hyperextension of the spine) in order to be able to control the load to lower it from shoulder height. At or above shoulder height the mechanical advantage gained from the lower limbs is lost. This manoeuvre is potentially hazardous (Pheasant, 1991).


Photograph 4 *Hyperextension of the back from handling heavy loads at or above shoulder height (Boeing 737-300)*

For the on-load of bags, direct to hold handling leads to a greater vertical lift distance compared with a belt loader. The vertical lift distance is the distance between the hand position at the start of the lift and the end. Photograph 5 shows a handler preparing to lift a bag from the bottom of the cart into the hold and one who is preparing to lift a bag onto a belt loader. The lift direct to hold is from approximately knee height to above shoulder height, whereas in the case of the belt loader the hands remain at just below waist level. A person's lifting capability will decrease with the extent of the vertical lift distance and/or a lift or lower that starts above shoulder height or below knee height (Ayoub & Mital, 1989).

When on/off-loading it could be possible that the vertical lift distance is greater at some point when using the belt loader if the bags were stacked on the cart above shoulder height. However, in this instance it is possible to control the height at which the bags are stacked and for some types of belt loader it is possible to adjust its height at this point.

***Photograph 5** The vertical lift distance of loading bags direct to hold and onto a belt loader*

It was observed that for on-load operations, handlers tended to pull bags toward them from the back of the cart before lifting them. However, during off-load operations, handlers have to reach out at least an arms distance away to place bags at the back of the cart. The extent of the reach required is illustrated in Photograph 6. Handling a load at a distance increases the risk of injury because the muscles have to oppose both the body weight and the load weight at a distance, leading to greater spinal compression forces. The use of the hand to support the body, as shown in the left picture of Photograph 6, will reduce the loading on the spine, but requires single hand handling. When stacking or unstacking bags, this may be possible for initial retrieval or final positioning of the load, but not for supporting the weight of a heavy bag. In theory the Mallaghan LBT90 conveyor belt system eliminates the need to reach out at this distance to stack bags.

***Photograph 6** The horizontal reach distance of handling bags on the cart*

3.2.5 The individual

The baggage handler population at EMA was exclusively male. With this type of physically demanding work it is likely that informal self-selection occurs, hence the male population. The need to wear personal protective equipment (PPE) including hi-visibility and weatherproof clothing can restrict movement, which will affect individual performance.

3.2.6 The environment

Space constraints – There is limited room to manoeuvre inside the hold leading to restricted movement and posture. There is typically only enough room to kneel although in the holds of larger aircraft (Airbus 320 family), there is room to stand in a stooped posture. The risks associated with handling in low-headroom, and the implications of handling in a stooped versus a kneeling posture are discussed in Tapley & Riley (2005). The space for manoeuvring outside the hold is dependent on the positioning of the carts and belt loaders as described above.

Floors – Generally the floor surface around the aircraft has to be kept clean and free from debris as this is vital to ensure engine and aircraft safety. However, given that handlers need to work outdoors in all weather conditions, there is likely to be an increased risk of slipping in wet and icy weather. The floors of the holds were generally smooth and level. However, there are instances where they are not and this can affect the handling technique employed in order to accommodate a poor surface. The flat bed lorries tend to have surfaces which, when wet or icy, will increase the risk of slips and trips with an associated increase in risk of falls from height.

Temperature – Baggage handlers will be exposed to extremes of weather. In the summer they could be exposed to high temperatures and/or humidity, which can cause rapid fatigue and perspiration on the hands can reduce grip. Some workers commented that since the introduction of security measures preventing the carriage of liquids airside they have sometimes experienced difficulty in getting access to sufficient drinking water.

Lighting – Lighting around the aircraft is generally to a good standard to allow safe movement and to prevent damage.

3.2.7 Overall risk ratings

Tables 8 and 9 illustrate the risk ratings given to the various methods encountered for external loading and off-loading of an aircraft, which includes handling direct to hold, handling direct to hold from a flatbed truck and a Mallaghan LBT90, and using a belt loader. Tables 10 and 11 illustrate the risk ratings given to tasks for loading and off-loading an aircraft inside the hold. These risk ratings are based on the MAC structure and extensive observation of video taken during site visits to GB airports and on the results presented above. Please refer to the appendices for further details of the video obtained and the observations made.

Table 8 Comparison table for off load external handling methods

Risk Factor	***Observation***	***Direct to hold***	***Direct: off flat-bed truck***	***Mallaghan***	***Belt Loader***
Hand distance from lower back	Retrieving items from the hold				N/A
	Reaching to place items at the back of the cart		N/A	N/A If belt is not moved forward	
	Reaching to lift items onto the top of the stack				
	Reaching to place items lower down the stack towards the front of the cart				
Vertical Lift region	Placing items at the top of the cart /lorry with hands above shoulder level				
	Placing items in the middle of the stack				
	Placing items at the base of the stack				
	Retrieving items from the hold with hands above shoulder level		N/A	N/A	N/A
	Placing items at floor level	N/A		N/A	N/A
Trunk twist/ sideways bending	Cart positioned at 45 degrees		N/A		
	Cart not positioned at 45 degrees. Flat bed lorry only - Postural constraints from restricted headroom				
Postural constraints	Restricted headroom.		Standing stooped		
	Restricted footing		Platform	Platform	
Floor surface	Truck and Mallaghan		Smooth metal Slippery when wet	Checker plate surface: could be slippery	

Table 9 Comparison table for on load external handling methods

Risk Factor	***Observation***	***Direct to hold***	***Direct: off flat-bed truck***	***Mallaghan***	***Belt Loader***
Hand distance from lower back	Placing item in the hold but not pushing down the hold				N/A
	Reaching into the hold to push items to the hold stacker (pushing force not assessed)				N/A
	Reaching to pull items from back of the cart		N/A	N/A If belt is not moved forward	
	Reaching to lift items from the top of the stack				
	Reaching for items lower down the stack towards the front of the cart				
Vertical Lift region	Lifting items from the top of the cart /lorry with hands above shoulder level				
	Lifting bags from the middle of the stack				
	Lifting bags from the base of the stack				
	Placing large items into the hold with hands above shoulder level		N/A	N/A	N/A
	Lifting items from floor level	N/A		N/A	N/A
Trunk twist/ sideways bending	Cart positioned at 45 degrees		N/A		
	Cart not positioned at 45 degrees Flat bed lorry only - Postural constraints from restricted headroom				
Postural constraints	Restricted headroom.		Standing stooped		
	Restricted footing		Platform	Platform	
Floor surface	Truck and Mallaghan		Smooth metal Slippery when wet	Checker plate surface: could be slippery	

Table 10 Comparison table for off-load internal operations

Risk Factor	***Observation***	***In hold stacking worker***	***In hold door worker***
Hand distance from lower back	Transferring items from the in-hold stacker to the belt/external worker.	N/A	Kneeling Standing stooped
	Reaching to un-stack items in the hold: arms outstretched with trunk in a bent/twisted posture.		N/A
	Transferring items (pushing or propelling) to the hold door		N/A
Vertical Lift region	Transferring items from the in-hold stacker to the belt/external worker.	N/A	Kneeling Standing stooped
	Un-stacking items: items tended to be pulled from the stack and allowed to drop to the floor		N/A
Trunk twist	Transferring items from the stack and down the hold		N/A
	Transferring items to the belt/external worker involves twisting and sideways bending	N/A	
Postural constraints	Restricted headroom.		
	Restricted footing	Kneeling	Kneeling
Floor surface	Uneven hold floor surface		

Table 11 Comparison table for on-load internal operations

Risk Factor	***Observation***	***In hold stacking worker***	***In hold door worker***
Hand distance from lower back	Transferring items (pushing or propelling) from the hold door to the in-hold stacker:	N/A	Kneeling Standing stooped
	Reaching to stack items in the hold: arms outstretched with trunk in a bent/twisted posture.		N/A
Vertical Lift region	Transferring items from the hold door to the in-hold stacker (stood stooped or kneeling)	N/A	Kneeling Standing stooped
	Stacking items: bags could be lifted from the hold floor and stacked at hold ceiling height.		N/A
Trunk twist	Transferring items from the floor/belt loader down the hold involves twisting and sideways bending	N/A	
	Stacking items: When kneeling and facing side on to the stack, worker would typically twist though 45 degrees either side to lift bags off the floor, turn and stack.		N/A
Postural constraints	Restricted headroom.		
	Restricted footing	Kneeling	Kneeling
Floor surface	Uneven hold floor surface		

3.2.8 Rating of perceived exertion

The scale of perceived exertion was explained to handlers prior to the start of observed handling and tended to be at a time when the handlers had a break in their workload. The handlers were asked to rate how they perceived their physical workload at the end of an on or off-load operation. The rating was done on an opportunistic basis due to the time constraints under which the handlers were working so only a proportion of ratings were obtained from all of the operations observed.

The values provided by each handler were combined and an average obtained for handling within the hold, at the door and for stacking. An average was also obtained for handling between the cart and the belt loader and between the cart and hold. These are shown below in Table 12.

Table 12 Ratings of perceived exertion by baggage handlers'

Location	*Task*	*Average rating*	*Workload*
Inside the hold	Handling at the door	5 SD=2.5, N=6	Heavy
	Stacking	6.2 SD=2.26, N=10	Heavy to very heavy
Handling on the ground	Handling between the belt loader and cart	3.6 SD=1.54, N=7	Light to heavy
	Handling direct to hold (incl. transfer of bags down the hold)	6.6 SD=1.88, N=4	Heavy to very heavy

3.2.9 Manual movement of GSE and aircraft steps

Manual movement of aircraft steps by pushing and pulling to and away from aircraft has been observed as a ground handling activity that can be associated with aircraft not positioned on a stand with an air bridge or with integral steps. Manual movement of other ground support equipment (GSE) has been described previously by Tapley and Riley (2005), and on the HSE website (http://www.hse.gov.uk/msd/experience/aircraftsteps.htm - accessed August 2008).

Aircraft steps vary in weight and size depending on the types of aircraft being loaded. Typically steps for a 737 series aircraft weigh approximately 1100kg to 1300kg at time of manufacture. There are some lighter versions available but these are found less commonly.

Aircraft step movement has been observed at several GB airports (separately to this project, but not reported previously) with a variety of methods used by handlers including:

- Steps towed with an electric tug to approximately 2 metres from aircraft then pulled in by hand with varying numbers of staff;
- Steps manually pulled into position from a range of distances varying between the back of the stand to close to the aircraft;
- Single handlers pulling steps from the front of the aircraft to the rear doorway.

Within these approaches there is further variation in the way in which the workers apply the force required to move and control the steps:

- Some steps have been observed to be moved by teams of three or four workers.
- More typically teams of two or three move the smaller sets of steps.
- Workers can apply force at a variety of locations around the steps.

Typically a team of two workers will work together with one applying a pulling force at the tow bar (for steering and braking), while the other(s) apply pushing force at the step handrail.

Due to the technical difficulties of simultaneously measuring the contribution of multiple workers, two measurement approaches were used:

- Two workers applying force to the step towbar through a wide handle attached to the S-beam load cell.
- One worker applying force to the step towbar as above, while the other worker applied pushing force from behind the steps at the handrails. The workers then swapped positions between sets of measurements.

Force measurements had been made previously with the cooperation of ground handling staff at Manchester Airport (Table 13). Force measurements were made using a calibrated Mecmesin Handheld Advanced Forge Gauge coupled to a calibrated S-Beam load cell (serial number: 400-047).

Table 13 Summary of average forces exerted by workers for two passenger step types.

Position of handler	***Average starting force kgf (Newton)***	***Rolling force kgf (Newton)***
Step type 1, manufactured by Airgate		
Combined force exerted by 2 workers pulling at the tow bar	91.5kgf (897 N)	54kgf (530N)
Individual force exerted by one worker pulling at the towbar while the other (unmeasured) worker pushed.	44.8kgf (439N)	25kgf (245N)
Step type 2, manufactured by AMSS*		
Individual force exerted by one worker pulling at the towbar while the other (unmeasured) worker pushed	70.8kgf (694N)	28.8kgf (282N)

*Only 1 method used for these steps as it was not possible for 2 handlers to pull on the tow bar.

L23, The Guidance to the Manual Handling Operations Regulations 1992 (as amended) Appendix 3, provides a guideline figure for men of 20kg for stopping or starting a load and a guideline figure of 10kg for keeping the load in motion. These figures assume the force is applied with the hands between knuckle and shoulder height.

Even for a minority of fit, well-trained individuals working under favourable conditions, operations which exceed the guideline figures by more than a factor of about two, may represent a serious risk of injury. The figures recorded are considerably in excess of the guideline figures set out above; this can clearly be seen in Table 14.

Table 14 Comparison of measured forces with HSE guidance values

Force recorded: starting force	***Guideline figure for starting forces (males)***	***Exceed guidelines by factor***
91.5kgf (897 N)	20kgf	X 4
44.8kgf (439N)	20kgf	X 2
70.8kgf (694N)	20kgf	X2.5
Force recorded: rolling force	***Guideline figure rolling forces (males)***	***Exceed guidelines by factor***
54kgf (530N)	10kgf	X 5
25kgf(245N)	10kgf	X 2.5
28.8kgf (282N)	10kgf	X 2.8

It is accepted that measurement of force is only one element in a push/pull risk assessment and that there are other factors which will have a significant impact on the amount of force required to move an object including:

- Maintenance of the object: poorly maintained wheels can significantly increase forces.
- Height of force application: if the worker has to push/pull outside the ideal range i.e. at knuckle height, forces are likely to be increased.
- Floor surface: a rough surface will increase forces, wet or slippery surfaces increase the risk of slips/trips while handling.

For comparison, measurements of the forces involved in manual movement of belt loaders and full baggage carts (Tapley and Riley, 2005) indicates average starting forces in the range 44 kgf to 54 kgf.

3.3 SUMMARY

- Approximately 50% of the time spent handling bags externally is in non-ideal postures regardless of the method used. There is evidence to suggest that individual differences in handling technique, cart location, and the number of handlers can affect the time handlers spend in non-ideal postures.
- The average bag weight of 4 flights was 17.4 kg. Between 15 and 20% of bags were in the 20 to 25 kg category.
- If handling 15 kg bags whilst standing at a frequency of 1 every 5 seconds there is a medium risk of injury.
- If handling 15 kg bags whilst kneeling at a frequency of 1 every 5 seconds there is a high risk of injury.
- For the short female (95% of British adults are taller), sill heights of 124 cm (standing shoulder height) or less are below shoulder height. However, when handling bags into the aircraft they are generally lifted higher than this in order to clear the sill height. Handling above shoulder height can increase the risk of injury.
- There is a greater vertical lift distance when handling bags directly into the hold.
- When reaching to stack items towards the rear of the cart, the risk associated with the hand distance from the lower back is classed as high. The hand reach is reduced when using the Mallaghan LBT90 as handlers can move bags forwards/back using a belt

mechanism. However, handlers commented that there were problems with the belt sticking, which could lead to more difficult handling situations.

- When loading bags direct to hold or from the Mallaghan LBT90 there can be an additional task requirement to push the bags down the hold to the in-hold stacker. Propelling/pushing items down the hold increases the physical stresses placed on the shoulder joint.
- Handlers perceive that transferring items between the cart and belt loader requires less exertion than transferring items directly to and from the hold.
- The direct to hold handling operations generally require workers to access and egress the hold without any means of assistance. There is considered to be some risk of injury associated with both unaided access and egress. Use of mechanical assistance, such as a belt loader, EBL, or a Mallaghan LBT90 usually provides a safer means of access and egress for in-hold workers.
- The forces exerted by individuals when performing the operation of manually moving passenger steps (and other GSE) is considered to present a serious risk of handling related injury or ill-health.

4 TRIAL OF AN EBL AT EAST MIDLANDS AIRPORT

Menzies Aviation and Servisair conducted a trial of an Extendable Belt Loader (EBL) over a three-week period in January 2008 at East Midlands Airport. HSE/L were present at these trials to assess the impact on the MSD risks when handling baggage on and off the aircraft. The EBL on trial was a Rampsnake provided by FMC Technologies Ltd.

4.1 APPROACH

It had been anticipated that pilot trials of the EBL using an off-line aircraft and 'dummy' suitcases would take place over a period of three days. The EBL would then be used for a live transfer of bags on selected aircrafts. Due to technical complications and inclement weather the pilot trials actually took place over a five day period with further 'live' trials taking place over the following two-weeks.

Two HSL Ergonomists were present during the pilot trials where a team of 3 handlers from either Menzies or Servisair took turns in using the EBL. Only two handlers used the equipment at any one time, one external and the other internal. Each member of the team of three tried to do both an on and off load, internal and external to the plane. After the team completed their pilot trial they were asked by the HSL Ergonomists to provide a rating of perceived exertion (see Section 4.1.3) and to give feedback on their experiences. A number of set questions had been prepared prior to the start of the trial (see Appendix C). Observation data of the live trials was collected on an opportunistic basis (a summary is given in Appendix B).

The analytical approach for this part of the study included an assessment and comparison of the risk ratings (based on the MAC) as outlined in Section 3.1.1. The OWAS postural analysis method was also used to assess handlers posture when handling bags on and off the cart. The approach taken was the same as outlined in Section 3.1.2.

4.2 RESULTS

4.2.1 Postural analysis

The method for the postural analysis was the same as described in Section 3.2.3. In total 1583 seconds of video was observed for the handling of items on and off the EBL externally. Figure 9 shows the total percentage of observed time in different back postures along with the 95% confidence intervals when using the EBL compared with the three methods assessed previously. The analysis shows that there was significantly more time spent with the back straight using the EBL compared with the other methods. There was also significantly less time spent with the back either bent or twisted. It is possible that these positive results occurred due to a change in worker behaviour as a result of being part of the trial and this difference may reduce under normal operating conditions.

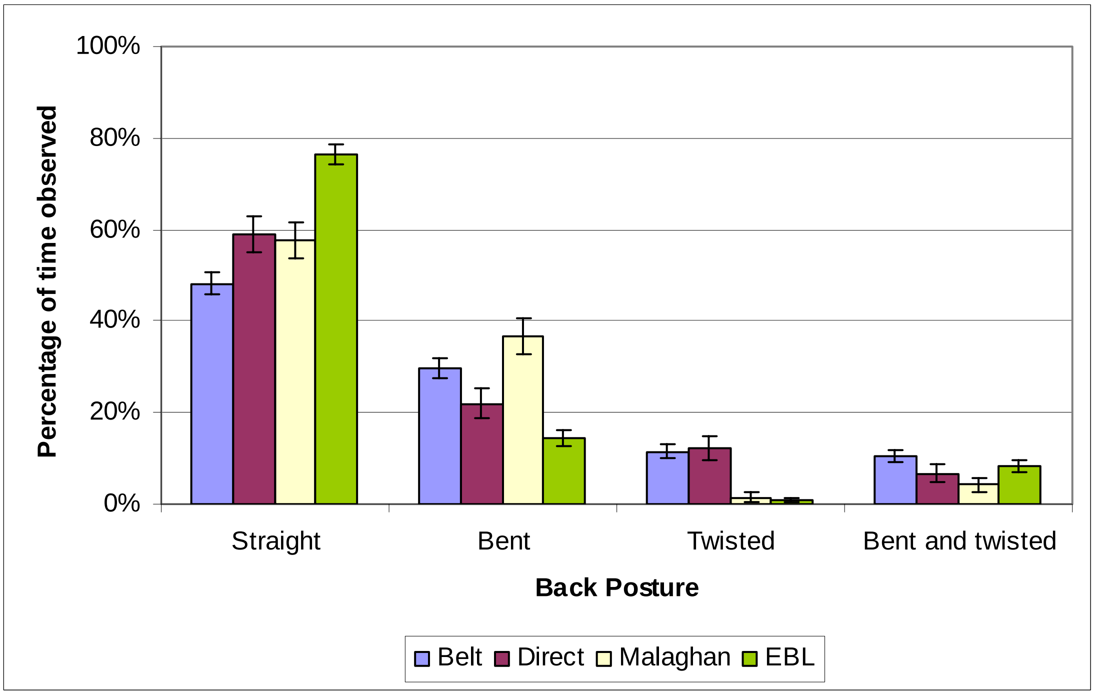


Figure 9 95% confidence intervals for the posture of the back

Figure 10 shows the total percentage observed time when either one or two hands were above shoulder height. There was no significant difference in this aspect compared to the other methods with the exception of direct to hold loading.

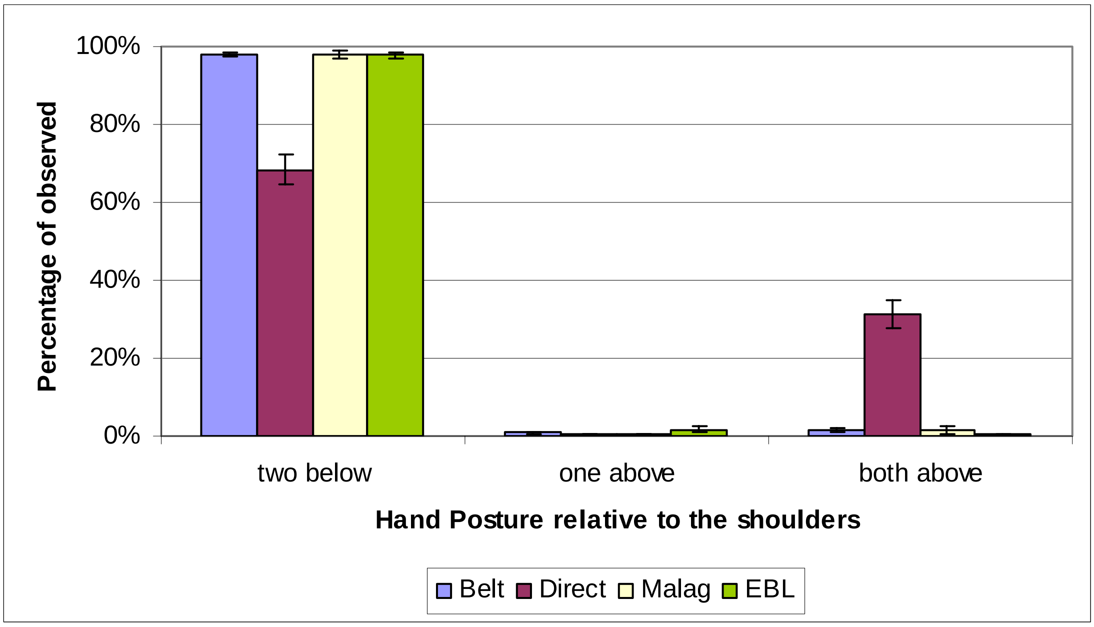


Figure 10 95% confidence intervals for the position of hands relative to shoulders

Table 15 shows the Action Categories assigned to the percentages of time observed in the range of back and arm postures when using the EBL compared to the other handling techniques. The time spent in bent and twisted postures fell into AC2 along with the belt loader and direct to hold. The bent and twisted postures were generally observed when handling bags on/off the cart.

Table 15 OWAS Action Categories applied to the percentage of observed time

	Belt Loader	*Direct to hold*	*Mallaghan*	*EBL*
Straight trunk	AC1	AC1	AC1	AC1
Twisted or bent sideways trunk	AC1	AC1	AC1	AC1
Bent forwards or backwards trunk	AC1	AC1	***AC2***	AC1
Bent and twisted or bent forward and sideways	***AC2***	***AC2***	AC1	**AC2**
2 hands below shoulder height	AC1	AC1	AC1	AC1
1 hand above shoulder height	AC1	AC1	AC1	AC1
2 hands above shoulder height	AC1	***AC2***	AC1	AC1

4.2.2 Cart location and number of handlers

The EBL can be adjusted out/in and up/down. The handlers tended to keep the end of the belt very close to the cart whether there were one or two handlers involved (Photograph 7). This therefore tended to negate the need to twist/turn between the cart and the EBL, which was observed when a single handler was transferring items to a belt loader (as shown in Photograph 1 in Section 3.2.3). This is also demonstrated in the postural analysis where virtually no twisting was observed when using the EBL. However, for two handlers to successfully use the EBL cooperation and communication will be required to ensure it is at a height/location convenient to both handlers.

Photograph 7 *One and two handler's loading bags onto an EBL*

4.2.3 Vertical lift distance

Handlers were observed to adjust the belt up and down for both on and off load operations (see Photograph 8). As a result for the on-load operation they were able to simply pull the bags onto the end of the belt. For the off-load operation handlers tended to lift items off the end of the belt to stack them, in the same manner as a belt loader is used with the exception that the vertical lift would be reduced if the belt is adjusted. Therefore, when loading items onto the cart towards the rear the hands will be extended away from the lower back and the risk of injury will not be changed for this factor.

Photograph 8 *Belt adjusted up and down*

4.2.4 Stacking items inside the hold

The EBL can also be extended down the length of the hold and moved from side to side and up/down. During the off-load, handlers were observed to pull the bags onto the EBL. As a result no lifting, twisting and propelling was required to pass the bag down the length of the hold to the hold door. During the on-load, handlers were primarily observed to lift the bags (see Photograph 9) off the EBL to stack them. The EBL was still adjusted up/down so the vertical lift distance would be reduced.

Photograph 9 *Stacking bags inside the hold*

One handler during a live trial was observed to move the EBL frequently and push the bags off the belt to stack them. However, when the frequency of the bags increased this technique was abandoned in favour of lifting them off the EBL. This indicates there is a significant training need for both internal and external handlers' to use the EBL effectively.

4.2.5 Overall risk ratings

Table 16 through to Table 19 illustrate the risk ratings given to the EBL based on the observations/analysis outlined above and compared to the other handling methods. Further details of the video obtained and observations made are given in Appendix B.

Table 16 Comparison table for off-load external handling methods

Risk Factor	***Observation***	***Direct to hold***	***Direct: off flat-bed truck***	***Mallag***	***Belt Loader***	***EBL***
Hand distance from lower back	Retrieving items from the hold				N/A	N/A
	Reaching to place items at the back of the cart		N/A	N/A If belt is not moved forward		
	Reaching to lift items onto the top of the stack towards the front					Belt used Belt not used
	Reaching to place items lower down the stack towards the front of the cart					
Vertical Lift region	Placing items at the top of the cart /lorry with hands above shoulder level					Belt used
	Placing items in the middle of the stack					Belt used
	Placing items at the base of the stack					Belt used
	Retrieving items from the hold with hands above shoulder level		N/A	N/A	N/A	N/A
	Placing items at floor level	N/A		N/A	N/A	N/A
Trunk twist/ sideways bending	Cart positioned correctly (at 45 degrees)		N/A			N/A
	Cart positioned incorrectly Flat bed lorry only - Postural constraints from restricted headroom					N/A
Postural constraints	Restricted headroom.		Stand stooped			
	Restricted footing		Platform	Platform		
Floor surface	Truck and Mallaghan		Smooth Slippery when wet	Platform could be slippery		

Table 17 Comparison table for external on-load handling methods

Risk Factor	*Observation*	*Direct to hold*	*Direct: off flat-bed truck*	*Mallag-han*	*Belt Loader*	*EBL*
Hand distance from lower back	Placing item in the hold but not pushing down the hold				N/A	N/A
	Reaching into the hold to push items to the hold stacker (pushing force not assessed)				N/A	N/A
	Reaching to pull items from back of the cart		N/A	N/A If belt is not moved forward		
	Reaching to lift items from the top of the stack					
	Reaching for items lower down the stack towards the front of the cart					
Vertical Lift region	Lifting items from the top of the cart /lorry with hands above shoulder level					Belt used Belt not used
	Lifting bags from the middle of the stack					
	Lifting bags from the base of the stack					
	Placing large items into the hold with hands above shoulder level		N/A	N/A	N/A	N/A
	Lifting items from floor level	N/A		N/A	N/A	N/A
Trunk twist/ sideways bending	Cart positioned correctly		N/A			
	Cart positioned incorrectly Flat bed lorry only - Postural constraints from restricted headroom					
Postural constraints	Restricted headroom.		Standing stooped			
	Restricted footing		Platfrom	Platform		
Floor surface	Truck and Mallaghan		Smooth metal Slippery when wet	Platform could be slippery		

Table 18 Comparison table for off-load internal hold operations

Risk Factor	***Observation***	***Handling with other methods***	***Stacking with EBL***
Hand distance from lower back	Transferring items from the in-hold stacker to the belt/external worker:	Standing stooped Kneeling	N/A
	Reaching to un-stack items in the hold: arms outstretched with trunk in a bent/twisted posture.		
	Transferring items (pushing or propelling) to the hold door		N/A
Vertical Lift region	Transferring items from the in-hold stacker to the belt/external worker.	Standing stooped Kneeling	N/A
	Un-stacking items: items tended to be pulled from the stack and allowed to drop to the floor		
Trunk twist	Transferring items from the stack and down the hold.		In front of the worker Behind worker
	Transferring items to the belt/external worker involves twisting and sideways bending		N/A
Postural constraints	Restricted headroom.		
	Restricted footing	Kneeling	Kneeling
Floor surface	Uneven hold floor surface		

Table 19 Comparison table for on-load internal hold operations

Risk Factor	*Observation*	*Handling with other methods*	*Stacking with EBL*
Hand distance from lower back	Transferring items (pushing or propelling) from the hold door to the in-hold stacker:	Standing stooped	N/A
		Kneeling	
	Reaching to stack items in the hold: arms outstretched with trunk in a bent/twisted posture.		
Vertical Lift region	Transferring items from the hold door to the in-hold stacker	Standing stooped	N/A
		Kneeling	N/A
	Stacking items: bags could be lifted from the hold floor and stacked at the hold ceiling height.		Belt used
			Belt not used
Trunk twist	Transferring items from the floor/belt loader down the hold		N/A
	Stacking items: When kneeling and facing side on to the stack, worker would typically twist though 45 degrees either side to handle bags between the floor and the stack.		No 45 degree twist either side
Postural constraints	Restricted headroom.		
	Restricted footing	Kneeling	Kneeling
Floor surface	Uneven hold floor surface		

4.3 HIERARCHY OF RISK REDUCTION

A comparison of the risk ratings within these summary assessments for the baggage handling approaches, for both internal and external working, indicates the following hierarchy of risk, starting with the lowest risk method:

- Using an EBL
- Using a belt loader
- Using a Mallaghan LBT90
- Loading direct to hold at ground level
- Loading direct to hold using a flat-bed truck

Considering each method in turn, the remaining 'residual risk' elements of the task can be described.

4.3.1 EBL

For the external worker(s) at the baggage cart the need to handle items while reaching to the far side of the cart during on and off-loads still remains. This is generally between cart level and shoulder level. If an EBL’s height adjusting belt is used, this risk is generally low. However, for EBLs without this capability the risk is the same as that for a conventional belt loader.

For the internal stacking and unstacking workers the risks are considerably reduced. There is a reduced need to lift and support loads. Items can be positioned at a suitable level for handling for a proportion of the time. The function of transferring items along the hold is performed entirely by mechanical means.

It is important to note that other approaches, such as the moving hold floor technology of the Sliding Carpet Loading System (SCLS) when used in combination with advanced belt loaders such as the RTT Longreach (Telair International AB) are considered to offer similar risk control advantages to the EBL technology (Riley, 2008).

4.3.2 Belt loader

For the external worker(s) at the baggage cart the need to handle items while reaching to the opposite side of the cart during on and off-load still remains. This is generally between cart level and shoulder level. There can be twisting and/or sideways bending of the trunk if the cart is positioned poorly.

Compared to the EBL, there is an additional need to manually move items along the hold. This function needs to be performed by an extra worker positioned within the hold doorway for on-loads, and by the un-stacking worker during off-loads. For the internal stacking and un-stacking workers, the risks are the same as for the Mallaghan LBT90 and direct to hold methods.

4.3.3 Mallaghan LBT90

The change in risk associated with the Mallaghan LBT90 is only for the external workers on it. Reach distances to grasp and place items are generally improved compared to using a beltloader, but there is an increased risk rating associated with the likely tendency to twist the trunk due to restricted platform space, although postural analysis suggests that in practice the percentage of time in these postures is small. There is a risk that the hand distance from the lower back is increased if the belt mechanism fails or jams temporarily. Also, if workers then have to stand on the belt to move the bags there is a risk of slipping. As for the belt-loader, there is still a high risk associated with handling to or from high on the stack, where hands can be raised above shoulder level. The platform surface has the potential to be slippery. The transfer of bags down the hold to the in-hold stacker is generally performed by the external worker positioned on the Mallaghan during on-loads and by the single internal worker during off-loading. For these reasons the risk is ranked slightly higher than for belt loader use. However, there are no baggage carts required, avoiding the possibility that they might be moved manually. The advantage of the Mallaghan LBT90 over direct to hold loading is that the external worker does not need to raise the bags as high to load and transfer them down the hold because they are stood on a height adjustable platform.

4.3.4 Direct to hold from ground level

In addition to the risks associated with reaching to the opposite side of the cart, the external workers are presented with an increased risk associated with a larger vertical lift region. Although the handling is all above the cart level, the level of the handling can extend upwards to head height and above.

As was the case for the Mallaghan LBT90, the transfer of bags down the hold to the in-hold stacker tends to be performed by the external worker(s) for on-loads although an additional internal worker located within the hold doorway may sometimes perform this function.

4.3.5 Direct to hold using a flatbed truck

For the external workers the main risks are associated with the hand distance from lower back and vertical lift region during the stacking and un-stacking on the flatbed. Handling of items occurs between close to floor level and shoulder level. Working at the hold doorway typically requires stooping, which can be prolonged. There is also a tendency for both trunk twisting and sideways bending for the external worker at the hold doorway. There is an increased risk of a fall from low height due to working on an open platform that has the potential to be slippery. The need for the external worker to transfer bags down the hold remains. For these reasons the risk is considered to be greater than when loading direct to hold from ground level.

The key residual risks associated with the range of work methods and equipment assessed is summarised in Table 20.

Table 20 Key residual risk areas associated with manual baggage handling methods

	Direct to hold: using flatbed truck	Direct to hold: at ground level	Mallaghan	Belt Loader	EBL
Reaching to place items at the rear of the cart	●	●	●	●	●
Reaching to floor level to handle baggage to and from the plane	●				
Reaching above shoulder height to handle baggage to/from the hold	●	●			
Manually transferring items down the hold to the in-hold stacker	●	●	●	●	
Reaching to floor level inside the hold to handle baggage	●	●	●	●	
High level of lifting inside the hold	●	●	●	●	
Restricted posture within the hold	●	●	●	●	●

4.3.6 Rating of perceived exertion

Ratings of perceived exertion were obtained from handlers after they had completed the pilot trials and after a live trial. The pilot and live trial ratings for handling inside the hold and handling between the cart and EBL were combined to give an average rating of perceived exertion (Table 21). When handling inside the hold the rating has more than halved when compared to the traditional stacking method.

Table 21 Ratings of perceived exertion by baggage handlers' during the trial of the EBL

Location	***Task***	***Average rating***	***Workload***

Handling inside the hold	Stacking	2.78 SD=1.48, N=16	Light to heavy
Handling on the ground	Handling between the cart and the EBL	2.57 SD=1.38, N=14	Light to heavy

4.4 QUALITATIVE DATA FROM QUESTIONNAIRE / INTERVIEWS

Where possible, handlers were asked a number of questions about their experience of handling items using the EBL. The aim of the questions was to prompt the handlers to provide feedback on their initial thoughts on the usability of the equipment and how they thought it affected handling. The questions included the positioning and moving of the EBL to and from the aircraft, handling within the hold and handling between the cart and loader (and vice versa). The feedback on handling was further broken down into on and off load. A total of 11 different handlers provided feedback.

There were three themes identified from the feedback on handling within and outside the hold. These were legroom (hold only), use of the belt and handling assessment. This feedback is shown below.

4.4.1 Handling within the hold

Legroom

- 3 of the 11 handlers commented that they felt that the EBL reduced the legroom available in the hold.

Using the extending belt

9 of the 11 handlers commented on the use of the internal extending belt. These comments included:

- Problems encountered when retracting and extending the EBL. For the on-load it was felt it was difficult to move the EBL back when the belt was full. One handler also mentioned that they had to lean out of the hold a little to retract/extend the EBL.
- Bags slipping off the side of the belt.
- Difficult to use the belt when close to the door and reaching into the top corner.

Handling assessment

7 of the 11 handlers commented on the affect they felt it had on handling: These comments included:

- Off-load is better as the handler does not have to propel bags down the hold.
- Off-load is considered to be a one-handled job and easier than the on-load.

- The task is improved as the handler does not have to lift off the floor/belt lifts so it requires less effort and is easier on the body.

- For the on-load the handler still needs to handle items to stack them/some manual handling will be required.

- The on-load needs the right pace and spacing to work well.

Observation of the video data showed that the pace and frequency of delivery of items for the on-load appeared to impact upon the handlers opportunity to use the adjustable EBL. This seemed to result in the handler needing to lift more in order to keep pace with the flow of bags. This appeared to be more of a problem as the handler neared the hold door. It is possible for the in-hold handler to adjust the speed of the EBL and even to stop it. However, it was not apparent that it was used frequently to help control the pace of the work.

4.4.2 Handling between the cart and the belt

The following comments were made about handling between the aircraft and the cart. These comments included:

Using the extending belt

3 of the 11 handlers commented on the use of the external extending belt:

- The extending belt can make it easier to load bags from the far side although this may be dependent on the cart location.

- When two people were involved in the on-load the belt was inadvertently knocked and swung between each person.

Handling assessment

- During on load bags can be pulled/slid onto the belt and not lifted.

- Position of the cart is important to minimise lifting and to give room to get around.

Observation of the video data showed that the use of the adjustable tongue varied between individuals and between two-person teams. In the case of the two-person team, on one occasion the belt was used and the handlers took turns to adjust it in accordance with their next item. A second team left the belt in one location and loaded the bags as they would usually.

4.5 SUMMARY

The following is a summary of the findings from the EBL trial:

- There is no requirement for the external or internal door handler to transfer bags down the hold – this is a significant reduction in the task requirement.

- Little or no lifting is required during the external on-load when the EBL is adjusted, which means there is either a reduced or no effect from the vertical lift distance, trunk twisting/sideways bending, and hand reach from the lower back.

- Handlers perceive that stacking items inside the hold requires less exertion using the EBL than when handling without it. The in-hold stackers commented that the off-load in particular is improved by the use of the EBL.

- The in-hold stacker is not handling items off the floor, which reduces the vertical lift. Depending on how the handler uses the EBL within the hold, there is a reduced need to lift and support the loads, particularly during the off-load. There also appears to be a reduction in twisting/sideways bending.

- The hand reach was still high when the in-hold stacker was observed to reach over the EBL to stack items in the top far corner.

- The frequency of bag delivery can affect the time available to adjust the EBL, and therefore the use of this function.

- There is limited space available for both the EBL and the handler, particularly in the smaller holds.

- A comparison of the risk ratings of the five different methods indicates that the use of an EBL provides the lowest level of risk, followed by a belt loader and a Mallaghan LBT90.

5 MUSCULOSKELETAL DISORDER SYMPTOMS

The Nordic Musculoskeletal symptom Questionnaire (NMQ) is a standard questionnaire (see Appendix D), which has been adapted by HSE (Dickinson et al., 1992) and is used by HSE to survey the prevalence of musculoskeletal 'trouble' across a number of work forces. The opportunity to administer this questionnaire was taken during the site visits made in August 2007. The HSL revised version of the HSE Musculoskeletal Symptom Questionnaire (HSEMSSQ; Marlow et al., 2005) was distributed to all Menzies Aviation and Servisair handlers encountered during the visits. The intention was simply to gather the first known UK data indicating the prevalence of MSD symptoms amongst baggage handlers. The data was to be shared with Menzies Aviation and Servisair once collated and made anonymous.

5.1 APPROACH

The questionnaire is split into three sections. The first deals with personal details including age, height, and weight. The second deals with details 'about your job' and the third is about musculoskeletal disorders and is linked to a diagram of the body, which identifies nine body regions. Three questions are asked about each of these regions:

1. 'Three months prevalence' of musculoskeletal 'trouble' is measured by questions that ask whether 'during the last 3 months' the respondent has experienced 'trouble (such as ache, pain, discomfort, numbness)' in each of the nine body regions.

2. 'Weekly prevalence' of musculoskeletal 'trouble' is measured by questions that ask for each body region, whether the respondent has had trouble 'during the last seven days'.

3. 'Three month disability' caused by musculoskeletal 'trouble' is measured by questions which ask whether the 'trouble' has, during the previous 3 months, prevented the respondent from 'carrying out normal activities (e.g., job, housework, hobbies).

An additional section on 'work characteristics' was added to the HSEMSSQ to measure psychosocial factors as well as the prevalence of musculoskeletal trouble. Pinder (2001) developed the 'work characteristics' question set, which were based on a Swedish original (Johansson and Rubenowitz, 1994). In all there are 30 questions distributed across 6 psychosocial factors. The six factors are:

1. Influence on and control over work (WCF1).

2. Supervisor climate (WCF2).

3. Stimulus from the work itself (WCF3).

4. Relations with fellow workers (WCF4).

5. Psychological workload (WCF5).

6. Management commitment to health and safety (WCF6).

Five-point Likert-type scales with anchors of 'Strongly disagree' = 1 and 'Strongly agree' = 5 were used and the questions were grouped by factor, with all positive responses being in the same direction. Scores for each factor were obtained by adding the scores on five items in the factor. The work characteristics section of the questionnaire were not analysed at this stage because the main focus was on the MSD symptom reporting.

A total of 16 Servisair and 16 Menzies employees completed a questionnaire about their job and musculoskeletal disorders. All of the respondents were involved in the process of ramp based baggage handling.

5.1.1 Distribution

The questionnaire was distributed at East Midlands Airport over a two-day period on the 20th and 21st of August. The HSE Inspector leading the project and two HSL ergonomists administered the questionnaire over a two-day period, following a briefing to staff on the purpose of the survey. This involved distributing the questionnaire to the handlers and others involved in the baggage handling process at opportune moments during the day, mainly when they were taking breaks in the rest room. A number of questionnaires were also left with the managers to be distributed to employees who were not available at the time of the visit.

5.1.2 Data analysis

A total of 32 questionnaires were completed at the time of the visit and a further 5 questionnaires were completed afterwards and forwarded in the post. The collected surveys were input into MS Excel worksheets adapted from previous work on the assessment of musculoskeletal prevalence (Binch et al., 2007). The data were analysed using MS Excel to produce charts and calculate frequency statistics.

5.2 RESULTS – PERSONAL DEMOGRAPHICS

The following sections summarise the responses of the 37 respondents surveyed relating to personal demographic aspects such as age, gender, height and weight.

5.2.1 Gender and age

All of the respondents were male (n=37). The youngest respondent was 19 and the eldest 59 years of age. The average age was 32 years old. Figure 11, shows the breakdown of ages in ten-year brackets. The chart shows that the number of people in the first three age categories is quite evenly distributed. Two of the respondents chose not to indicate their age.

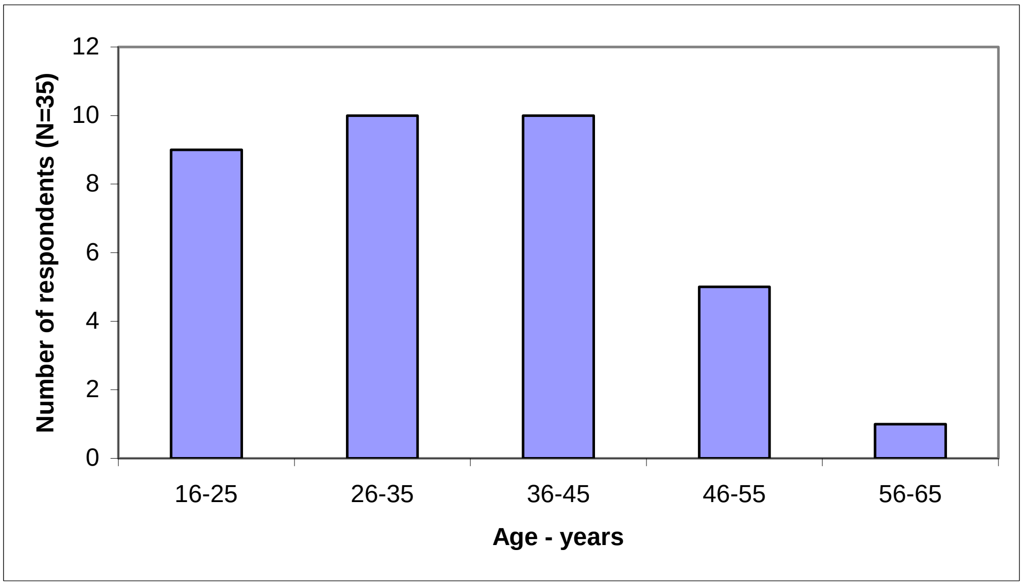


Figure 11 Chart to show respondents age

5.2.2 Height and Weight

The respondents reported an average height of 1.79 metres. The heights reported ranged from 1.65 metres (6th percentile) to 1.93 metres (99th percentile) tall. Three respondents chose not to report their height. As can be seen from Figure 12, the greatest number of respondents reported their height as being between 1.75-1.79 and 1.85-1.89 metres tall. More than half (53%) of the respondents are less than 1.8 metres tall.

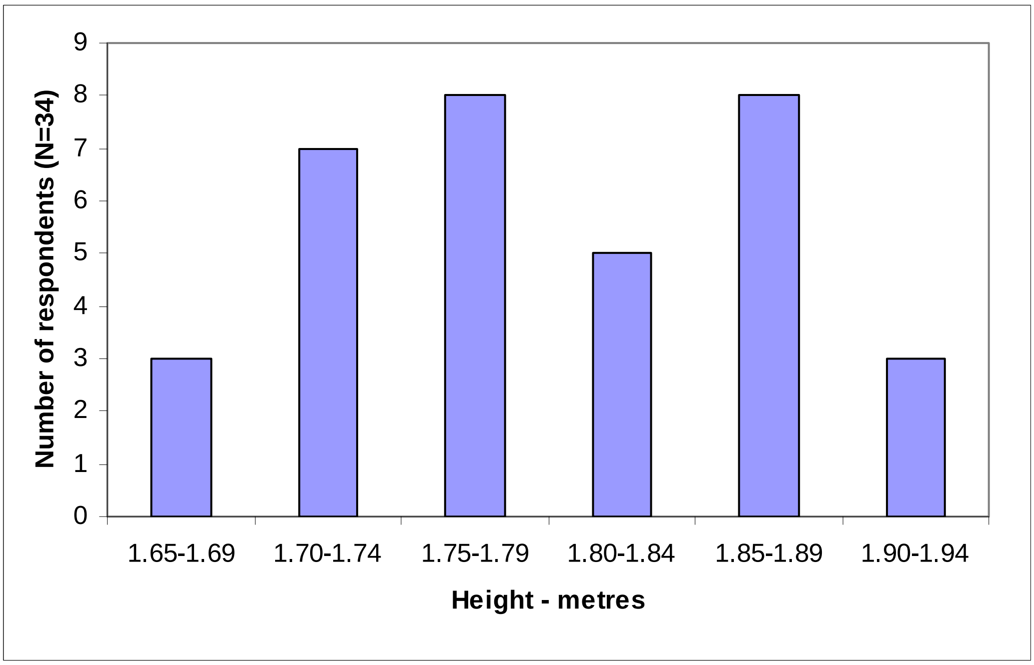


Figure 12 Chart to show respondents height

Of the respondents completing the survey, 94% (n = 35) reported their weight. An average weight of 83 kg was reported with the self-reported weight for the respondents ranging from 59 to 121 kg. As can be seen in Figure 13, over half the respondents (66%, n = 23) reported weights between 70 and 89.9 kg.

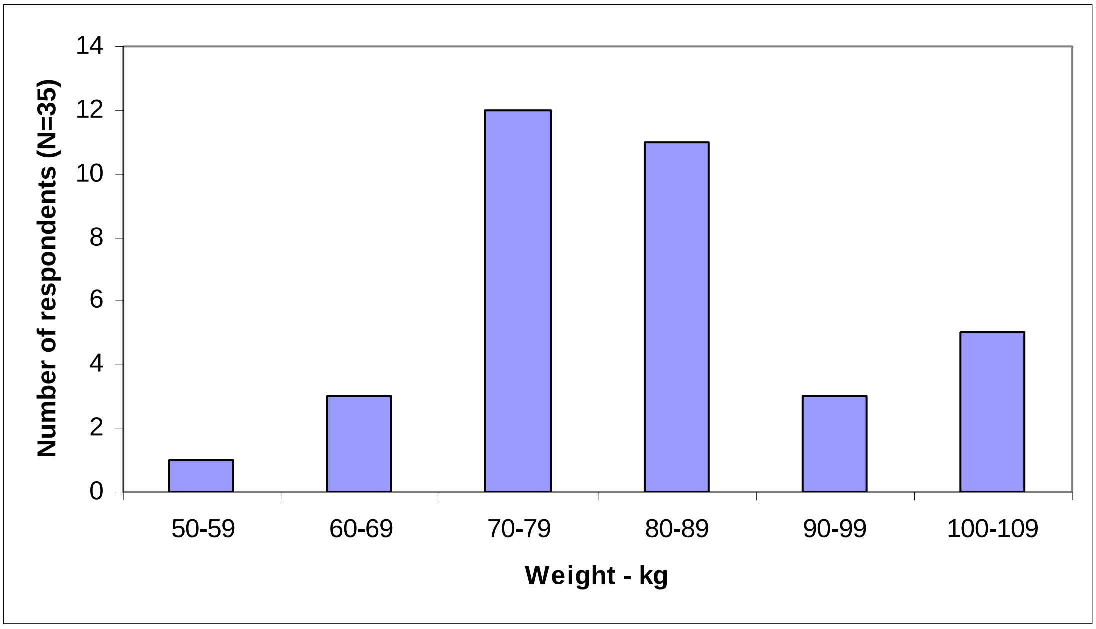


Figure 13 Chart to show respondents weight

5.2.3 Workplace demographics

This section summarises the responses of the 37 respondents to questions relating to job title, tenure, and length of shift.

Three job title options were included on the survey – baggage handler, supervisor (2IC or Leading Hand) and manager (Ramp or Duty Manager). Of the 37 respondents, 78 % (n = 29) reported their job title as baggage handler, 14% (n = 5) as supervisor, and 8% (n = 3) as a manager. The average length of service of a baggage handler was 2.69 years, whereas for supervisors it was 7.85 years and managers it was 12.81 years.

The number of hours worked by Baggage Handlers ranged from 30 to 60 hours, with an average of 41 (n=29). The number of hours worked by Supervisors ranged from 40 to 55 hours, with an average of 45 (n=5) whereas managers hours ranged from 39 to 60, with an average of 46 (n=3).

5.3 RESULTS - MUSCULOSKELETAL DISORDER SYMPTOMS

The HSL revised version (Marlow et al., 2005) of the HSEMSSQ was used to obtain information on musculoskeletal disorders. The HSEMSSQ asks about musculoskeletal "trouble" in nine body areas that are illustrated in an accompanying diagram. Two periods are used: the previous three months (found to be equivalent to 12 months) and the previous seven days. 'Trouble' was defined in the questionnaire as "ache, pain, discomfort, numbness, tingling or pins and needles". A further set of questions for each of the nine body parts asks whether the disability due to musculoskeletal trouble had prevented the person "carrying out normal activities (e.g., job, housework, hobbies)" and if during the last three months this trouble had been caused or made worse by work.

5.3.1 Reports of musculoskeletal trouble

Table 22, gives the proportions of subjects reporting musculoskeletal trouble in the nine body areas of the NMQ in the previous three months and the previous seven days. It also gives the proportion reporting disability due to musculoskeletal trouble in the previous three months. Data are also reported for whether the respondent considered that any trouble they had experienced in the previous three months had been caused or made worse by their work.

Table 22 Self reports of musculoskeletal trouble in nine body areas (N=31 to 37)

	Trouble in the previous 3 months	Trouble in the previous 7 days	Disability due to trouble in the previous 3 months	Trouble in the previous 3 months caused by the job	Trouble in the previous 3 months made worse by the job
Neck	36.1%	25.0%	8.3%	11.8%	5.9%
Shoulder	43.2%	24.3%	10.8%	25.7%	2.9%
Elbows	24.3%	11.1%	8.3%	6.1%	3.0%
Wrists/hands	35.1%	24.3%	10.8%	11.4%	5.7%
Upper back	31.4%	17.1%	2.9%	12.1%	0.0%
Lower back	73.0%	43.2%	28.6%	45.2%	0.0%
Hips/thighs/buttocks	11.1%	5.6%	2.8%	0.0%	0.0%
Knees	51.4%	27.0%	18.9%	22.9%	5.7%
Ankles/feet	24.3%	10.8%	8.1%	5.7%	0.0%

The most common reports of trouble were in the lower back: 73% reported trouble in the previous 3 months and 43% reported trouble in the previous 7 days. Trouble in the lower back in the past 3 months was also sited as the most common body part that lead to disability (i.e. prevented the person carrying out normal activities) at 29% with 45% of respondents reporting that the trouble was caused by work. The knees were the second most commonly reported body part that gave trouble in the previous 3 months at 51% with 27% saying they had caused trouble in the past 7 days. Less than a quarter (23%) of respondents thought that trouble with their knees was caused by work. The hips/thighs/buttocks gave the least amount of trouble and no respondents thought this trouble was caused by or made worse by work.

Figure 14, shows the prevalence of trouble in the previous 3 months, the disability due to the trouble and the work relatedness (caused or made worse by the job) of the trouble.

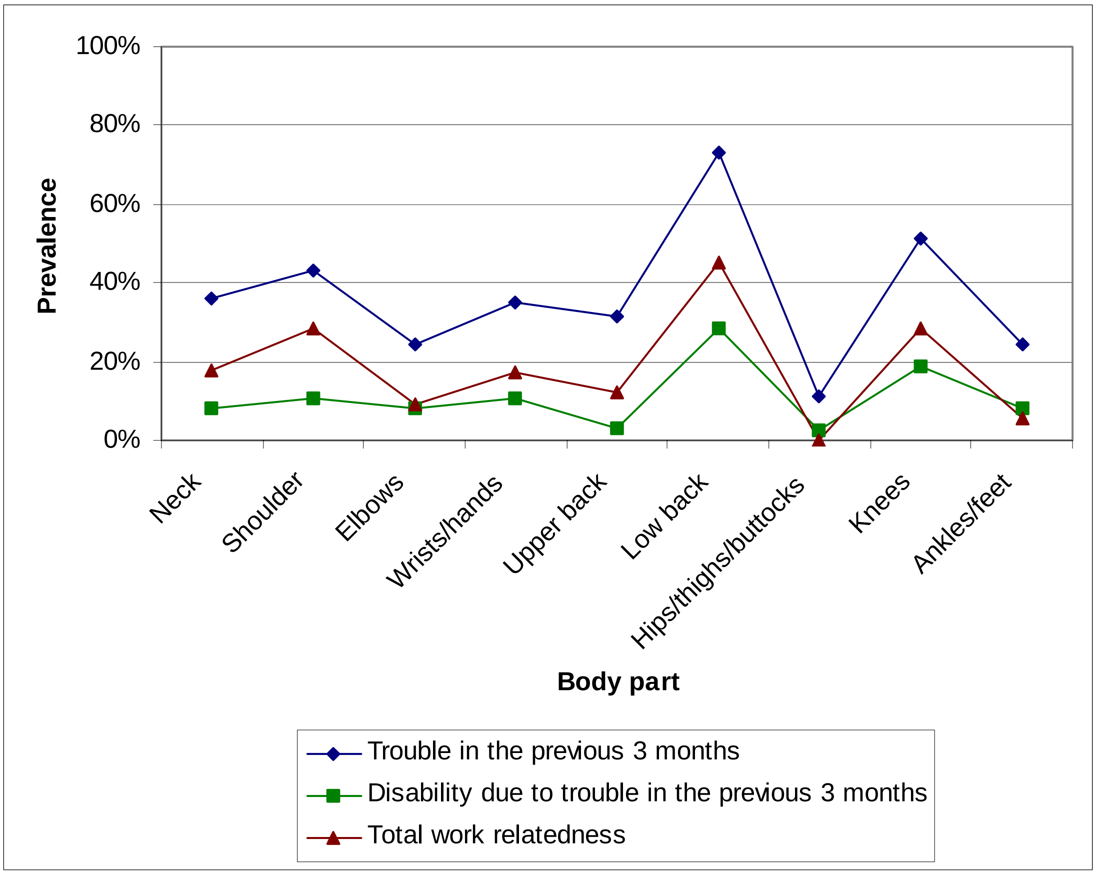


Figure 14 Prevalence of trouble, disability and work relatedness in nine body parts

Table 23 shows the prevalence of 7-day trouble, disability, and work relatedness relative to the frequency of reports of trouble in the past 3 months across all nine-body parts. In all body areas except the ankles/feet, elbows and hip/thighs/buttocks, more than 50% of those who reported trouble in the previous 3-months also reported trouble in the previous 7-days. The highest rates were for the wrist/hands and the neck both at 69%. This suggests that of the individuals experiencing musculoskeletal problems, the symptoms do not disappear rapidly. For the ankles/feet and elbows, just under half (44%) reported problems in the previous 7 days so this suggests that symptoms would seem to disappear more quickly compared to the wrists/hands and neck.

Trouble caused by work ranged between 0% in the hips/thighs/buttocks to 56% in the shoulder. However, there were no reports that lower or upper back trouble were made worse by work, which was also the case for the hips/thighs/buttocks and ankles/feet. The wrists/hands and the neck both had the highest number (15.4%) of reports of trouble made worse by work.

Table 23 Reports of seven-day trouble, disability and work-relatedness relative to reports of trouble in the previous three months

	Trouble in the previous 3 months (N)	Trouble in the previous 7 days	Disability	Trouble caused by work	Trouble made worse by work
Neck	13	69.2%	23.1%	30.8%	15.4%
Shoulder	16	56.3%	25.0%	56.3%	6.3%
Elbows	9	44.4%	33.3%	22.2%	11.1%
Wrists/hands	13	69.2%	30.8%	30.8%	15.4%
Upper back	11	54.5%	9.1%	36.4%	0.0%
Lower back	27	59.3%	37.0%	51.9%	0.0%
Hips/thighs/buttocks	4	50.0%	25.0%	0.0%	0.0%
Knees	19	52.6%	36.8%	42.1%	10.5%
Ankles/feet	9	44.4%	33.3%	22.2%	0.0%

Table 24 (and Figure 15), compares the three-month prevalence of musculoskeletal troubles with 3 previous manual handling surveys carried out by HSL/HSE using the same questionnaire. The jobholders at the manufacturing site tended to be process workers and craftsmen. The “industrial workers” were measured at baseline as part of a longitudinal study of lower back pain risks (Pinder, 2004). The track worker data surveyed jobholders who were responsible for maintaining and laying railway track. This covers a very diverse range of jobs that all involve significant manual handling. Table 25 (and Figure 16) compares the seven-day prevalence this time replacing the track worker data with construction worker data taken from the Nordic reference data (1986/87).

Baggage handling produced the highest prevalence rates for trouble experienced in the last three-months/year for seven (neck, shoulders, elbows, wrists/hands, upper back, lower back, knees,) of the nine body parts. This scenario is the same for the seven-day reports.

Table 24 Comparison of three-month prevalence of musculoskeletal troubles with three HSL/HSE surveys

	Baggage Handing (N=31-37)	Manufacturing site (N=166)	Industrial workers (N=500-511)	Track Workers (n=25)
Neck	36.1%	22.2%	29.6%	14%
Shoulder	43.2%	27.6%	28.5%	24%
Elbows	24.3%	7.9%	15.1%	4%
Wrists/hands	35.1%	23.5%	31.7%	16%
Upper back	31.4%	17.3%	12.4%	4%
Lower back	73.0%	39.6%	43.6%	64%
Hips/thighs/buttocks	11.1%	7.1%	13.6%	8%
Knees	51.4%	20.0%	23.5%	20%
Ankles/feet	24.3%	18.1%	22.2%	24%

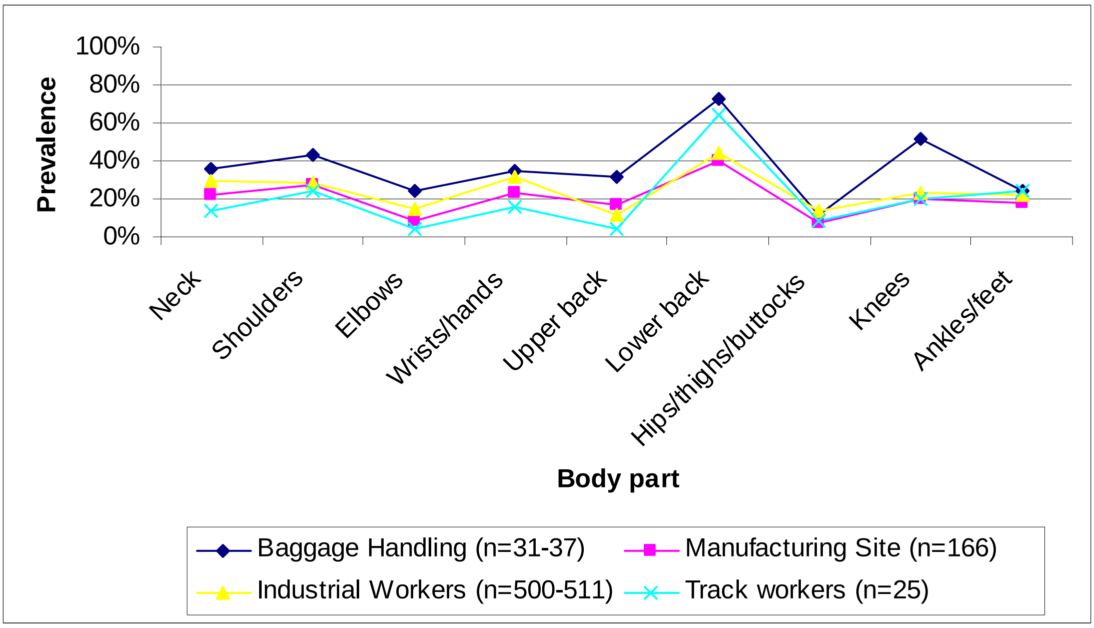


Figure 15 The three-month prevalence of musculoskeletal trouble in three HSL/HSE surveys

Table 25 The seven-day prevalence of musculoskeletal trouble in two HSL surveys and one Nordic Reference survey

	Baggage Handing (N=31-37)	Manufacturing site (N=166) HSL survey	Industrial workers (N=500-511) HSL survey	Construction Workers (n=104) Nordic reference data 1986/87
Neck	25.0%	12.2%	15.8%	18%
Shoulder	24.3%	15.8%	15.3%	22%
Elbows	11.1%	6.0%	7.4%	10%
Wrists/hands	24.3%	14.1%	19.2%	13%
Upper back	17.1%	11.6%	5.4%	10%
Lower back	43.2%	21.7%	21.8%	23%
Hips/thighs/buttocks	5.6%	5.1%	7.5%	13%
Knees	27.0%	12.9%	14.2%	24%
Ankles/feet	10.8%	14.7%	16.4%	13%

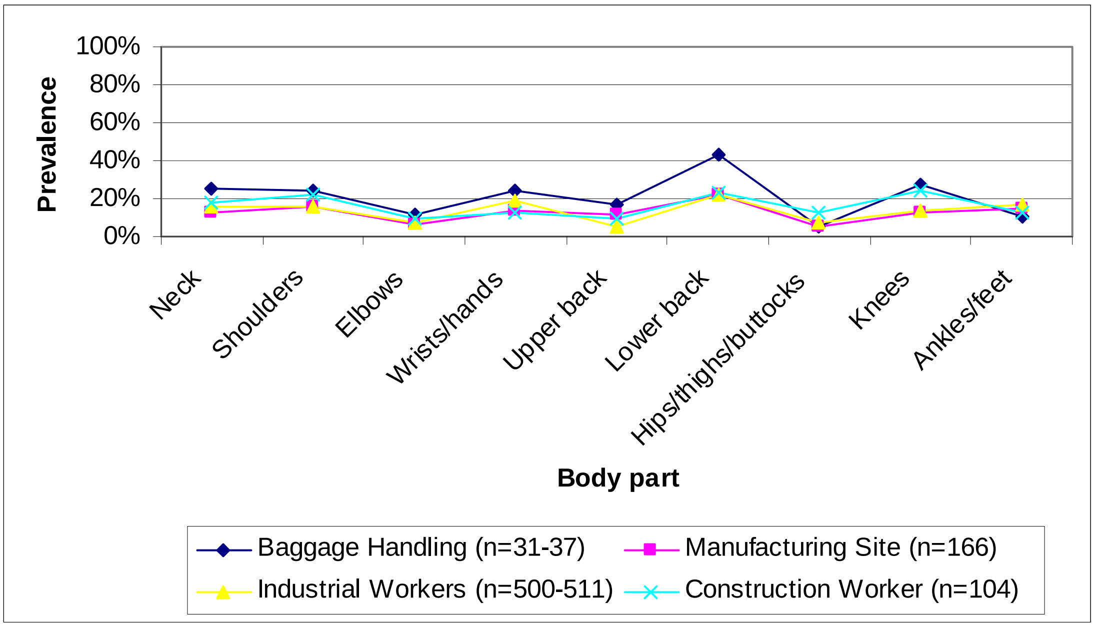


Figure 16 The seven-day prevalence of musculoskeletal trouble in two HSL surveys and one Nordic Reference survey

The results obtained from the EMA sample compare favourably with other musculoskeletal symptom self reports among baggage handlers gathered using the NMQ. Andersson et al (1984), report their survey of SAS baggage loading employees, with 62% annual prevalence for lower back problems, 45% annual prevalence for knee pain, and 33% annual prevalence for neck and shoulder pain. Stålhammar et al (1986), report a 60% annual prevalence of lower back and knee pain, and over 50% annual prevalence of shoulder pain and 40% neck pain.

5.4 SUMMARY

- The average age of the respondents was 32 with an age range of 19 to 59.
- The average height reported was 1.79 metres with height ranges between 1.65 metres (6^{th} percentile) to 1.93 metres (99^{th} percentile).
- The most common reports of trouble experienced by baggage handlers in the past three months are in the lower back (73%) knees (51%), and shoulders (43%).
- Over 40% who had trouble with their lower back thought it was work related.
- The baggage handling results follow a similar trend pattern to other manual occupations including craftsmen, industrial workers, track workers and construction workers.
- Baggage handlers at EMA report more trouble in the upper and lower back and the knees compared to the other occupations.
- Two other separate NMQ surveys of baggage handlers reported a high prevalence of trouble in the lower back, knees, shoulders and the neck. These results compare favourably with the EMA survey.
- The results provide evidence of the demanding nature of airport ground handling work.

6 CONCLUSIONS

6.1 BAGGAGE HANDLING METHODS RISK COMPARISON

The assessment of the current baggage handling methods identifies a number of manual handling related factors, which expose a significant proportion of the working population to the risk of injury. This includes the vertical height and distance of the lift, the hand reach from the lower back, trunk twisting and sideways bending, postural constraints and the grip on the load. The potentially high load weights combined with the frequency of handling also contribute to the risk of injury. The evidence presented in this report, and other studies including previous work by the HSE (Tapley & Riley, 2005 and Riley, 2008) provide a strong case for this task to be re-designed to reduce the risk of injury.

A comparison of the risk ratings of five different baggage handling methods indicates the following hierarchy of risk, starting with the lowest:

1. EBL type technology – There is a risk reduction for the external worker in terms of postural improvement for an EBL with a height adjusting and extending belt, however, for other EBLs without this capability the risk is the same as that for a conventional belt loader. There is a considerable risk reduction for the internal worker through the automation of the transfer of the bags down the hold, the reduction in lifting required, and the posture when lifting. There are other approaches that perform similar functions, such as the combination of moving hold floor and advanced beltloader technology (e.g. SCLS and RTT Longreach).

2. Beltloader – The vertical lift region when using a belt loader generally remains above knee and below shoulder level. When poorly set up the there may be an increased tendency for trunk twisting and/or sideways bending. Compared to the EBL, there is an additional need to manually move items along the hold. This function needs to be performed by an extra worker positioned within the hold doorway for on-loads, and by the un-stacking worker during off-loads. For the internal stacking and un-stacking workers, the risks are the same as for the Mallaghan LBT90 and direct to hold methods.

3. Mallaghan LBT90 – The change in risk associated with the Mallaghan LBT90 is only for the external workers on it. The vertical lift region is similar to that observed when using a belt loader, and reach distances to grasp and place items are generally improved compared to using a beltloader. There is a risk that the hand distance from the lower back is increased if the belt mechanism fails or jams temporarily. Also, if workers then have to stand on the belt to move the bags there is a risk of slipping. The external handler will generally have the additional risk associated with transferring the bags down the hold to the in-hold stacker. Due to the relative position of the stack and the hold, there is considered to be an increased tendency for trunk twisting, but in our observations the proportion of time spent in these postures was small. The platform surface has the potential to be slippery. For these reasons the risk is ranked slightly higher than for belt loader use. However, there are no baggage carts required, avoiding the possibility that they might be moved manually.

4. Direct to hold from ground level – The vertical lift region can be between cart and above head height depending on the sill height of the hold door. There is also the additional risk associated with reaching to the opposite side of the cart compared to the Mallaghan LBT90. The external handler will generally transfer the bags down the hold to the in-hold stacker.

5. Direct to hold using a flatbed truck – The vertical lift region occurs between close to floor level and shoulder level. Depending on the headroom, the hold doorway can restrict the external handlers posture. There is also a tendency for both trunk twisting and sideways bending for the external worker at the hold doorway. There is an increased risk of a fall from low height due to working on an open platform that has the potential to be slippery. The need for the external worker to transfer bags down the hold remains. For these reasons the risk is considered to be greater than when loading direct to hold from ground level.

The EBL technology trialled in this project reduces the risk of injury primarily through the mechanisation of the transfer of bags down the hold and the use of height adjustable belts. The outcome of the trial is that this type of technology can significantly reduce the risk of injury, particularly to the internal stacker. The following comments apply to any EBL that has similar operational features to that studied. Further observations relating to the use of the EBL include:

- The external adjustable element of the EBL studied can reduce lifting during on-load operations when used. Consequently there is no vertical lift distance, almost no twisting between the cart and EBL, and a reduced effect on the body of the hand distance from the lower back. For other EBLs that do not have this capability the risk is the same as that for a conventional belt loader.

- The internal adjustable element of the EBL can reduce lifting and the vertical lift distance when used effectively. It also appears to reduce the need to twist (through up to 45 degrees) either side.

6.2 MUSCULOSKELETAL SYMPTOM REPORTS

The HSEMSSQ questionnaire results provide further evidence that the current baggage handling methods are physically demanding with 73% of handlers reporting trouble with their lower back in the past 3-months, 51% reporting trouble in their knees and 43% reporting trouble in their shoulders. Compared to other NMQ data from physically demanding tasks, baggage handling produced the highest prevalence rates for trouble experienced in the last three months/year. The results of the EMA survey also compare favourably with other NMQ survey data from baggage handlers, which also report a high prevalence of trouble in the lower back, knees, shoulder and neck.

6.3 MANUAL MOVEMENT OF GSE AND AIRCRAFT STEPS

The routine manual pushing and pulling of GSE, and especially passenger steps can expose staff to very high levels of risk.

There are a range of reasonably practicable ways, which are commercially available, that will eliminate the need to manually move aircraft steps including:

- Pedestrian controlled tugs;

- Pedestrian controlled powered GSE, such as the aircraft steps in use at Amsterdam Schipol;

- Driveable GSE/steps.

6.4 OTHER OBSERVATIONS

Other observations made include the falls from height risk associated with direct to hold on-loading and off-loading, since there is no equipment present to assist with access to, or egress from the aircraft. Belt-loaders, EBLs and Mallaghan LBT90s provide a means for workers to access and egress the hold. Baggage carts and flatbed trucks are often used to gain access/egress, however since these are typically not designed as a means of access, there are likely to be associated fall risks. Similarly, where staff are working on flatbed trucks (which have no edge protection), and within the hold at the hold door there is also the risk of a serious injury resulting from a fall.

7 RECOMMENDATIONS

The following recommendations are made to reduce the musculoskeletal ill-health (and other) risks that baggage handlers are exposed to:

- This study shows that EBL type technology significantly reduces musculoskeletal risks through the mechanisation of the transfer of bags down the hold and improvements in posture and lifting. Therefore the GB aviation industry should consider using such technologies as a way to partly mechanise the task of handling baggage within the hold of the aircraft.

- For the external on and off-load of bags the vertical level and lift distance of the bags is more favourable when using a belt loader or Mallaghan LBT90 compared to direct to hold loading from the ramp. A mechanical means should therefore be used in place of direct to hold loading wherever appropriate.

- It is considered that workers loading bags with the Mallaghan LBT90 may be likely to twist the trunk due to the location of the bags being parallel to the hold, however, postural analysis suggests that the proportion of time spent in these postures is small. Because of the relatively small sample of workers observed using this equipment, it is recommended that its use be assessed further.

- The high risk manual movement of aircraft steps should be avoided and the following methods of mechanisation should be explored, pedestrian controlled tugs; pedestrian controlled powered steps; and driveable steps.

- Means of risk reduction and control should also be explored for the other ancillary manual handling operations that handlers perform. For example, the baggage cart positioning, and the placement and collection of cones around the aircraft. Where some form of mechanical assistance is already in place, ensure that it is used. Further training and supervision may be required to achieve this.

- A suitable means of access and egress to the aircraft for baggage handlers should be identified and provided, both in terms of safety from of falls from height and enabling effective working postures. For example for staff working on flatbed lorries there is no edge protection and there is restricted headroom and footing, which leads to more twisting and sideways bending when handling.

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9 APPENDICES

APPENDIX A

Table 26 Details of video recorded (times are in hh:mm:ss)

Aircraft Type	Tape No.	Date	Video recording duration	Methods captured
737/300	3 and 4	21/08/07	00:16:04 00:08:06 internal 00:07:58 external	On and off load external: direct to hold, single worker On and off load internal: single worker
737/500	3 and 4	21/08/07	00:19:54 00:10:06 internal 00:09:46 external	On and off load external: direct to hold, single worker On and off load internal: single worker
737/800	1 and ST1	20/08/07	01:05:57 00:32:28 internal 00:33:29 external	On and off load external: direct to hold and belt loader, two workers On and off load internal: two workers
757/200	2 and ST2 3 and 4	20/08/07 21/08/07	001:14:56 00:30:59 internal 00:43:57 external	On and off load external: belt loader, single worker On and off load internal: two workers
A319	3 and 4	21/08/07	00:14:20 00:07:07 internal 00:07:13 external	Off load external: belt loader, two workers Off load internal: two workers
A321	1 and ST2	20/08/07	00:44:49 00:20:41 internal 00:20:08 external	On and off load external: belt loader (on) and Mallaghan (off) On and off load internal: two workers (on) and single worker (off)
Embraer	3	21/08/07	00:01:59 00:00:20 Internal (unusable) 00:01:39 external	Off load external: direct to hold, single worker
BAE146	6	25/10/07	00:00:53	On load external: direct to hold, two workers
Jetstream J41	6	25/10/07	00:04:36	On load external: direct to hold from flat bed truck, two workers
SAAB 2000/800	6	25/10/07	00:01:46	On load external: direct to hold from flat bed truck, two workers
Fokker 70/100	6 and ST3	25/10/07 & 25/09/07	00:13:44 00:02:43 internal 00:11:01 external	On and off load external: direct to hold (at rear of aircraft used flat bed truck for on load), up to three workers On load internal: single worker

External on-load operations

Loading bags from cart to belt loader

Table 27 Assessment of loading bags from a cart to a belt loader

Risk factor	***Observations***	***Risk rating***
Load/frequency	Previous study: average frequency rate of 1 lift per 6 seconds. Present study: Average frequency rate of 1 lift per 4.5 seconds for a single worker	
	Bags below 10kg	Low
	Bags between 10kg and 16kg	Medium
	Bags between 16kg and 24kg	High
	Bags above 24kg	V. High
Load/frequency	Average frequency rate of 1 lift per 9 seconds for two workers	
	Bags below 12kg	Low
	Bags between 12kg and 19kg	Medium
	Bags between 19kg and 29kg	High
	Bags above 29kg	V. High
Hand distance from lower back	Bags to the front of the cart	Low
	Base of stack 600mm, hands at knee height for 1 layer	
	Bags from rear of carts: workers' flex the trunk with the upper arms angled away from the body to reach bags to the rear of the cart. However, the bags tend to be pulled from the stack with one hand, and allowed to drop to the bottom of the cart before being lifted. The spare hand is often used to support the body weight when leaning forward. Hence a low/medium risk rating to differentiate between bags held with the hands at a distance from the low back.	Low/Med
Vertical lift region	Top of stack 1600mm, hands at shoulder height, bags pulled forward then lowered to the belt loader.	Med
	Base of stack 600mm, lateral transfer at knee height.	Low
Trunk twist	If cart is positioned correctly (45° angle to loader) there should be no twist during the load. This was observed occasionally.	Low
	The cart tended to be positioned behind the worker leading to frequent twisting of the trunk with some sideways bending.	High
Postural constraints	The degree of restriction on posture is dependant on the distance and angle of the cart to the belt loader, the number of workers handling at the same time, and the kind of cart in use. Where there are no restrictions on posture the risk is low.	Low/Med
Carry distance	Approximately 2 to 4 metres, provided cart is positioned correctly	Low
Grip on load	Grip ranges from good to poor. Items tend to have only one handle. The typical example would be a suitcase; the single handle may be useful for pulling on, but not useful for lifting. This is due to the lack of space on the handle for both hands and because of the resulting orientation of the case. Grip will therefore be around the corners of the case. Softer items such as holdalls can be easier to grasp in a power grip and may have more handles. There are also large awkward and bulky items like bicycles in boxes, golf club bags, folded pushchairs, etc. If items have no handles they are more awkward to grasp.	Low Medium

Loading bags from cart direct to hold

Table 28 Assessment of loading bags from a cart direct to hold

Risk factor	***Observations***	***Risk rating***
Load/frequency	Previous study: Average frequency rate of 1 lift per 6 seconds. Present study: Average frequency rate of 1 lift per 6.8 seconds	
	Bags below 10kg.	Low
	Bags between 10kg and 18kg.	Medium
	Bags between 18kg and 26kg.	High
	Bags above 26kg	V.High
Hand distance from lower back	Bags to the front of the cart Base of stack 600 mm, hands at knee height for 1 layer	Low
	Bags from rear of carts: workers' flex the trunk with the upper arms angled away from the body to reach bags to the rear of the cart. See Table 17.	Low/Med
	Hands will always be far from low back when placing and pushing the bag into the hold.	High
Vertical lift region	Bags are moved across body and pushed up and into the hold, hands will usually be above shoulder height when placing and pushing bags into hold.	High
	Top of stack is an almost lateral transfer with push up and into hold.	Medium
	Base of stack will involve a transfer from knee height to shoulder height or above.	High
Trunk twist	If cart is positioned at a 45° angle to the aircraft it is expected that trunk twisting during loading will be reduced.	Low
	Generally the cart was positioned parallel to the aircraft so frequent twisting of the trunk with some sideways bending was observed.	High
Postural constraints	The degree of restriction on posture is dependant on the distance and angle of the cart to the aircraft, the number of workers handling at the same time, and the kind of cart in use. The height of the hold means the worker has to reach to roughly shoulder height so this is considered as a restriction on posture.	Medium
Carry distance	Approximately 2 to 4 metres, provided cart is positioned correctly.	Low
Grip	Grip ranges from good to poor as described above	Low/Med

Loading bags from a Mallaghan LBT90 direct to hold

Table 29 Assessment of loading bags into the hold from a Mallaghan LBT90 – worker stood on Mallaghan platform

Risk factor	***Observations***	***Risk rating***
Load/frequency	FREQ DATA TO BE CONFIRMED	
Hand distance from lower back	Bags to the front of the cart Base of stack 600 mm, hands at knee height for 1 layer Bags from located one row back: If the belt is not working correctly/not moved workers' will have to flex the trunk with the upper arms angled away from the body to reach bags further back. See Table 17 for further details. Hands will generally be extended away from the trunk when pushing the bag down the hold.	Low Low/Med High
Vertical lift region	There is almost a lateral transfer of bags from the Mallaghan into the hold where bags are stacked at or below shoulder height	Low
Trunk twist	Some twisting and sideways bending was observed.	High
Postural constraints	There is limited standing space available on the Mallaghans' platform, which can restrict posture.	Medium
Carry distance	Very short carry distance	Low
Grip	Grip ranges from good to poor as described above	Low/Med

Loading bags from flat bed lorry to hold (Includes Fokker, J41, SAAB 2000/800)

Table 30 Assessment of loading bags into the hold from a flat bed lorry – specific to small aircraft

Risk factor	***Observations***	***Risk rating***
Load/frequency	Previous study: Average frequency rate of 1 lift per 6 seconds. Present study: Average frequency rate of 1 lift per 7 seconds	
	Bags below 10kg.	Low
	Bags between 10kg and 18kg.	Medium
	Bags between 18kg and 26kg.	High
	Bags above 26kg	V.High
Hand distance from lower back	A worker collected a bag/s from the cart and placed it onto the flat bed truck. Bags to the front of the cart Base of stack 600 mm, hands at knee height for 1 layer	Low
	Bags from rear of carts: workers' flex the trunk with the upper arms angled away from the body to reach bags to the rear of the cart. See Table 17.	Low/Med
	A second worker lifted the bag into the hold from a kneeling position to a third worker inside the hold. When reaching into the hold the back was flexed and the upper arms angled away from the body.	High
Vertical lift region	Cart to truck: Bags stacked between knee and elbow height	Low
	Base of stack will involve a lift from below knee height to below elbow height	Medium
	Bags are lifted off the floor of the truck, moved across the body and up into the hold.	High
Trunk twist	If cart is positioned at a 45° angle to the aircraft it is expected that trunk twisting during loading will be reduced.	Low
	To load the bags into the hold, the worker would typically twist through 45 degrees either side.	High
Postural constraints	Cart to flat bed truck: The degree of restriction on posture is dependant on the distance and angle of the cart to the truck, the number of workers handling at the same time, and the kind of cart in use. Where there are no restrictions on posture the risk is low.	Low
	Truck to hold: The hold door opened up and outwards. The height of the truck to the aircraft, coupled with the height of the overhead door means there is reduced headroom. Consequently the worker had to kneel to handle bags into the hold.	High
Carry distance	Approximately 2 to 4 metres, provided cart is positioned correctly.	Low
Grip	Grip ranges from good to poor as described above.	Low /Medium

Internal on-load operations

Transferring bags from the hold door to the in-hold stacker

Table 31 Assessment of transferring bags from the hold door to the in-hold stacker inside narrow-bodied aircraft

Risk factor	***Observations***	***Risk rating***
Load/frequency	Previous study: Average frequency rate of 1 lift per 5-6 seconds. Present study: Average frequency rate of 1 lift per 4.2 seconds with a belt loader. Average frequency rate of 1 lift per 6 seconds from a cart. These workers were observed to both lift and propel the items or to slide them with a pushing action. Forces exerted for propelling items along the hold are unquantified.	
	Bags below 10kg.	Low
	Bags between 10kg and 16kg.	Medium
	Bags between 16kg and 24kg.	High
	Bags above 24kg	V.High
Hand distance from lower back	Standing stooped: When standing stooped it was typical for the worker to rest the hands on the knees/thighs for support between items. Workers were observed to be close to the extremes of reach when reaching to grasp items from the conveyor and when pushing or propelling items away.	High
	Kneeling: The hand distance from lower back appeared to be less than when stooping as the back tends to remain straight as the bags are passed in front of the body.	Medium
Vertical lift region	Standing stooped:	
	If the worker lifts the items off a belt loader before propelling them along the hold, the vertical lift distance is roughly between knee and elbow level.	Medium
	If the worker lifts the items off the floor the vertical lift region is increased.	High
	Kneeling:	
	If the worker lifts the items off a belt loader before propelling them along the hold, the vertical lift distance is roughly above knee and below elbow height.	Low
	If the worker lifts the items off the floor the vertical lift region is increased.	Medium
Trunk twist	Trunk twist was frequent (turning towards in-hold stacker), and could be combined with sideways bending.	High
Postural constraints	Posture can be constrained by the amount of space available between the conveyor and the loaded luggage and the co-worker. When the hold door opens inwards this reduces headroom in the region of the hold door. This is likely to either increase the extent of stooping while kneeling and/or restrict the positions that the worker can be in while performing this task. The headroom limits postures to standing fully stooped, kneeling, squatting, sitting or lying. When standing stooped the trunk is angled at over 60 degrees.	High
Carry distance	N/A	
Grip	Grip ranges from good to poor as described above.	Low/Med

Stacking bags inside hold

Table 32 Assessment of stacking bags inside the hold of narrow-bodied aircraft

Risk factor	***Observations***	***Risk rating***
Load/frequency	Previous study: Average frequency rate of 1 lift per 5-6 seconds. Present study: Average frequency rate of 1 lift per 5.3 seconds	
	Bags below 10kg.	Low
	Bags between 10kg and 16kg.	Medium
	Bags between 16kg and 24kg.	High
	Bags above 24kg	V.High
Hand distance from lower back	Workers were observed to regularly be at the extremes of reach when reaching to grasp the bags off the floor.	High
	When placing items at the top corners of the stack the workers were observed to be close to the extremes of reach, often coupled with twisting of the torso.	High
	When placing items towards the bottom of the stack the hand distance from the low back was less.	Medium
Vertical lift region	Stacking bags towards the bottom of the hold	Medium
	Stacking bags towards the top of the hold (lifting bags form the hold floor)	High
Trunk twist	There was frequent twisting and sideways bending of the trunk. The worker tended to face side-on to the stack and would typically twist through 45 degrees either side to lift a bag off the floor and place on the stack. The most extreme twist was seen when reaching behind the body.	High
Postural constraints	The flat area of the hold floor limits the amount of space available for kneeling, especially in the small holds. In the small holds the headroom limits postures to kneeling, squatting, sitting or lying. When kneeling in the small holds the low ceiling height meant the neck was generally held flexed by 20 degrees. In the larger holds, where workers could stand in a stooped posture, the neck was held in extension and was also frequently rotated. Kneeling in the large holds, workers tended to be able to keep their neck straight. Fokker: Due to the very limited space the worker had their back flexed whilst on their knees with their neck bent laterally.	High
Carry distance	N/A	
Grip	Grip ranges from good to poor as described above. Outside handlers are able to present bags to allow inside handlers optimum grip as the item arrives at the hold door.	Low/Med

Internal Off-load Operations

Un-stacking bags in-hold and transferring to hold door internal worker or hold door for external worker

Table 33 Assessment of un-stacking bags and transferring them to the hold door

Risk factor	***Observations***	***Risk rating***
Load/frequency	Previous study: Average frequency rate slightly faster than 1 lift per 4 seconds. Present study: Average frequency rate of 1 lift per 4.7 seconds (single worker) And Average frequency rate of 1 lift per 4.6 seconds (transferring to hold door internal worker). Observations include a frequency rate of 1 lift per 3 seconds, which for a bag weighing above 15 kg represents a high or very high risk of injury. The main approach is to pull items from the stack, although some were lifted/lowered to the hold floor. The force requirements of the push/pull elements have not been quantified.	
	Bags below 10kg.	Low
	Bags between 10kg and 16kg.	Med/High
	Bags between 16kg and 24kg.	High/V.High
	Bags above 24kg	V.High
Hand distance from lower back	When reaching for items at the top corners of the stack the workers were observed to be close to their extremes of reach, often coupled with twisting of the torso. When reaching for items towards the bottom of the stack the hand distance from the low back was less. The worker was observed to be close to the to the extremes of reach when pushing/propelling items down the hold (see Table 26)	High Medium Med/High
Vertical lift region	The bags tended to be pulled/lifted from the stack and allowed to drop to the floor before being pushed or propelled towards the hold door.	
Trunk twist	There was frequent twisting and sideways bending of the trunk. The worker tended to face side-on to the stack and would typically twist through 45 degrees either side to retrieve a bag from the stack, turn and propel down the hold. The most extreme rotation was observed when reaching behind.	High
Postural constraints	The flat area of the hold floor limits the amount of space available for kneeling, especially in the small holds. In the small holds the headroom limits postures to kneeling, squatting, sitting or lying. When kneeling in the small holds the low ceiling height meant the neck was generally held flexed by 20 degrees. In the larger holds, where workers could stand in a stooped posture, the neck was held in extension and was also frequently rotated. Kneeling in the large holds, workers tended to be able to keep their neck straight.	High
Carry distance	N/A	
Grip	Grip ranges from good to poor as described above.	Low/Med

Transferral of bags from the in-hold stacker to the hold door/belt loader

Table 34 Assessment of transferring bags from the in-hold stacker to the hold door

Risk factor	***Observations***	***Risk rating***
	Previous study: Average frequency rate slightly faster than 1 lift per 4 seconds. Present study: Average frequency rate of 1 lift per 4.6 seconds Loads are lifted/lowered/supported and pushed/pulled. The force requirements of the push/pull elements have not been quantified.	
	Bags below 10kg.	Low
	Bags between 10kg and 16kg.	Med
	Bags between 16kg and 24kg.	High
	Bags above 24kg	V.High
Hand distance from lower back	Standing stooped: When standing stooped it was typical for the worker to rest the hands on the knees/thighs for support between items. Workers were observed to be close to the extremes of reach when reaching to grasp and lift/push items onto the conveyor. Kneeling: The hand distance from lower back is less than when stooping as the back tends to be straight and the bags are passed in front of the body.	High Medium
Vertical lift region	Lifting items was not typical. Items were pulled towards the worker and then pushed away out of the hold door to drop onto the conveyor.	Low
Trunk twist	Standing stopped: The worker could move their feet to retrieve bags. However some trunk twisting was observed. Kneeling: Workers tended to face the doorway and pulled/pushed the bags across the front of their body, twisting and leaning sideways to do so with the feet/legs/pelvic girdle remaining fixed due to kneeling. A 45-degree twist to the side was typical.	Medium High
Postural constraints	Posture can be constrained by the amount of space available between the conveyor and the loaded luggage and the co-worker. The hold door can open inwards, which reduces the headroom. This is likely to either increase the extent of stooping while kneeling and/or restrict the positions that the worker can be in while performing this task. The headroom limits postures to standing fully stooped, kneeling, squatting, sitting or lying.	High
Carry distance	N/A	
Grip	Grip ranges from good to poor as described above.	Low/Med

External off-load operations

The risks identified previously for external on-load operations direct to hold using a belt loader are the same for the external off-load with the following exceptions:

1. Hand distance from the lower back when stacking bags towards the rear of the cart. The risk rating is classed as ‘high’ during the off-load because the bags are lifted onto the stack with the arms out stretched and the trunk flexed forward.

2. Transferral of bags down the hold: This function is not performed by the external worker during the off-load.

The details below indicate the risk ratings given for off-loading onto a Mallaghan LBT90 and onto a flat-bed truck from a Fokker.

Off-loading onto a Mallaghan LBT90

Table 35 Assessment of loading bags onto a Mallaghan LBT90 (worker stood on Mallaghan platform)

Risk Factor	***Observations***	***Risk rating***
Load/frequency	Average frequency rate of 1 lift every 7.5 seconds. 1 worker.	
	Bags below 10 kg	Low
	Bags between 10 kg and 17 kg	Med
	Bags between 17 kg and 26 kg	High
	Bags above 26 kg	V. High
Hand distance from lower back	Base/Front of Mallaghan: Generally the worker stood sideways on to the hold and trolley. The worker would handle the bag from the hold below shoulder height, pass it in front of the body and drop it down onto the belt.	Low
	Top of stack/Front of Mallaghan: The hand distance from the low back is increased when loading bags at the top of the stack.	Med
	1 layer back: On occasions, the worker would reach out and propelling a bag on to the top of the stack after the belt had been moved back – at this point the hand distance from the low back is extreme and the risk is high.	High
Vertical lift region	There is almost a lateral transfer of bags from the hold into the Mallaghan.	Low
	The height to which the bags are stacked will increase the vertical lift region. On occasions the worker lifted the bags from below shoulder height to above head height.	High
Trunk twist / sideways bend	There was some twisting and sideways bending of the trunk observed when stacking the bags.	High
Postural constraints	There is limited space to move on the platform. See Table 19.	Med
Carry Distance	N/A	
Grip	Grip ranges from good to poor as described above.	Low/Med

Off-loading from the hold direct to a flat-bed lorry – Fokker 70/100 only

The method for off-loading a Fokker 70/100 involved a worker either standing or kneeling on the truck or standing on the ground whilst leaning into the hold to pull the bags out. They would then propel/push the bag to a second worker on the truck who stacked the bags. When enough space became available a worker climbed into the hold, a second worker then pulled the bags from the hold and passed them to a third worker who stacked the bags at the back of the truck stood on the ground.

Table 36 Assessment of transferring from the hold of a Fokker onto a flat-bed truck

Risk Factor	***Observations***	***Risk rating***
Load/frequency	Previous study: Average frequency rate of 1lift per 6 seconds Present study: Average frequency rate of 1 lift per 6 seconds.	
	Bags below 10 kg	Low
	Bags between 10 kg and 16 kg	Med
	Bags between 16 kg and 24 kg	High
	Bags above 24 kg	V. high
Hand distance from lower back	Standing or kneeling on the truck and reaching into the hold: the back was flexed and the upper arms angled away from the body.	High
	Standing on the ground: there was much less trunk flexion, although the upper arms were angled away from the body.	Medium
	Stacking bags: The stacker was at full reach to pick the bags up from the bed of the lorry (floor) and then stack them.	High
Vertical lift region	Standing or kneeling on the truck and reaching into the hold: handlers who kneeled transferred the bags between shoulder and knuckle height.	Medium
	Standing stooped: the handler transferred bags between knee and floor height.	High
	Standing on the ground: Handlers on the ground were transferring bags between elbow and shoulder height .	Medium
Trunk twist / sideways bend	Standing or kneeling on the truck and reaching into the hold: Frequent twisting of the trunk with some sideways bending was observed.	High
	Standing on the ground and transferring bags from the hold: the handler tended to turn using their feet to transfer bags, which reduced the degree of trunk twisting with no sideways bending.	Medium
Postural constraints	The posture is restricted by the size of the hold door and the location of the truck.	
	The posture was less restricted handling bags from the hold when standing on the ground.	Medium
	When handling bags from the hold directly from the truck the hold door restricted the posture.	High
Carry Distance	Approximately 2 to 4 metres	Low
Grip	Handholds ranged from good to poor as described above.	Low/Med

APPENDIX B

Table 37 Details of video recorded for the trials of an EBL (times are in hh:mm:ss)

Aircraft Type	*Tape No.*	*Date*	*Video recording duration*	*Methods captured*
737/300	1, 2 and 6	10/01/08 16/01/08	01:18:02	On and off load internal and external: single worker Tape 6 data is live capture
757/200 (TC)	8 and 12	22/01/08 24/01/08	00:34:50	Internal on load: single worker External on load: 1/2 workers
A319 (EJ)	3-7 and 9-12	15/01/08 18/01/08 23/01/08 24/01/08	04:56:53	On and off load external: 1/2 workers On and off load internal: single worker
A319 (EJ)	T1 & T2	04/03/08	00:17:13	On and off load internal: single worker

External On-load Operations

Table 38 Assessment of loading bags from a cart onto the aircraft using an extending belt

Risk Factor	***Observations***	***Risk rating***
Hand distance from lower back	Bags to the front of the cart Base of stack 600 mm, hands at knee height for 1 layer Bags to the rear of the cart: worker needs to flex the back with the upper arms extended to reach to the rear of the cart. Bags are pulled off the stack, allowed to drop to the base of the cart before being placed on the belt. As bags are generally not lifted this has been given a low/medium risk rating.	Low Low/Med
Vertical lift region	Belt adjusted: Very little lifting observed. Tongue spanned the gap between belt and cart and was raised up and down so bags were pulled/half lifted onto the tongue. Belt not adjusted: The lifting required would be the same as when using a standard belt loader (see Table 22.	Low Med
Trunk twist	There were occasions when the trunk was twisted or bent sideways when retrieving bags off the cart. However, as the load was pulled and not lifted at the same time the risk is considered to be low. There appeared to be no difference in postures for either one or two workers.	Low
Postural constraints	Posture not restricted.	Low
Carry Distance	N/A	
Grip	Grip ranges from good to poor as above	

Internal On-load operations –Kneeling (737/300, 757, A319)

Handlers adopted different techniques when using the extending belt loader in the hold. The techniques observed included belt adjustment with one hand and pushing bags off with the other (pilot trial) and belt adjustment followed by a two-handed lift/push (live trial). In the third technique the handler kneeled face-on to the belt and lifted bags off it but made few attempts to adjust the belts height/location. This method appeared to be used/reverted to as the frequency of the bags increased.

Table 39 Assessment of stacking bags inside the hold from an extending belt whilst kneeling

Risk Factor	***Observations***	***Risk rating***
Hand distance from lower back	*Belt adjusted (pilot – bags not pushed not lifted):* The workers' hands remained closer to the low back when placing items towards the bottom of the stack plus items tended to pushed and not lifted.	Low
	The hands were further away from the low back when placing items toward the top of the stack.	Low/Med
	The workers were observed to be closer to the extremes of reach when lifting/pushing and placing items at the top corners of the stack, leaning over the belt to do so.	Med
	Belt not adjusted (pilot and live – bags lifted): Bags were lifted off the end of the belt to stack them. The arms could be angled from the low back to reach the items off the end of the belt.	Medium
	The workers were observed to be closer to the extremes of reach when lifting/pushing and placing items at the top corners of the stack, leaning over the belt to do so	High
Vertical lift region	*Belt adjusted (pilot):* The height of the belt was raised/lowered, which reduced the lift region coupled with bags being pushed into place and not lifted.	Low
	Belt not adjusted (pilot and live): If the belt is not adjusted up/down the lift region is greater.	Med
	If the belt remains on the floor whilst placing items at the top of the stack, the vertical lift region is considered to be from floor level to above shoulder height.	High
Trunk twist / sideways bend	*Belt adjusted (pilot):* Trunk generally remains straight. Twisting of the trunk was observed when the worker reached behind to push bags onto the stack.	Low Medium
	Belt not adjusted (pilot and live): When the worker lifted and stacked bags to their front, they tended to pass the bags across their front, which involved some trunk twisting.	Low/Med
	Twisting of the trunk with some sideways bending was observed when the worker reached behind to place bags onto the stack.	High
Postural constraints	There is kneeling room only in the 737/300. The hold width appeared quite narrow in this aircraft. There is generally limited space to manoeuvre with the EBL.	High

Internal On-load operations – Stooped (757/A319)

Table 40 Assessment of stacking bags into the aircraft hold from an extending belt whilst standing in a stooped posture

Risk Factor	*Observations*	*Risk rating*
Hand distance from lower back	The workers' hands remained closer to the low back when placing items towards the bottom of the stack plus items tended to be pushed and not lifted. However, standing stooped with hands outstretched increases the distance of the hands from the lower back compared with kneeling with a straight trunk.	Med
	The hands were further away from the low back when placing items toward the top of the stack.	Med/High
	The workers were observed to be closer to the extremes of reach of reach when lifting/pushing and placing items at the top corners of the stack, leaning over the belt to do so.	High
	Bags lifted off the end of the belt to stack them.	Medium
Vertical lift region	*Belt adjusted (pilot):* The height of the belt was raised/lowered, which reduced the lift region.	Low
	Belt not adjusted (pilot and live): If the arm is not adjusted up/down the lift region is increased.	Medium
	If the belt is situated on the floor whilst placing items at the top of the stack, the vertical lift region is considered to be from floor level to above shoulder height.	High
Trunk twist / sideways bend	*Belt adjusted (pilot):* Trunk generally remains straight.	Medium
	Twisting of the trunk was observed when the worker reached behind to push bags onto the stack coupled with an already flexed trunk.	High
	Belt not adjusted (pilot and live): When the worker lifted and stacked bags to their front, they tended to pass the bags across their front, which involved some trunk twisting.	Med/High
	Twisting of the trunk with some sideways bending was observed when the worker reached behind to place bags onto the stack.	High
Postural constraints	The space available appeared more limited as the handler neared the hold door.	High

Internal Off-load Operations – Kneeling (737/300, 757. A319)

Un-stacking bags in the aircraft hold whilst kneeling and using an extending belt.

Table 41 Assessment of un-stacking bags in the aircraft hold onto an extending belt

Risk Factor	***Observations***	***Risk rating***
Hand distance from lower back	Belt adjusted (pilot): Bags pulled onto the belt from the lower half of the stack.	Low
	Bags pulled onto the belt towards the top of the stack whilst kneeling – hands further away from the low back although the risk still considered to be low as the bags were not lifted.	Low/Med
	Stooping: standing stooped with hands outstretched increases the distance of the hands from the lower back compared with kneeling with a straight trunk. Belt not adjusted (pilot and live): the lack of adjustment of the belt appears to have no impact so the risk is considered to be the same as described above.	Medium
Vertical lift region	Belt adjusted: The items were pulled from the stack onto the belt.	Low
	Belt not adjusted: If the items did not land onto the belt when they were pulled from the stack they would need to be handled off the floor and placed onto the belt.	Medium
Trunk twist	Un-stacking bags at the front of the worker.	Low
	When the worker reached behind to pull bags from the stack, twisting of the trunk was observed.	Med
Postural constraints	There is kneeling room only in the 737/300. The hold width appeared quite narrow in this aircraft. There is generally limited space to manoeuvre with the belt. There is more space available in the holds of larger aircraft although this appeared more limited when the handler was by the hold door.	High

External Off-load operations

Table 42 Assessment of taking bags off the extending belt and loading them onto a cart.

Risk Factor	*Observations*	*Risk rating*
Hand distance from lower back	Bags to the front of the cart Base of stack 600 mm, hands at knee height for 1 layer	Low
	Bags to the rear of the cart: worker needs to flex the back with the upper arms extended to reach to the rear of the cart. As bags tended to be lifted off the belt this has been given a high risk rating.	High
Vertical lift region	Belt adjusted: Very little lifting observed. Tongue spanned the gap between belt and cart and was raised up and down so bags were handled onto the cart at roughly the height they were stacked.	Low
	Belt not adjusted: The lifting required would be the same as when using a standard belt loader.	Med/High
Trunk twist / sideways bend	There were occasions when the trunk was twisted or bent sideways when loading bags onto the cart. However, there is no twisting between the cart and the belt as the belt spans the gap. It appeared that the extent of twisting and/or sideways bending was dependent on the location of the delivery of the bags/adjustment of the belt. There appeared to be no difference in postures for either one or two workers.	Med/High
Postural constraints	Posture was not restricted.	Low

APPENDIX C

EMA Extendable Belt Loader Usability testing	
Date:	Company:
Run No:	Aircraft Type:

1. How did you find preparing and positioning the EBL at the aircraft?

CR10 rating for preparing EBL:

2. How did you find deploying the EBL into the hold?

CR10 rating for deploying EBL:

3. How did you find handling within the hold?

CR10 rating for handling in the hold:

4. How you find handling between the cart and the EBL (and vice versa)?

CR10 rating for handling between cart and EBL:

5. How did you find retracting the EBL?

CR10 for retracting the EBL:

6. How did you find moving the EBL away from the aircraft?

CR10 rating for removing EBL from the aircraft:

APPENDIX D

EMA Baggage Handling Project

HEALTH & SAFETY LABORATORY

This questionnaire is designed to help us find out more about muscle and joint aches and pains experienced by baggage handlers. Your responses will be treated as **confidential**. Please answer all the questions, and return the completed questionnaire to ________________ .

Personal Details

Name

1 Are you male or female? Male 1☐ Female 2☐

2 What is your date of birth? _________/_________/19_____

3 How tall are you? _______ Feet/Inches or _______ cm

4 How much do you weigh? _______ Stones/Pounds or _______ kg

5 Are you left or right handed?
1☐ Right Handed
2☐ Left Handed
3☐ Able to use both hands equally

About Your Job

6 What is your job?
1☐ Baggage Handler
2☐ Supervisor - 2IC or Leading Hand
3☐ Manager – Ramp or Duty Manager

7 How many years and months have you been doing baggage handling work? ______________________________

8 On average how many breaks per shift do you have and how long are they? ______________________________

____

9 How many hours a week do you work (including overtime but excluding main meal break)? ______________________________

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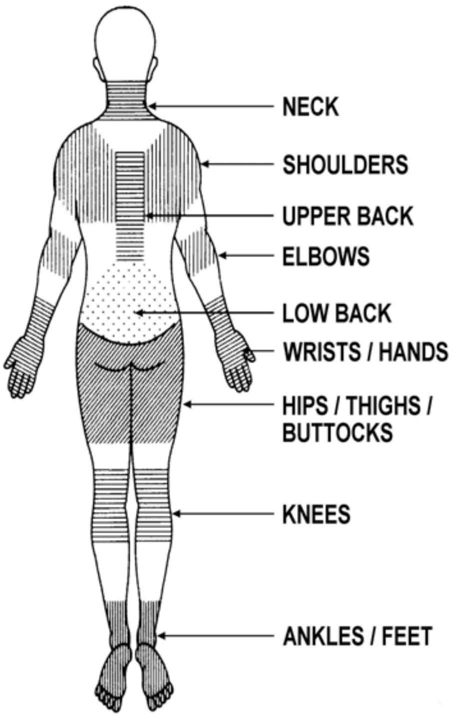
MUSCULOSKELETAL DISORDERS

Musculoskeletal disorders affect the muscles, nerves, joints, and ligaments. A 'bad back', neck ache and a 'slipped disc' are examples of musculoskeletal disorders. Musculoskeletal disorders can affect all parts of the body.

The next page asks about musculoskeletal troubles, such as aches or pains, you may have had recently. Please use the tick boxes - ☐ - to answer each of the four questions for each part of the body shown in the picture on the right.

The picture shows how the body has been divided. The areas of the body are not sharply defined and some parts overlap. You should decide for yourself which part (if any) is or has been affected.

Please make sure you put one tick only for each question. For example, you could tick *Yes* for the right elbow, or the left elbow, or both elbows.



MUSCULOSKELETAL DISORDERS

	Have you at any time during the **last three months** had **trouble** (such as **ache, pain, discomfort, numbness, tingling,** or **pins and needles**) in your:	Have you had this **trouble** during the **last seven days?**	During the **last three months** has this trouble **prevented** you carrying out normal activities (e.g., job, housework, hobbies)?	During the **last three months** has this trouble been **caused** or **made worse** by your job?
Neck	**1** No Yes 1☐ 2☐	**2** No Yes 1☐ 2☐	**3** No Yes 1☐ 2☐	**4** No Yes 1☐ 2☐Caused 3☐Made worse
Shoulders	**5** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**6** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**7** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**8** No Yes 1☐ 2☐Caused 3☐Made worse
Elbows	**9** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**10** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**11** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**12** No Yes 1☐ 2☐Caused 3☐Made worse
Wrists/ hands	**13** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**14** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**15** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**16** No Yes 1☐ 2☐Caused 3☐Made worse
Upper back	**17** No Yes 1☐ 2☐	**18** No Yes 1☐ 2☐	**19** No Yes 1☐ 2☐	**20** No Yes 1☐ 2☐Caused 3☐Made worse
Lower back (small of back)	**21** No Yes 1☐ 2☐	**22** No Yes 1☐ 2☐	**23** No Yes 1☐ 2☐	**24** No Yes 1☐ 2☐Caused 3☐Made worse
Hips/ thighs/ buttocks	**25** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**26** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**27** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**28** No Yes 1☐ 2☐Caused 3☐Made worse
Knees	**29** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**30** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**31** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**32** No Yes 1☐ 2☐Caused 3☐Made worse
Ankles/ feet	**33** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**34** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**35** No Yes 1☐ 2☐Right only 3☐Left only 4☐Both	**36** No Yes 1☐ 2☐Caused 3☐Made worse

Please check you have answered **ALL** of the questions on this page, even if you have never had trouble in any part of your body.

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WORK CHARACTERISTICS

Please use the tick boxes to show how much you agree or disagree with each of the following statements:

	Strongly Disagree 1	2	3	4	Strongly Agree 5
1 You can influence how fast you work	☐	☐	☐	☐	☐
2 You can influence your working methods	☐	☐	☐	☐	☐
3 You can influence how work tasks are shared out	☐	☐	☐	☐	☐
4 You have control over the technical aspects of your work	☐	☐	☐	☐	☐
5 You can influence the rules and regulations at work	☐	☐	☐	☐	☐
6 You have sufficient contact with your immediate supervisor	☐	☐	☐	☐	☐
7 Your supervisor asks your advice on work-related problems	☐	☐	☐	☐	☐
8 Your immediate supervisor considers different viewpoints	☐	☐	☐	☐	☐
9 Your immediate supervisor provides sufficient information	☐	☐	☐	☐	☐
10 You and your immediate supervisor communicate well	☐	☐	☐	☐	☐
11 Your work is interesting	☐	☐	☐	☐	☐
12 Your work is varied	☐	☐	☐	☐	☐
13 You have opportunities to use your skills in your job	☐	☐	☐	☐	☐
14 You have opportunities to learn new things at work	☐	☐	☐	☐	☐
15 Overall, you feel satisfied in your work	☐	☐	☐	☐	☐
16 You have good contacts with your fellow workers	☐	☐	☐	☐	☐
17 You have opportunity to talk with fellow workers about the job	☐	☐	☐	☐	☐
18 You find the atmosphere at work cheerful	☐	☐	☐	☐	☐
19 You have opportunities to discuss work-related problems	☐	☐	☐	☐	☐
20 You consider your fellow workers to be your friends	☐	☐	☐	☐	☐
21 The amount of stress you are under at work is acceptable	☐	☐	☐	☐	☐
22 Your workload is acceptable	☐	☐	☐	☐	☐
23 Your job does not make you feel exhausted	☐	☐	☐	☐	☐
24 Your rest breaks at work are long enough	☐	☐	☐	☐	☐
25 You are not under too much mental strain at work	☐	☐	☐	☐	☐
26 Your employer worries about your health and safety	☐	☐	☐	☐	☐
27 Your employer tells you it is important to report accidents	☐	☐	☐	☐	☐
28 Your employer takes care to make your work safe	☐	☐	☐	☐	☐
29 Your employer checks regularly if your work is making you ill	☐	☐	☐	☐	☐
30 Your employer makes sure health and safety rules are followed	☐	☐	☐	☐	☐
	1 Strongly Disagree	2	3	4	5 Strongly Agree

Thank you for completing this questionnaire!

10 GLOSSARY

Anthropometrics – Branch of Ergonomics that deals with body measurements

Belt Loader – See Photograph 10

Photograph 10 *Example of a belt loader*

Direct to hold loading – See Photograph 11

Photograph 11 *Example of direct to hold loading from a cart*

EBL – Extending Belt Loader. See photographs 12 to 14

Photograph 12 *Example of an EBL known as the Rampsnake (Source: http://www.fmctechnologies.com/upload/rampsnake.pdf).*

Photograph 13 *Example of an EBL known as the Powerstow (Source: Helle Rohde Neilsen at Powerstow A/S)*

Photograph 14 *Example of an EBL known as the Mongoose (Source: Tom Lange, NMC-Wollard Inc.)*

EMA – East Midlands Airport.

Flatbed truck – Loading baggage from and to a flatbed truck. See Photograph 15

Photograph 15 *Loading baggage to and from a flat bed truck*

Narrow-bodied aircraft - (Dell, 2007) “Single aisle passenger transport aircraft such as the Boeing B717, B727, B737, McDonnell Douglas DC9, MD83 and MD87 and Fokker F28 & F100, as well as all commuter aircraft, seating up to around 150 passengers, that are designed to have the baggage loaded in bulk, one item of baggage at a time (Dell, 2007)”.

In addition to the Airbus A320 family of aircraft, we also include the diverse group of smaller ‘regional’ jet and turboprop aircraft such as the Bombardier/de Havilland Dash8, Embraer ERJ 145, McDonnel Douglas MD80/90/95 series, BAE Jetstream J41, Fokker F70/F100, and Saab 2000 and similar aircraft.

NMQ – Nordic Musculoskeletal Questionnaire. See also HSEMSSQ.

Mallaghan LBT90 – See Photograph 16

Photograph 16. *Malaghan mechanical baggage handling aid. (Source: Niall Mallaghan, Mallaghan Engineering Ltd.)*

HSEMSSQ – HSE Musculoskeletal symptom questionnaire, derived from the NMQ

Percentile – Used to express the proportion of the population with that attribute, such as body measurements, for example, 50^{th} percentile stature represents the average stature of the population, 5th percentile stature means 95% of the population are taller, whereas 95th percentile stature means 95% of the population are shorter.

Sliding Carpet Loading System – Manufactured by Telair International AB, see *Photograph 17*.

Photograph 17 *The SCLS (Source: Fredrik Letzén, Telair International AB)*

RTT Longreach – Manufactured by Telair International AB, and intended primarily for use in combination with the SCLS.

Photograph 18 *The RTT Longreach (Source: Fredrik Letzén, Telair International AB)*

Health and Safety Executive

Musculoskeletal ill-health risks for airport baggage handlers

Report on a stakeholder project at East Midlands Airport

In Great Britain the majority of baggage handling is contracted out from the airline to ground handlers and is often viewed as a 'stand alone' part of the aircraft turnround process. Little consideration has been given to the design and working of the interface between the aircraft (airline carrier), airport (operator), handling equipment (supplier/manufacturer) and those persons undertaking the baggage handling work (ground handlers). Unless these factors are dealt with at an early stage, there is often little or no opportunity for the ground handler to address and reduce the risks. Fully effective risk reduction during the baggage handling activity will only be achieved if all the parties involved actively work together.

This report describes the work undertaken to gather further information on the musculoskeletal ill-health risks associated with baggage handling operations and to appraise the efficacy of new Extending Belt Loader (EBL) technology. The GB aviation sector health and safety steering group (Revitalising Health and Safety in Air Transport - RHSAT), which includes the HSE, identified the requirement for a working partnership. Staff from the HSE, HSL, East Midlands Airport (EMA), Menzies Aviation, Servisair, EasyJet, BMI Baby and the Civil Aviation Authority (CAA) formed a collaborative working group to take this work forward. The evidence presented in this report, and other studies including previous work by the HSE (Tapley & Riley, 2005 and Riley, 2008) provide a strong case for this task to be re-designed or mechanised to reduce the risk of injury.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

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