= Kawasaki Heavy Industries C151 =

The Kawasaki Heavy Industries C151 is a type of train that is one of the four current types of electric multiple unit on the North South and East West Lines of Singapore 's Mass Rapid Transit (MRT) system . These are the oldest trains built for the system ; they were introduced in 1987 and are still in operation . Sixty @-@ six trainsets consisting of six cars each and a single money trainset consisting of four cars were purchased . These trains are operated by SMRT Trains .

These trains were manufactured from 1986 to 1989 in batches by a Japanese consortium consisting of Kawasaki Heavy Industries , Nippon Sharyo , Tokyu Car Corp and Kinki Sharyo following a round of intense competitive bidding by rolling stock manufacturers from around the world . No visible differences can be found in any of these batches , which were built to agreed specifications .

The trains underwent a two @-@ year mid @-@ life interior refurbishment programme by Hyundai Rotem . After major train disruptions on 15 and 17 December 2011 , further plans to upgrade its mechanical components to increase its reliability were made . The first trainset to receive this upgrade , which included a replacement traction system , entered service in July 2015 .

= = History = =

= = = Tendering process = = =

With construction of the Mass Rapid Transit system underway in 1983 , Contract 151 called for the procurement of rolling stock ? 150 cars in Phase One and an option for 246 cars in Phase Two . In what Financial Times described as " a time when manufacturers were begging for orders " for the global rolling stock market , competition for the contract was intense . At least eight companies from around the world submitted bids for what they had nicknamed the " Big One " . Bidders included Metro @-@ Cammell with Singapore Automotive Engineering , Kawasaki Heavy Industries with three Japanese manufacturers , MAN AG with AEG , Siemens and Brown , Boveri & Cie , Francorail with Alsthom @-@ Alantique , SOFRETU and Singapore Shipbuilding and Engineering , ASEA with Sembawang Shipyard , and a Bombardier Transportation @-@ led consortium with Hawker Siddeley Canada and Brown Boveri Canada .

Competition for the contract was so fierce that it involved last @-@ minute discounts , offers of free parts and allegations of sabotage . Metro @-@ Cammell , Kawasaki and ASEA were shortlisted for the final round . Metro @-@ Cammell based its design on the Hong Kong MTR M @-@ Train EMU and proposed to use the GEC propulsion system had they won the contract . Metro @-@ Cammell also delivered a concept mock @-@ up and was originally the favourite to win the contract . However , analysts became concerned that a measuring error involving the London Underground 1983 Stock during the evaluation period could jeopardise their bid .

In 1984 , the Japanese consortium of Kawasaki Heavy Industries with Nippon Sharyo , Tokyu Car Corp and Kinki Sharyo was awarded Contract 151 at a cost of S $ 581 @.@ 5 million for the construction of 396 passenger cars . Kawasaki won the contract ; its bid ? aided by favourable financing from Mitsui and positive economic conditions in Japan ? was 12 % lower than those of other bidders . The award was the largest single contract awarded in the initial construction of the system . Kawasaki also promised to supply $ 20.9m worth of complimentary spare parts after delivery . The loss of Contract 151 was a massive financial blow to Metro @-@ Cammell , who were forced to reduce their workforce by half later that year .

= = = Initial construction = = =

A mock @-@ up was manufactured in Japan after Kawasaki won the contract . It was shipped to Singapore and put on public display during the 1984 National Exhibition held in November 1984 at World Trade Centre . The mock @-@ up featured three choices of seating arrangements and colour

schemes ; members of the public were invited to give feedback on these options . The finalised interior design of the C151 trains consisted of a fully longitudinal seating arrangement . The bucket seats were made of plastic ; glass partitions separated the seating areas from the passenger doors . Strap lines for standing passengers were installed in the middle of every car . The colour scheme of each adjacent car 's interior is distinct to make car identification in cases of fault reporting easier for passengers . Originally the colour scheme of the driving trailer cars was orange , that of the second and fifth motor cars was blue , and that of the two centre motor cars was green . There were nine seats between two doors ; this was reduced to seven after the first round of refurbishment .

While the rolling stock and Mitsubishi Electric propulsion equipment were constructed in Japan , many parts were sourced from Europe . The trains were fitted with Stone Platt air @-@ conditioning , Duwag bogies , Sig gangways , Scharfenberg couplers and Westinghouse brakes . Mitsubishi Electric 's propulsion equipment was estimated to consume 50 % less electricity than Hong Kong 's existing MTR M @-@ Train EMU . Its Automatic Train Control (ATC) signalling system was supplied by Westinghouse , capable of running at pre @-@ programmed speeds and activated by the train driver . While theoretically possible to design for a fully driverless operation using this signalling technology , MRT Corporation (MRTC , now SMRT Corporation) decided against this option . The trainsets were assembled in Kobe , Japan , and then shipped to Singapore by Neptune Orient Lines . The first trainset was delivered to MRTC on 8 July 1986 at Bishan Depot , officiated by Yeo Ning Hong .

= = = First refurbishment = = =

On 3 September 2004 , Hyundai Rotem , Mitsui , RM Transit Technology and dU LexBuild received an order to refurbish all 396 carriages , costing S $ 142 @.@ 7 million in total . The works included the refurbishment of interior fixtures , the addition of wheelchair spaces , the upgrading of onboard communications equipment , enhancement of the public announcement system , and general improvement of the cars ' appearance . SMRT Corporation said the reasons for refurbishment were wear and damage of important components over the past two decades and water leaks from the air @-@ conditioning system on some trains . The company chose this option instead of buying new rolling stock , which would have cost S $ 792 million . The first refurbished train began revenue service on 5 November 2006 , and all remaining trainsets had been refurbished by the end of 2008 .

The exteriors of refurbished trains resemble those of the C751B rolling stock . The interior fittings were replaced with white walls and new seats and installed further back to allow more standing space . The colour of seats in the driving trailer was changed from orange to red . Seats of the refurbished cars were lengthened from 43 cm (17 in) to 48 cm (19 in) . Four of seven seats per row were designated as priority seats and were differentiated using a darker colour .

The Mitsubishi Electric propulsion system was retained , having performed better than expected . The wheelchair space was made available on the end of two mid @-@ train cars , nearest to the lifts in above @-@ ground stations . LED displays that blink to warn passengers of closing doors were introduced in the upper middle section of the door . Additional loudspeakers and advertisement panels were also introduced . Hand grips were moved to the support bars of the seats on the ceiling and grabpoles were located near the doors and at both ends of each carriage . The air @-@ conditioning system was modified to match the system used in the C751B cars , with air @-@ conditioning vents and in @-@ flow fans installed .

In November 2008 , SMRT Corporation and Land Transport Authority (LTA) announced that the last ten refurbished trainsets would have one @-@ third of their seats replaced with metal rails to create extra standing space . The move was justified on grounds of allowing more standing space onboard during peak @-@ hour services . The reduction of seats per row from nine to seven after refurbishment was already unpopular among commuters ; the decision to further reduce seating capacity drew sharp criticism against the operator and LTA . As of December 2015 , all 66 C151s from one @-@ third of their seats have been replaced by metal bars to create extra standing space .

= = = Second refurbishment = = =

Following major train disruptions on 15 and 17 December 2011 , the Committee of Inquiry (COI) found that despite the first refurbishment of the C151 rolling stock , " there does not appear to be any upgrade in terms of engineering components " . The COI was particularly critical of the inadequate and ageing emergency battery installed on the C151 and recommended the installation of a Train Integrated Management System (TIMS) found on the C751B and C151A trains .

In response , SMRT announced it was replacing important engineering components on all C151 trains by 2019 . This included changing the existing Mitsubishi Electric propulsion system for the newer Insulated @-@ gate bipolar transistor (IGBT) and Permanent Magnet Synchronous Motor (PMSM) propulsion system by Toshiba , technology currently used in the Tokyo Metro 's 1000 series and 16000 series trains as well as Hankyu 1000 series trains . On 30 July 2015 , trainsets 055 / 056 and 131 / 132 began using this new propulsion system , distinguishable from the original fleet by the whining noise when accelerating or decelerating . In tandem with the replacement of the signalling system on the East @-@ West Line and North @-@ South Line with the newer Thales SelTrac signalling system , new equipment had to be installed in the passenger compartment of the trailer cars .

= = Operational details = =

= = = Money train = = =

Kawasaki built a four @-@ car unit to serve as a money train . This was decommissioned from service in 2007 and both set 301 and 302 are used by the Singapore Armed Forces (SAF) for training purposes . The mock @-@ up C751B is used for the ITE College West for training purposes .

= = = Passenger announcement and information systems = = =

These trains originally had no visual passenger information systems ; station announcements had to be made by the train operator . An automatic audio announcement system using voice synthesizers was installed on each train by September 1994 . The first iteration of the door closing buzzer announcements , which replaced the initial door chimes , was fully introduced by April 1997 .

SMRT first attempted to install a passenger information system SMRTime on trains using LCD displays in 1999 ; these have since been removed . In November 2006 the doors of three cars (carriage number 3006 , 1006 and 2006) were installed with a dynamic , in @-@ train system displaying station information for testing ; these are similar to ones used by Hong Kong 's MTR . An initial prototype of STARIS based upon the existing Automatic Transit Info System was developed in @-@ house ; this was removed before the end of the year without entering service .

Two years later , four units of vacuum fluorescent displays (VFD) were mounted on the ceiling . Eight units of dynamic route maps were mounted above every door in each car in trainset 053 / 054 for a two @-@ month trial . This new SMRT Active Route Map Information System (STARiS) was then progressively introduced to all C151 trainsets , and subsequently to C651 and C751B trains for a cost of S $ 12 million ? S $ 20 @,@ 000 per car . It became standard equipment on all new rolling stocks subsequently introduced on the East @-@ West Line and North @-@ South Line .

= = Livery and numbering = =

The cars had an aluminium @-@ alloy double @-@ skinned construction , and were delivered unpainted to save time . A red adhesive strip ran through the length of the cars in the middle to match the operator 's visual branding . The unpainted cars had a shiny appearance upon delivery ,

but as dirt and grime accumulated it became a recurring problem for the operator and attracted several public complaints . In response , MRT Corporation built a wash machine at Bishan Depot in an attempt to clean up the cars ' exterior proper . After refurbishment , the problem was solved by covering the cars ' exterior entirely with giant stickers , creating a livery that is similar to the newer C751B and C151A rolling stocks .

= = Train formation = =

A complete six @-@ car trainset consists of an identical twin set of one driving trailer (DT) and two motor cars (M1 and M2) permanently coupled together . The configuration of a C151 trainset in revenue service is DT ? M1 ? M2 ? M2 ? M1 ? DT .

The car numbers of the trains range from x001 to x132 , where x depends on the carriage type . Kawasaki Heavy Industries built sets 001 ? 020 , 051 ? 062 , and 093 ? 102 , Kinki Sharyo co @-@ built sets 021 ? 030 , 063 ? 072 , and 103 ? 112 , Nippon Sharyo co @-@ built sets 031 ? 040 , 073 ? 082 , and 113 ? 122 , and Tokyu Car Corp co @-@ built sets 041 ? 050 , 083 ? 092 , and 123 ? 132 . Individual cars are assigned a four @-@ digit serial number by the rail operator SMRT . A complete six @-@ car trainset consists of an identical twin set of one driving trailer and two motor cars permanently coupled together . For example , set 099 / 100 consists of carriages 3099 , 1099 , 2099 , 2100 , 1100 and 3100 .

= = Major incidents = =

Since its introduction , C151 rolling stock has been involved in three high @-@ profile incidents :

On 5 August 1993 two C151 trains collided at Clementi station because of a 50 @-@ litre (11 imp gal ; 13 US gal) oil spillage on the track by a maintenance locomotive , resulting in 132 injuries .

On 17 May 2010 , Oliver Fricker trespassed and vandalised car 1048 (trainset 047 / 048) with graffiti at Changi Depot . The graffiti was initially mistaken for an advertisement and was not spotted until the car was filmed and the video was uploaded to YouTube by a trainspotter . Fricker was convicted and sentenced to seven months ' imprisonment and caning . The public perceived this incident to have serious security implications , as the depot was considered a sensitive installation .

In the major MRT disruption of 15 December 2011 , one C151 train (trainset 067 / 068 , T139 in the COI) was stalled in the tunnel and its backup battery failed . The passenger compartments in T139 experienced a blackout and loss of ventilation , leading to one passenger smashing a train door window to avoid suffocation . The battery failure led to criticism by the COI on the condition of the aging emergency batteries installed on all C151 trains . SMRT has since proposed an upgrading plan to address this issue .

= = = Minor incidents = = =

On 25 May 2012 , a C151 train 's glass window panel was reportedly to be shattered on its own at Admiralty causing no injuries or death . This is unrelated to similar issue as well as other defects found on the C151A trains as acknowledged by the SMRT on 5 July 2016 .