Sigma Expert Solutions
Tel 919-307-4835
info@sigmaexpertsolutions.com
sigmaexpertsolutions.com

MOVING WALKWAY FOR URBAN PUBLIC TRANSIT

FIELD OF INVENTION

[0001] This invention relates to using moving walkways, or travelators as a means of mass transit in urban areas. More particularly, the use of variable speed parallel moving walkways to provide efficient transport with a higher throughput and shorter travel duration than current mass transit systems.

BACKGROUND

[0002] Mass transit in urban centers has been centered around busing or subway systems – both options require stopping and starting at stations and provide non-continuous service. A large fraction of the transit time is spent waiting for a conveyance and for loading and offloading at station stops.

[0003] Replacing current urban mass transit with continuously moving walkways provides multiple benefits over current mass transit solutions as described below:

[0004] 1. A trip can start at any time without having to wait for a conveyance, or subject to a time-table.

[0005] 2. Riders are evenly dispersed over the entire system, minimizing the potential for system overcrowding.

[0006] 3. Space requirements are lower than for a conventional system with the same ridership due to the more efficient use of the entire volume of the transit system.

[0007] Moving walkways as public conveyance have been envisioned in the past but were hampered by the speed of a standard walkway. Various approaches were taken to address the need to increase walkway speed while still enabling riders to enter the system easily and safely. Two general approaches have been used in the past. The first is to install parallel walkways with a speed differential to allow for stepwise speed increase by transitioning from one walkway to the other. The other approach is to provide for linear acceleration of a walkway so the entrance speed is similar to normal walkways, with a subsequent speed increase during transit.

[0008] Parallel walkways with a speed differential were used as a means of providing a low entry speed with the ability to transfer to a higher speed for longer distances. This concept is not suitable as urban transit for two reasons.

[0009] 1. Transferring between walkways at different speeds is difficult, especially without handrails or for those with disabilities.

[0010] 2. The maximum speed increase per transfer is limited to the speed differential between walkways. This speed differential is limited to the capabilities of the riders to adjust to the sudden speed change. For efficient transit speeds to be achieved a prohibitive number of parallel walkways would be required.

[0011] Moving walkways that provide for linear acceleration have seen more interest, with several solutions developed to date. All concepts start at an entry speed similar to standard moving walkways, accelerate to some higher speed, and then deaccelerate at the end of the walkway. Examples include the Speedaway by Dunlop, Trottoir Roulant Rapide (TRR) by CNIM, and the ACCEL system by ThyssonKrupp. This concept alone has the following limitations when applied to urban transit:

[0012] 1. The speed increase is limited to the design capabilities. A practical limit of three to five times the initial speed is likely. Assuming an entrance speed of half walking speed, the final speed will still be insufficient for long distance travel.

[0013] 2. The system is “point to point”. There is no means to exit at discrete locations from the walkway other than at its terminus.

[0014] 3. Maintaining and repairing such a technically complex system in a public transit setting where continuous operation is required would be challenging.

[0015] Neither of these solutions independently provides a solution. The former is plagued by a limited amount of speed increase, and a requirement for a great many parallel walkways to establish a practical speed. The latter has a practical limitation on the amount of acceleration possible, inability to serve multiple destinations, and is technically complex for long distances.

BRIEF SUMMARY OF THE INVENTION

[0016] The innovation described combines the use of two or more parallel walkways, each capable of independent linear acceleration. Implementation is through newly invented walkway segments that are independently powered and operate in tandem with adjoining segments to form a continuous walking surface. Each segment can expand and contract to compensate for segment spacing during speed changes. The concerns discussed in the background for existing technology are each addressed by this innovation as described below:

[0017] Paragraph [0009] – The parallel walkways have the capability to match speed with an adjacent walkway during the transfer resulting in no speed differential.

[0018] Paragraph [0010] – A variable speed walkway can start at a low speed during the transfer and accelerate to increase the speed by a factor of 3 or more, providing high speed gains without addition of more parallel walkways. This is a multiplicative gain, not an additive gain as with parallel belts, so starting at a high speed (after an initial transfer) amplifies these benefits.

[0019] Paragraph [0012] – The ability to transfer to a parallel walkway in low speed configuration while the current walkway is in high speed configuration allows for continual compounding of the speed increase without the need to create walkways capable of higher levels of acceleration.

[0020] Paragraph [0013] – Users can exit to lower speed walkways in designated transfer points where adjacent walkway speeds are matched, and dis-embark at regular intervals.

[0021] Paragraph [0014] – The use of individual segments allows for repair and/or replacement of only one segment without shutting down the entire walkway, ensuring continuity of transit.

[0022] This innovation could be implemented in multiple ways, ranging from installation in small diameter underground tunnels, replacement of existing subway systems, on surface streets, replacing pedestrian walkways, or elevated platforms.

BRIEF DESCRIPTION OF DRAWINGS

[0023] Figure 1 – A cutaway of the invented system at a typical station. The illustration includes the platform, onboarding walkway, tunnel walkway layout, and separation barriers.

[0024] Figure 2 – Graphic summarizing the different speeds of walkways within the system and highlighting transfer areas. The spacing of horizontal lines is indicative of the walkway speed.

[0025] Figure 3 – A side view of a section of the separation barrier between walkways at the end of the transition section. This illustration highlights the design elements that preclude injury to riders and removal of gap spanning plates.

[0026] Figure 4 – A section view across two walkways in a transfer area showing the layout of the walkway segments, rails, and gap spanning plates.

[0027] Figure 5 – A complete walkway segment as it would be installed in the system prior to connection with other segments.

[0028] Figure 6 – An illustration of a walkway segment in the process of extending its length to compensate for a speed increase.

[0029] Figure 7 – A schematic of the segment chassis without installed expansion plates, showing the main components used to meet the design objectives.

[0030] Figure 8 – A schematic of a single expansion plate detailing critical components.

DETAILED DESCRIPTION

[0031] The invention consists of two or more variable speed moving walkways running in parallel. **FIG 1** shows implementation in a small (12 foot diameter) tunnel **101** with three walkways. Similar installations could occur in existing subway tunnels or aboveground installations with minor modification.

[0032] In the example application shown in **FIG 1**, the first two walkways vary their speed and are termed the low-speed **102** and high-speed **103** walkways. The third walkway, termed the express walkway **104**, maintains a speed equal to the top speed of the high-speed walkway. Transfer between adjacent walkways is allowed when their speeds are matched, with a physical barrier **105** separating the walkways where there is speed differential.

[0033] Entry into the walkway system is from a platform **106** that provides access to the onboarding walkway **107**. The onboarding walkway starts at standard moving walkway speeds and accelerates to match the lowest speed of the low-speed walkway. Once the rider has transferred to the low-speed walkway, a barrier separates the onboarding walkway from the low-speed walkway allowing it to accelerate and match the lowest speed of the high-speed walkway.

[0034] At the location detailed in **FIG 1**, the high-speed walkway **103** and express walkway **104** are at the same speed, as indicated by the lack of barrier. The low-speed walkway **102** has deaccelerated to match speed with the maximum speed of the onboarding walkway.

[0035] In the implementation represented by **FIG 1**, the walkway segments can increase their length by a factor of three. Combined with a reasonable onboarding speed, the speeds of each walkway can be determined. Note that this is an example and other applications of this invention may result in different speeds and speed multipliers.

[0036] Onboarding Walkway Speeds – Entry at 1.5mph with a speed increase to 4.5mph

[0037] Low Speed Tunnel Walkway Speeds – Operates at 4.5mph at the transfer area with the onboarding walkway and increases speed to 13.5mph for transfer to the high speed walkway.

[0038] High Speed Tunnel Walkway Speeds – Operates at 13.5mph at the transfer area with the low speed tunnel walkway with a speed increase to 40.5mph for long distance travel and transfer to the express walkway.

[0039] Express Walkway Speed – Maintains a constant 40.5mph throughout the system during normal operation.

[0040] Use of the system is best understood by following a trip from point A to point B for the implementation represented by **FIG 1**. A passenger enters an onboarding station, at point A. Entry is through a lane for the onboarding walkway, which allows metered entrance to spread out traffic during congested periods. The onboarding walkway starts at a speed of 1.5mph.

[0041] The onboarding walkway accelerates to match the speed of the low speed walkway. Transferring onto the low speed walkway introduces the rider to the walkway transit system. At the end of the transfer section, a barrier separates the low-speed walkway from the station and the low-speed walkway accelerates to match the high-speed walkway. Transfers to the high-speed walkway and express walkway are performed similarly. Note that for short trips or during high congestion, transfer to the high-speed or express walkways may be omitted as appropriate.

[0042] To exit the system at point B, signage provided is used to indicate when to transfer from one walkway to the next. Upon entering the station, the low-speed walkway matches the speed of the onboarding walkway to allow for transfer and exit to the station at point B.

[0043] **FIG 2** shows the variation in speeds through a section of the transit system. The graphic relates to the implementation used as an example in **FIG 1**, with three onboarding walkways **201** representing three station stops. The rate of travel is indicated graphically by the spacing of horizontal bars, with larger intervals indicating a higher rate of travel.

[0044] The areas designated for transfer **202** are where the adjacent walkways are at a matched speed. The length of the transfer zone is sufficient to allow for riders to comfortably move from one walkway to the other, whether transferring to a lower speed or higher speed walkway.

[0045] Where walkways have a speed differential, a physical barrier **203** is introduced to prevent injury due to the high speed differential of adjacent walkways outside of transfer areas.

[0046] The boundaries of the system are defined by the tunnel walls **204**. Openings in the tunnel walls are located to coincide with stations and onboarding walkways.

[0047] **FIG 3** shows where walkways are separated after completion of a transfer. A physical separation barrier **301** between walkways is introduced slowly to prevent injury due to walkway speed differentials. The introduction angle of the separation barrier **302** is dependent on the maximum potential speed of the transition area, with high speed areas having a lower angle than slow speed areas to provide sufficient warning to riders.

[0048] The barrier is introduced as a walkway level set of crowned rollers **303** that rises to gently move riders towards one of the walkway surfaces. The rollers continue until the barrier reaches the level of the handrail (detail not shown for clarity), which is synchronized with the applicable walkway.

[0049] Gap plates **304** are removed by the barrier assembly using a secondary rail **305** and transported to the next transfer area for insertion. Removal is performed to allow for the differential velocity between adjacent walkway segments (separated by a barrier) in the transit sections of the system.

[0050] A cross section of the walkway with the supporting railing system is shown in **FIG 4**. Walkway segments are supported by a rail system **401** through installed rollers **402**. Some of the rollers in the segment are powered and provide the motive force for the segment.

[0051] The rail system provides power to the walkway segments through power rails **403**. Since the walkway segments have independent battery systems, non-continuous power may be provided, or sections of the electrified rail system can be under maintenance without impacting walkway operation.

[0052] The rail system has integrated sensors embedded in the power rail assembly support **404** to determine the location of all segments, their speed, and provide feedback to the central control system on operations. Similarly, these sensors, and associated transmitters **405** are used to communicate with and direct the operation of walkway segments.

[0053] Gap plates **406**, as described previously, cover the rail system in the transfer areas to prevent injury, provide a continuous surface for riders, and synchronize adjacent walkways.

[0054] The walkway railing system is supported by pilings **407** connected to the structure surrounding the walkway system. Space remaining underneath the walkway can be used to run additional services, or provide for a means to remove walkway segments for maintenance at certain locations.

[0055] Walkway segments do not extend beyond the width of the railways except for the rollers. This allows for a rail switching system to be used that can remove a walkway segment vertically (to a space below) from the main walkway surface. By this means, individual segments can be removed for maintenance and repair without disrupting the rest of the system.

[0056] The walkway segment shown in **FIG 5** is in a storage configuration prior to incorporation with the walkway system. Each walkway segment consists of a walkway segment chassis **501** and a set of expansion plates **502** stored beneath the main tread plate **503**. The number of expansion plates used will depend on the application based on the amount of speed multiplication desired and space availability below the walkway surface.

[0057] The chassis of the walkway provides structural support through rollers **504** mounted to its frame that are captured by the rail system. When expansion plates are deployed, auxiliary rollers **505** are inserted into the railing system channel to provide additional support and alignment.

[0058] **FIG 6** shows a walkway segment in the process of expanding as part of a connected walkway system with the chassis side plate removed for clarity. The top tread of the next segment and the associated coupling plate are shown for illustration as well. Physical connections are made with adjacent walkway segments to a flexible coupling plate **601** , and expansion plate rollers **602** are deployed to further support walkway surfaces.

[0059] The first walkway expansion plate **603** is extended out of the walkway segment chassis **604** using a traction system controlled by the chassis processor. In **FIG 6** this is shown as a rack and pinion system **605**, though other types of positive linear motion control could be implemented.

[0060] During extension, the chassis maintains communications with the expansion plate and provides it power through linear slides on the underside of the expansion plate contacting brushes **606** on the chassis. The contacts provide pathways for monitoring and control of expansion plate actions, as well as monitoring of system health parameters, and providing power to operate locking motors and roller extension systems.

[0061] Once an expansion plate is clear of the plate stored below it in the chassis, the second plate is lifted into place by the vertical positioning system **607** to align with the back of the deployed expansion plate.

[0062] A horizontal positioning system **608** moves the expansion plate to abut the deployed expansion plate. This also connects the second expansion plate with the linear slide system, providing power, monitoring, and control.

[0063] Sensors in the second expansion plate determine proximity to the first expansion plate, and upon command from the chassis deploy a locking mechanism between the two expansion plates.

[0064] Expansion plates are deployed as needed in the process outlined above. Retraction of expansion plates is performed in reverse of the process for expansion.

[0065] **FIG 7** highlights the critical features of the walkway segment chassis. The walkway segment chassis provides monitoring, control, support, and motive power to the entire walkway segment. Riders only interact with the main tread plate **701** that rests on the rest of the frame components (shown removed for access to components below). Motive power is provided through installed traction motors **702** driving one or more rollers engaged with the railing system. Linear motors or similar technology could be used based on the needs of the installation and economy of the solution. The drive system is controlled by an onboard controller that is directed by a central control system. The same enclosure **703** houses all monitoring and control processors for the walkway segment.

[0066] Communications with central control and speed sensing is performed with an optical transmitter and sensor system **704**, though alternative methods such as monitoring roller speed and wireless communication would be equally appropriate given the installation requirements. Monitoring functions include system health of components based on embedded temperature and vibration sensors, and current and voltage usage of components. This information is used to determine maintenance cycles and is part of the information communicated to the central control system.

[0067] To ensure continuous monitoring of chassis components, expansion plate position sensors **705** are used in multiple locations to determine location of expansion plates and report movement back to the control system for feedback.

[0068] A system of stepper motors is used for controlling positioning of expansion plates within the chassis as described below.

[0069] The vertical positioning stepper motor **706** drives lead screws to adjust height of the expansion plate support beams, lifting the stacked expansion plates to the appropriate location.

[0070] The horizontal positioning stepper motor **707** located in the horizontal positioning system housing controls the horizontal position of expansion plates by operating a pusher plate **708**, enabling capture by the rack and pinion system.

[0071] The rack and pinion stepper motor **709** operates the rack and pinion system through a series of chain drives, providing horizontal control of expansion plates when they are deployed on the rail system.

[0072] Where the walkway segment chassis interfaces with an adjacent walkway segment, there is a locking plate **710** that is designed to interface with the locking system on extension plates. Flexibility in the walkway system is provided through the design of the connection between the locking plate and the walkway segment chassis. A central bushing **711** allows for limited vertical and horizontal rotation of the locking plate relative to the centerline of the walkway segment, allowing for variations in the railing system, and accommodating gradual turns and changes in elevation.

[0073] Power to all onboard electrical systems is provided by an onboard battery **712** charged through contacts **713** connected to the walkway system power rails. The capacity of the battery is sufficient to operate the segment for short durations of time without external power applied by the railing system to ride through temporary power outages, or traverse areas of the rail system where power is unavailable due to design, fault, or maintenance.

[0074] **FIG 8** is a breakaway of a single expansion plate. All expansion plates used in the system are identical and interchangeable, regardless of position in the walkway segment chassis or number of expansion plates used in a walkway segment.

[0075] Each expansion plate contains 6 main components: a tread plate **801**, structural frame **802**, plate locking system **803**, roller deployment system **804**, linear conductive slides **805**, and electronics enclosure **806**.

[0076] The tread plate **801** is sized and grooved to interact with the underside of the walkway segment chassis. The surface area is maximized within the space envelope available in the walkway segment chassis.

[0077] The structural frame **802** provides support to all other expansion plate components and connects the expansion plate to the rest of the walkway.

[0078] The expansion plate locking system **803** is used to ensure a positive connection along the walkway surface, engaging features on adjacent expansion plates or a walkway segment chassis to ensure walkway continuity. The system shown is a screw type connection driven by motors, though other systems including wedge style locks, solenoid activated bolts, or similar could be similarly employed. Proximity sensors **807** are integrated into the locking surface to ensure that the target locking surface is in range and is properly engaged.

[0079] A roller deployment system **804** (shown extended) is used to extend and retract rollers **808** during different phases of deployment. The system shown consists of a worm drive that pushes rollers out supported by a large bearing surface **809**. This system was chosen due to its robust design and simplicity, but other means of roller deployment that use electro-mechanical means could be easily employed.

[0080] After the rollers associated with an expansion plate are clear of the walkway segment chassis, they are deployed to interface with the rail system. This provides additional support for the walkway. Similarly, as expansion plates are retracted, the rollers are retracted prior to being pulled into the walkway segment chassis for storage.

[0081] Guide wheels **810** connected to the frame rest on the expansion plate below, ensuring alignment and movement during expansion plate deployment.

[0082] A linear conductive slide **805** is provided on both sides of the expansion plate. This slide interfaces with the walkway segment chassis through a sliding connection on its surface, and to adjacent expansion plates with a pin and socket connection on the ends.

[0083] The slide shown has four contact rails per slide with the walkway segment chassis. This provides the ability for power to be provided to the expansion plate and for low fidelity communication between the walkway segment chassis processor and expansion plate microcontroller. Due to the continuous nature of the linear slide and connection to adjacent expansion plates, all expansion plates deployed onto the rail system will be able to communicate and receive power from the walkway segment chassis.

[0084] A rack **811** mounted to the underside of the tread plate interfaces with the walkway segment chassis pinion to control movement of the expansion plates when deployed on the rails.

[0085] The electronics enclosure **806** includes controllers for previously mentioned systems, monitoring of proximity sensors and system health sensors, a microprocessor to manage expansion plate functions and communication with the walkway segment chassis, and a small battery to power the electronics when power is not available from the walkway segment chassis.

CLAIMS

[0086] The above description is intended to be illustrative and not restrictive. Other embodiments may be used, such as by one of ordinary skill in the art upon reviewing the above description. The information provided is to allow the reader to easily ascertain the general nature of the invention and submitted with the understanding that is will not be used to limit the scope or meaning of the claims. As a provisional application, much of the components and their functions are grouped together to streamline the explanation. This should not be interpreted as intending that any unclaimed disclosed features is essential.

[0087] The following claims are provided with each claim standing on its own as a separate embodiment where multiple claims may be combined with each other in various combinations or permutations.

1. A mass transit system consisting of two or more parallel moving walkways capable of variable speed with constant speed transfer areas between walkways. Critical characteristics are immediate availability of transit without special equipment and average transit speeds rivaling current mass transit solutions.

Implementation could be in existing tunnel infrastructure, newly developed small diameter tunnels, on surface streets, on elevated paths, or within and integrated with commercial spaces.

2. A moving walkway system as described in Claim 1 consisting of independently operable segments that are joined together to create an uninterrupted walking surface.

3. An independent walkway segment as described in Claim 2 that rides on a permanently installed rail system. Each segment has the ability to extend and contract its length as necessary to compensate for speed variation while maintaining an unbroken walking surface.

4. A walkway segment as described in Claim 3 with an independent power supply and monitoring and control system to provide continued operation during central system power outages or track segment maintenance.

5. A walkway segment as described in Claim 3 containing one or more expansion plates that are automatically added and removed from the walkway rail system as directed by a central control center.

6. A walkway segment as described in Claim 3 that monitors status of all controlled components and system health parameters to determine operation and maintenance intervals based on communication with a central control center.

7. A walkway segment as described in Claim 3 that can be removed from the walkway rail system for maintenance and repair without disrupting walkway operations.

8. A walkway expansion plate as described in Claim 5 that is capable of deploying rollers to engage with the walkway rail system and positively engage adjacent walkway segments or expansion plates.

9. A walkway rail system as described in Claim 3 that supports independent walkway segments on either side, and provides power and signal information from a central control center.

10. A gap plate that interfaces with the walkway segment of Claim 3 when speeds of adjacent walkways are synchronized. The gap plate covers the area between the walkway segments over the rail system described in Claim 9 to provide a continuous surface between parallel walkway segments in transfer areas.

11. A gap plate as described in Claim 10 that interlocks and rests on adjacent walkway segments to ensure matched speed and passenger safety.

12. A flexible connection between walkway segments described in Claim 3 that allows for small curvature turns and elevation changes within the walkway system described in Claim 1. This ensures flexibility of implementation, even in existing infrastructure installations.

13. A walkway separation barrier between adjacent walkways travelling at different speeds to enhance rider safety.

14. A method of introducing the separation barrier described in Claim 13 prior to adjacent walkways diverging in speed that involves slowly introducing the barrier as a rising wall between the walkways containing rollers that divert riders to one of the two walkways.

15. A method of adding and removing gap plates described in Claim 10 prior to and after the walkway transition areas described in Claim 1.

16. A central control system that monitors and controls walkway segments in Claim 3 by constant communication through facilities installed in the railway system described in Claim 9.

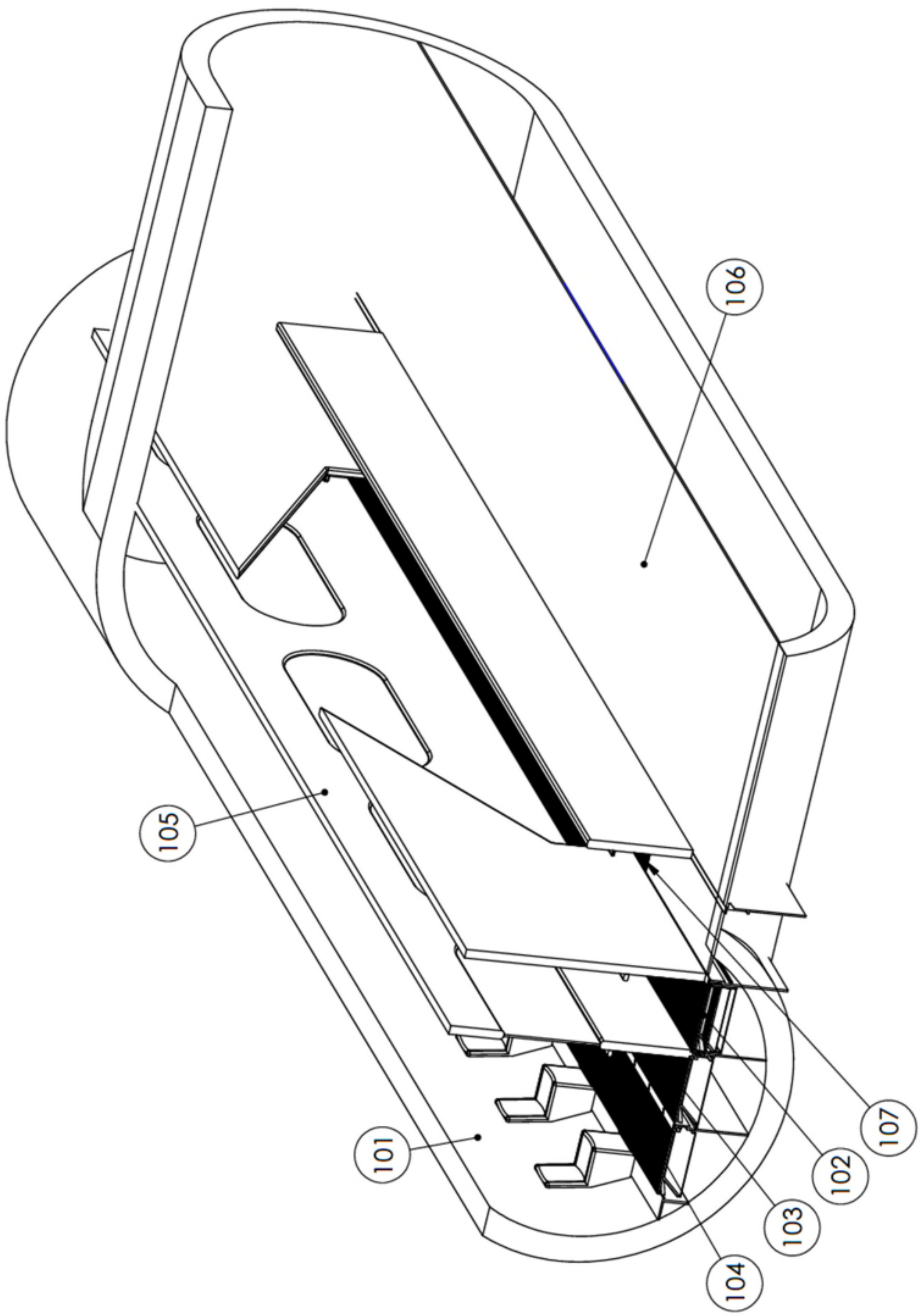

FIG. 1 – LOADING STATION LAYOUT

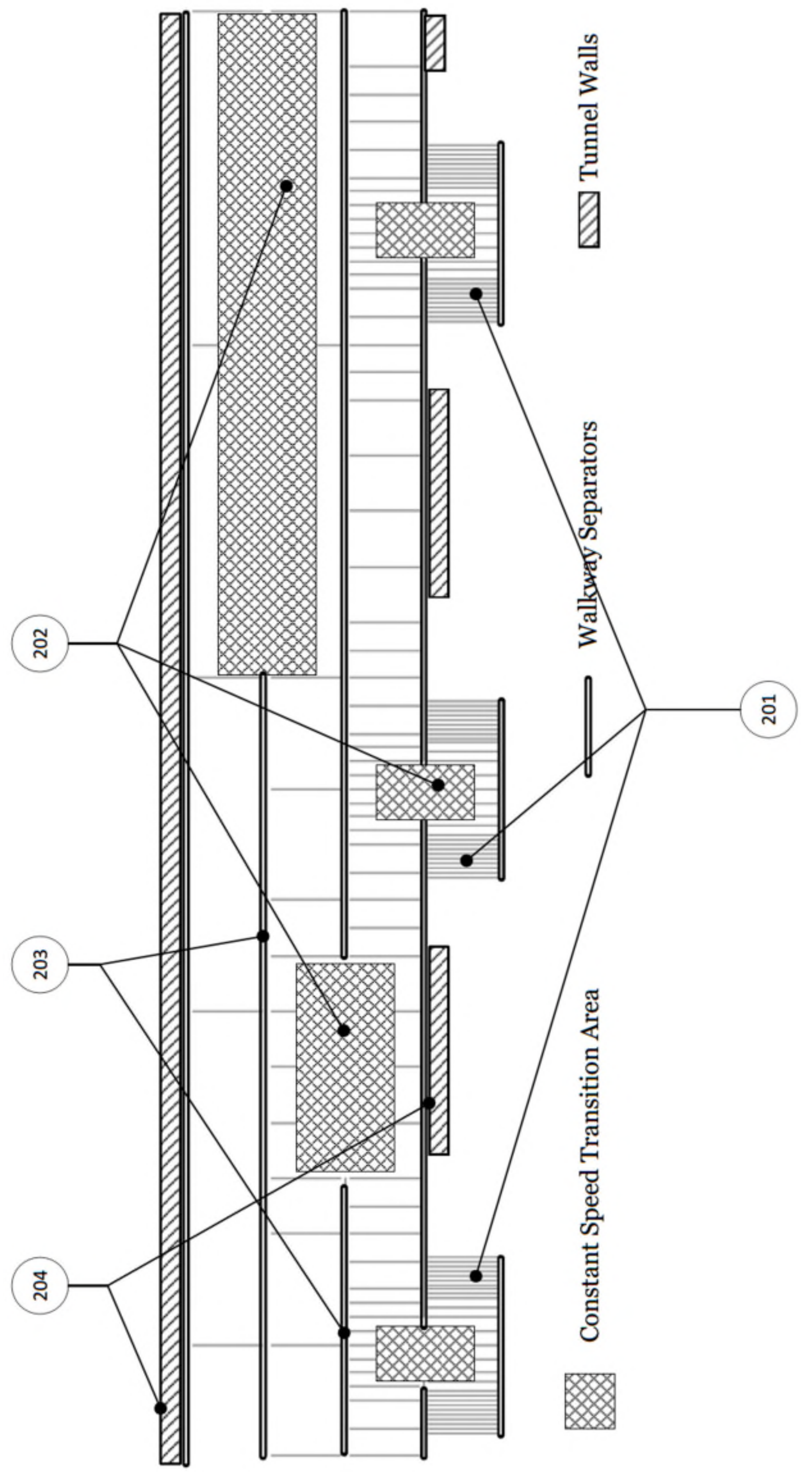

FIG. 2 – WALKWAY SPEED SCHEMATIC

Sigma Expert Solutions
Tel 919-307-4835
info@sigmaexpertsolutions.com
sigmaexpertsolutions.com

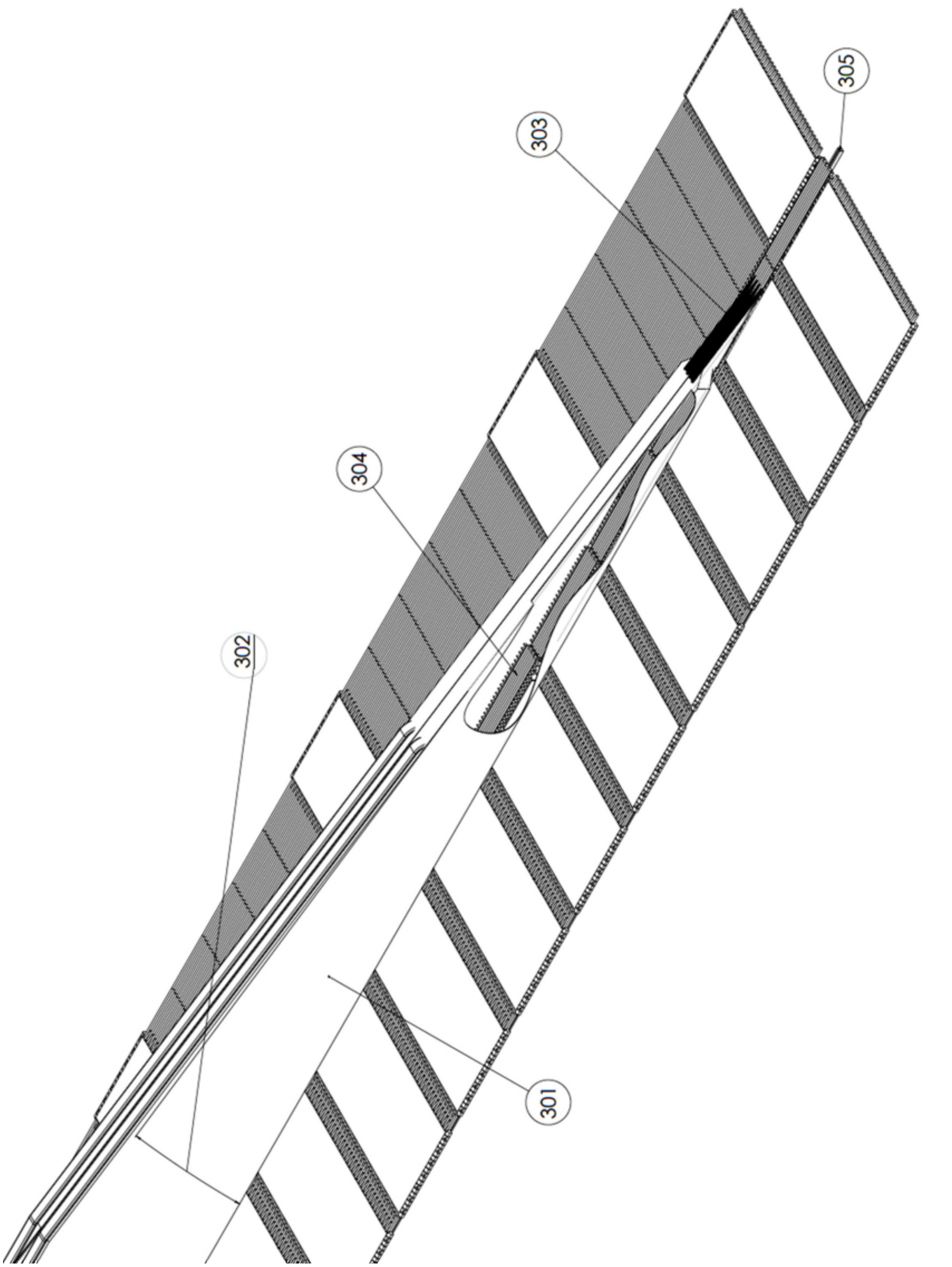

FIG. 3 – SEPARATION BARRIER

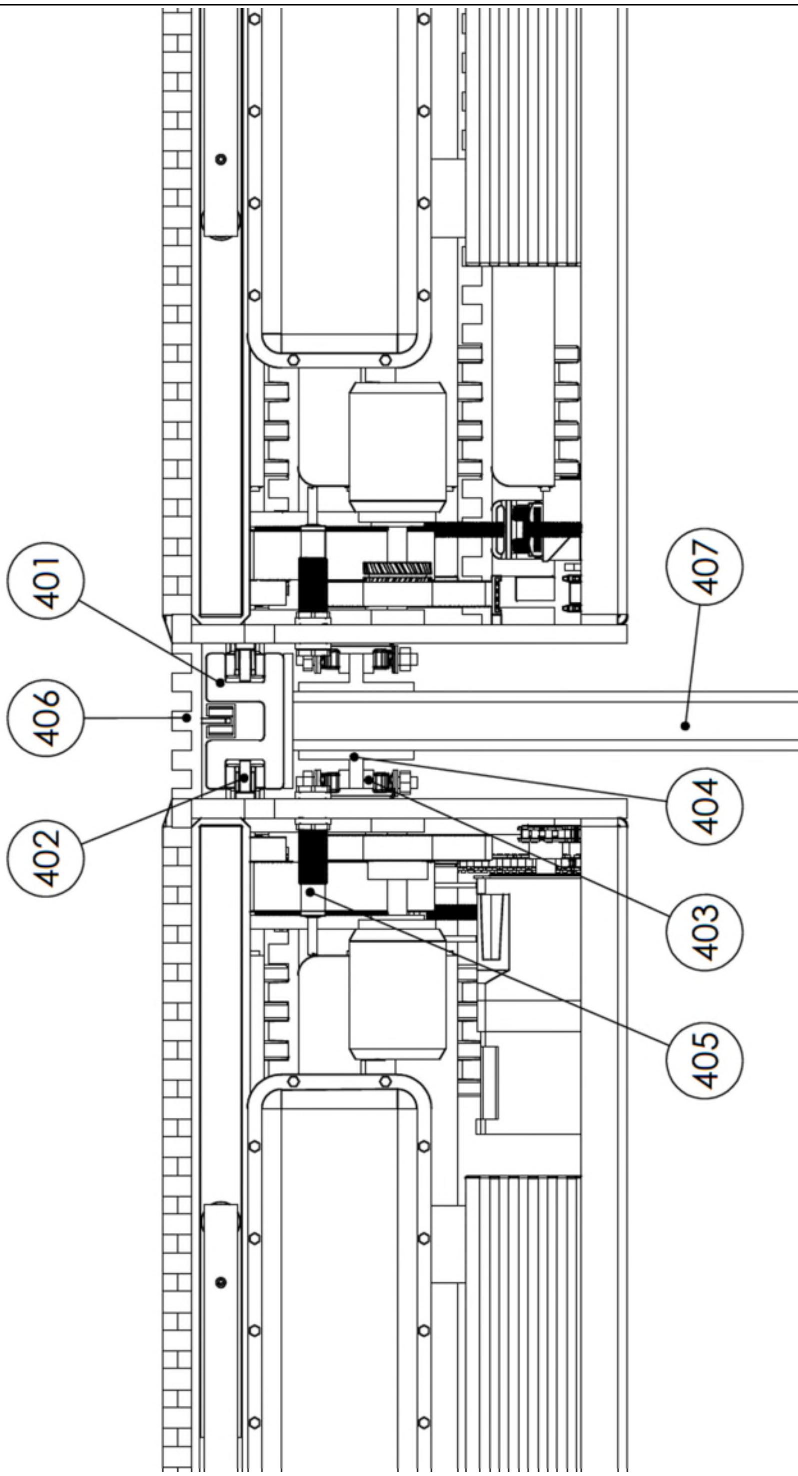

FIG. 4 – WALKWAY SECTION VIEW

DRN:0001-005-PPA-01, R00

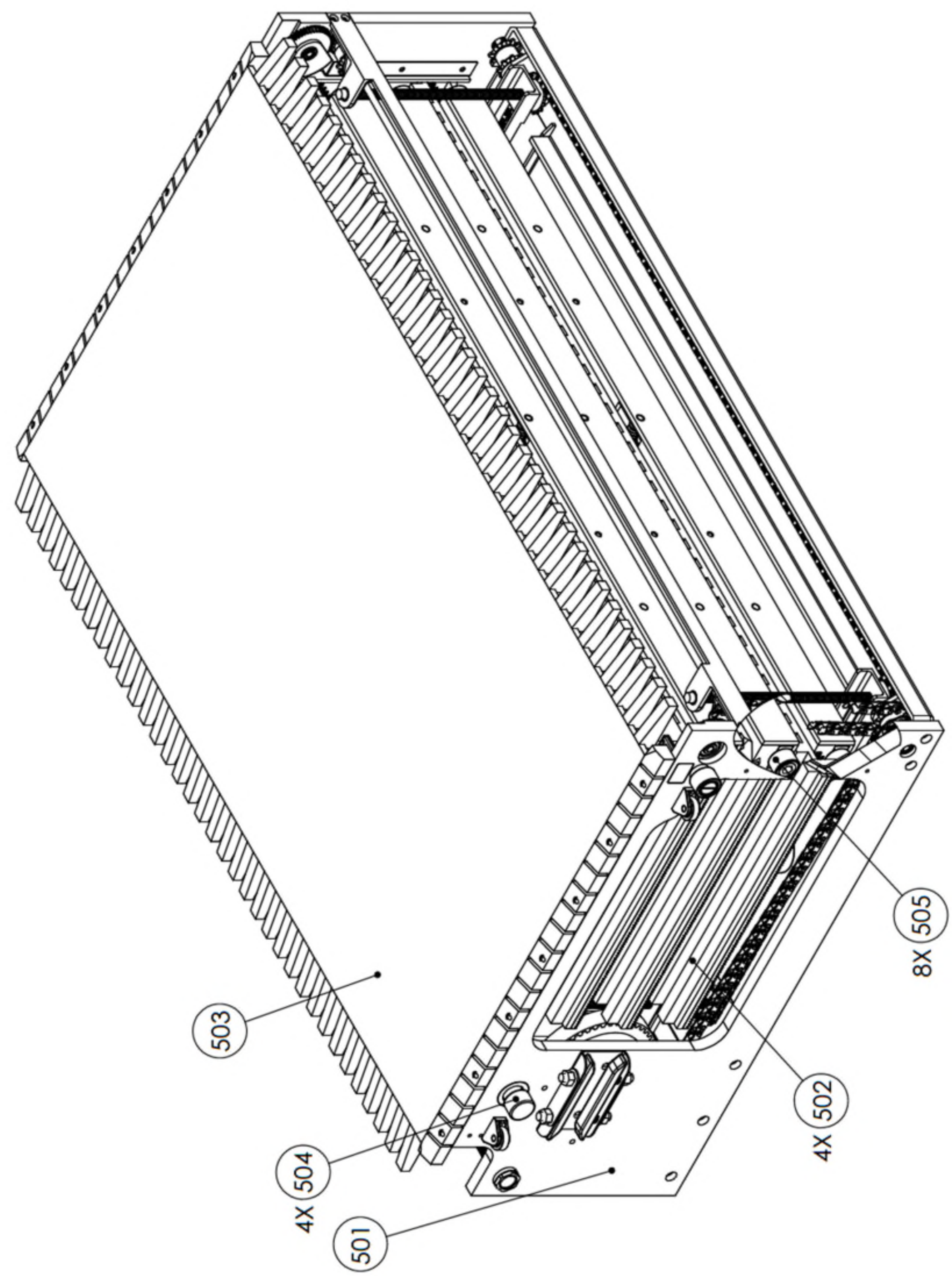

FIG. 5 – WALKWAY SEGMENT ASSEMBLY

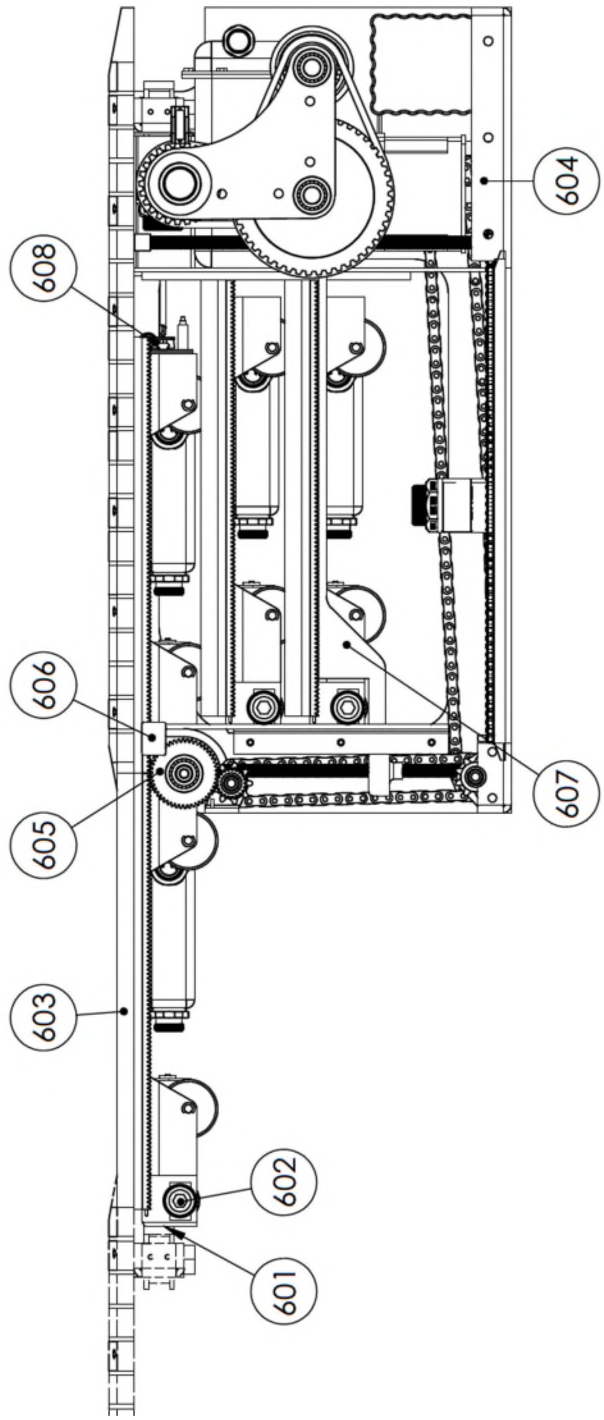

FIG. 6 – OPERATION DURING EXTENSION

Sigma Expert Solutions
Tel 919-307-4835
info@sigmaexpertsolutions.com
sigmaexpertsolutions.com

DRN:0001-005-PPA-01, R00

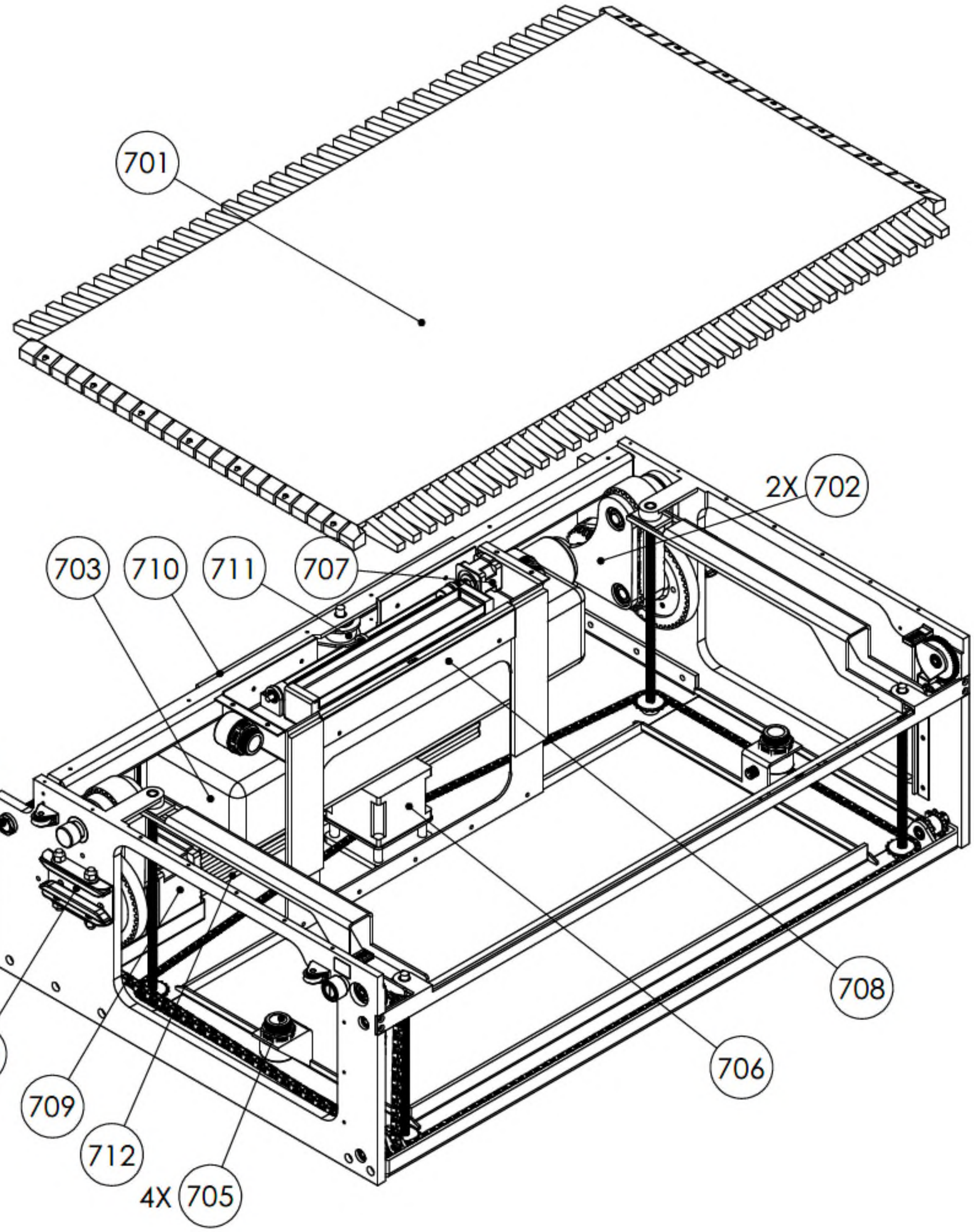

FIG. 7 – WALKWAY SEGMENT CHASSIS

Sigma Expert Solutions
Tel 919-307-4835
info@sigmaexpertsolutions.com
sigmaexpertsolutions.com

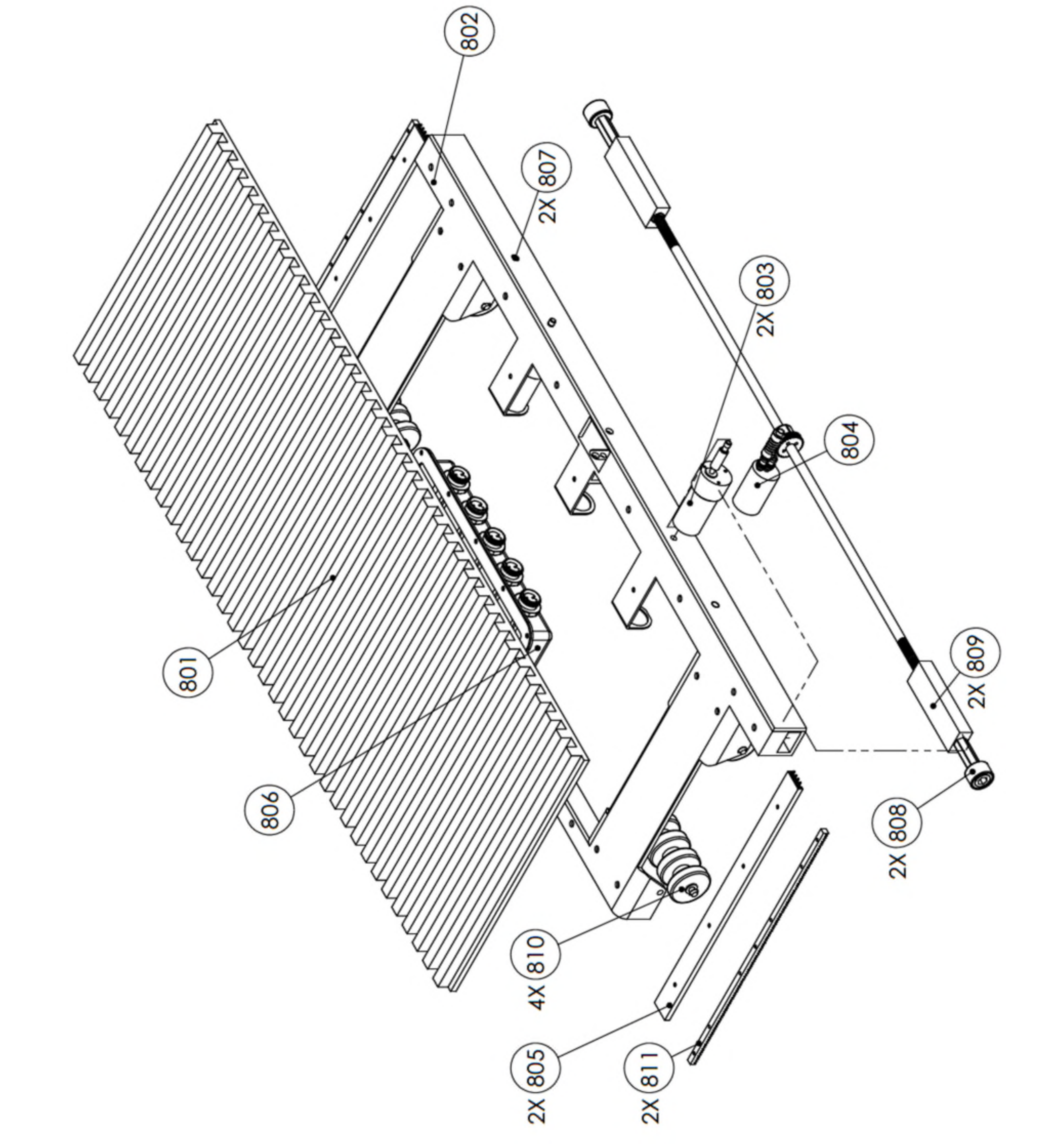

FIG. 8 – WALKWAY SEGMENT EXTENSION PLATE