



## KEN ERICKSON INNOVATION AWARD

### 2020 ENTRIES

PROJECT: **Torsion Bar Backdrive**

ENTRANT: **Engineering and Maintenance, Sydney Trains**



**Transport**  
Sydney Trains

### Application for Ken Erickson Innovation Award

#### **Key Delivery Team**

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***Engineering and Maintenance Directorate, Sydney Trains***

#### **EXECUTIVE SUMMARY:**

The torsion backdrive system was identified as a key innovation to achieving Sydney Trains' long term objective of reducing the possession duration required for major turnout renewal construction works. It was originally developed in response to clearance issues identified during the design phase of several projects, however the many construction and maintenance benefits it offers have resulted in it being more widely used.

The torsion backdrive system allows for a reduction in the critical construction path by eliminating the need to fit and adjust the back-drive on site. Further, it has been designed to be robust enough to be left preinstalled on a turnout switch panel resulting in a fully modular turnout renewal construction methodology. Thus, for the first time in the NSW network a switch panel with a backdrive can be pre-assembled and transported to site via work train and installed as one piece – minimising the resource heavy and time consuming in situ mechanical construction during turnout renewal track installation works.

Successful introduction of the new arrangement involved close consultation with manufacturers to review and refine design and specifications to ensure the system was suitable for the Sydney Trains Network. Extensive risk assessment and safety assurance processes facilitated the creation of documentation to ensure any risk introduced by the new system were identified and sufficiently controlled. Further, consultation with construction and maintenance crews was also undertaken to ensure all requirements were communicated and complied with.

The torsion bar backdrive received Type Approval from the Asset Standards Authority in July 2020, and, due to the identified benefits for both construction and maintenance, has been adopted as the preferred configuration by both the Turnout Renewal Program and the Signalling Asset Strategy Council when rolling out new turnout infrastructure within the Sydney Trains Network. The torsion bar backdrive was designed completely in house by Sydney Trains Signal Mechanical Design.

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## Description of the Entry

This entry for the PWI 2020 Ken Erickson Innovation Award is for the development and subsequent ASA Type Approval granted in July 2020 for the torsion bar backdrive.

Over the last 5 years, Sydney Trains has added 2,000 plus extra services each week to respond to the rapid increase in rail patronage. With more trains running on the network each day, asset wear rates have increased but the increase in rail traffic also means we have lost our routine maintenance windows between the weekday peaks. Increasingly, routine maintenance, major periodic maintenance and Transport growth projects compete for a finite number of weekend possessions.

Possession availability remains the single biggest constraint to timely project delivery. At the same time, weekend road congestion in Sydney is driving an increase in customer demand for weekend rail services and a decline in tolerance for the inconvenience of weekend trackwork. Sydney Trains is responding to these challenges with a range of initiatives aimed at reducing the time required to perform various asset renewals in order to be able to maximise possession utilisation.

Currently, the Sydney Trains long term asset renewal strategy for turnouts involves the upgrade of existing conventional turnouts to 60kg tangential turnouts. For many common turnout arrangements, a backdrive is added to the signalling mechanical design in order to assist with the opening and closing of the longer switch.

Clearance issues identified during the design phase of various junctions within the Sydney Trains Network led to the development of the torsion bar backdrive. It occupies a smaller footprint on the switch panel, thus eliminating kinematic envelope clearance issues created by the new signalling infrastructure required for the upgrade to the tangential concrete turnouts. It thus follows that the same constraints on loading switch panels onto engineering trains for delivery to site no longer apply, and are now bound by the outline of the concrete bearers, resulting in various safety and construction benefits.



***Torsion Bar Backdrive installed at Rhodes 51A points***

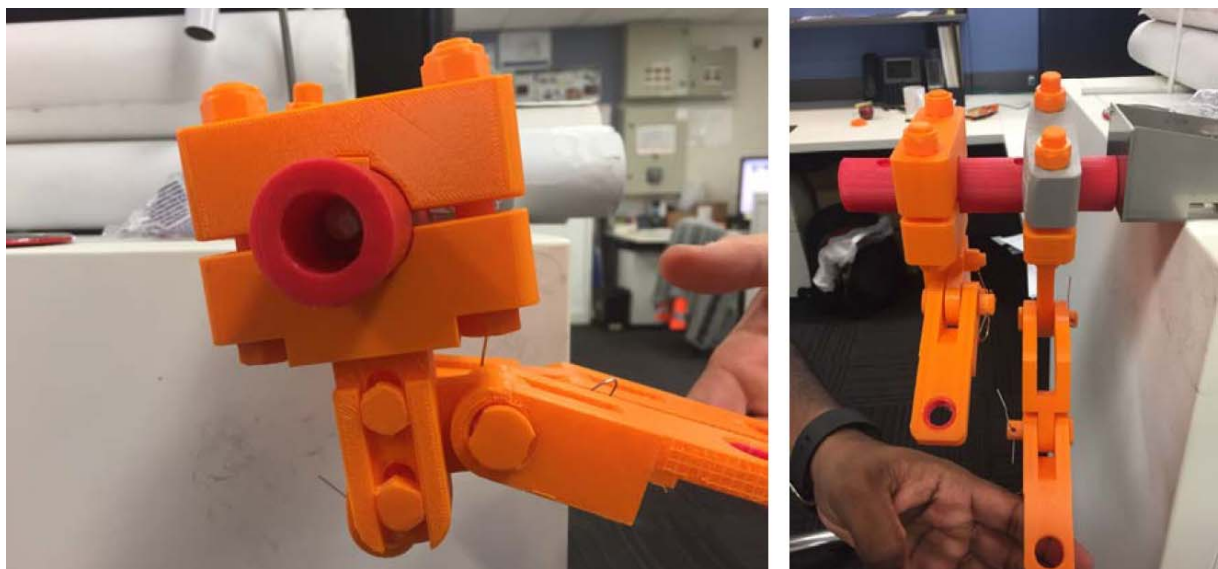
The torsion bar backdrive was developed with contribution from the following stakeholders:

- Engineering and Maintenance Directorate, Sydney Trains, led by Signalling Design
  - Signalling Mechanical Design: providing design, support and driving type approval
  - Major Works Signals Commissioning Engineers
  - Major Works Turnout Construction delivery teams – constructability of design, access to site and utilisation of approved heavy plant for construction of concrete turnouts
  - Major Works Signal Mechanical Project Operations
  - Major Works Planning Teams to identify clearance issues in concept phase
  - REC – for the fabrication of components
  - Track Design
- Voestalpine Railway Systems Australia Pty Ltd – development and provision of modified inbearers

## Introduction

The initial driver for the development of the torsion bar backdrive was to overcome clearance issues at Gordon and Turrella where turnout upgrade works were being undertaken. Upgrading conventional turnouts to 60kg tangential turnouts necessitated the installation of backdrives to assist with the movement of these long switches. Significant rework to track and OHW design and consequent delay to turnout renewal programs in critical junctions would have occurred had a solution not been developed, potentially resulting in reliability and financial impacts for the organisation. Further, rather than developing a bespoke solution for each of the junctions, the challenge was to provide a solution that could be rolled out across all tangential turnouts.

The torsion bar backdrive was developed in-house by Sydney Trains signals mechanical engineers, led by Andrew Mackenzie, in collaboration with Major Works Delivery. Guided by Andrew, the team saw this project from concept through to implementation. After initial development and testing using 3D simulation and FEA software and 3D printed scale models, full scale prototyping began in the Major Works turnout prebuild location with progression to installation and, over time, the design was optimised based on results of monitoring and testing.



**3D printed prototypes for preliminary assessment**

During the development phase it was recognised the torsion system would offer many benefits to construction and maintenance. So it was with a view to the future that a series of trials were organised once the backdrive design was finalised in order to evaluate the suitability of the design for various stages of installation:

- Rhodes 51AB – A trial designed to test the resilience of the backdrive during construction
- Rhodes 52AB - The first example in Sydney Trains of a turnout being installed with the entire point operating mechanism, including the torsion bar backdrive, fitted.
- Waterfall 58AB – A proof of concept exercise to demonstrate that the points equipment could be fitted to the turnout off-site and the entire switch panel transported using tilt wagons, installed using the DESEC turnout handler, ballasted with trains and tamped without damage. Waterfall 58 points was the first example in Sydney Trains of a turnout being assembled off-site, transported and installed with the entire point operating mechanism, including the backdrives, fitted and connected

Following the success of the Waterfall 58A&B Renewal in March 2020, full type approval was granted by ASA in July 2020 for its use across the Sydney Trains network where it has been recognised as the preferred option going forward when installing tangential concrete arrangements.

## Judging Criteria

This application will address the following judging criteria in turn with reference to Waterfall 58A&B Turnout Renewal, which was completed in March 2020:

- i) Difficulties Overcome
- ii) Contribution / Impact to Rail
- iii) Technical Input
- iv) Degree of Innovation in Rail aspects
- v) Contribution to Safety
- vi) Systems Assurance
- vii) Commercial Benefits

### *i) Difficulties Overcome*

In order to arrive at the final design which was eventually type approved by the ASA, there were a number of difficulties that needed to be overcome, which include the following:

- Managing the expectations from our Asset Management client that the works would occur within the specified financial year and subsequent opportunity costs of allowing these projects to slip into future financial years
- Whilst there are torsion bar style arrangements that exist in other rail networks, this was the first time installing this type of system within the Sydney Trains network. A number of trials were required in order to obtain the supporting evidence to show that the system was fit for purpose. These occurred over multiple delivery weekends, with revisions made to the individual components based on performance under traffic and feedback from key stakeholders
- The design of the arrangement to ensure a system that is no less effective than the existing T-crank arrangement
- Training and working with the delivery teams – Signals Designers would often be on site to oversee the pre-assembly and functionality of the backdrive prior to delivery, as well as during the delivery weekends in order to ensure the quality control of the final product
- Creation of components and subsequent engineering drawings in order to allow components to be fabricated by Sydney Trains
- Modification of steel inbearers to accommodate the new profile of the backdrive
- Determining the limits of pre-assembly in order to maximise construction efficiencies without degrading the integrity of the asset
- Implementation of change and engagement of key stakeholders within a short timeframe
- Satisfying the requirements of the ASA in order to obtain the Certificate of Type Approval
- Capitalising on initial investment in order to realise its construction benefits– pushing the envelope to determine the robustness of the system during a complete pre-assembly and installation in track
- Collaboration with track design to ensure compatibility with approved general arrangements for concrete tangential turnouts

In March 2020, the final construction trial was undertaken. For the renewal of Waterfall 58A&B points, the torsion backdrive was pre-assembled off-site at Chullora and affixed to the switch panel. This panel was then loaded onto the tilt wagons with the DESEC turnout handler, and transported to site. There, during the delivery weekend, it was installed with the DESEC, allowing for a direct reduction in the critical path for the requisite signal commissioning works.



## *ii) Contribution / Impact to Rail*

Taking into consideration the life cycle of the infrastructure, there are multiple benefits arising from the use of the torsion backdrive that contribute to the Sydney Trains rail network:

- It is a preferred alternative solution to the existing T-crank arrangement that can be fitted to the current tangential turnout layouts
- The reduced clearance in comparison to existing arrangements means that complete redesign of junctions will not be required in order to upgrade life expired assets.
- Constructability – again, when upgrading to 60kg rail and concrete bearers, changing configuration the lower profile backdrive arrangement assists in ensuring the constructability as well as improving installation times, reducing time on taken on the critical path during the short possession weekends
- Maintainability – with less parts to adjust than with the traditional T-crank arrangement, the torsion backdrive makes for a simpler and more expedient adjustment during both construction and maintenance. The modular nature of the design, which uses a small number of subassemblies in different arrangements to support all turnout radii used by Sydney Trains, permits less holding of spares in maintenance depots.
- Reliability and recovery – the simple, low maintenance design eliminates a number of failure modes associated with incorrect adjustment or lubrication. The simplicity of the design also facilitates rapid fault finding and rectification in the event of point failure.
- Resistance to damage – the single bar assists during maintenance resurfacing but is also more robust than the existing parts used. The increased robustness of the design reduces the likelihood of damage resulting from impact caused by plant activities or dragging equipment.
- Less manual handling – fewer and lighter components than the T-crank arrangement translates into less manual handling through pre-assembly and construction.
- Reduction in trip hazards around the backdrive for both construction and maintenance inspection and adjustment
- Improved quality – full pre-assembly is possible offsite in a controlled environment. Points rodding can be left on the switch panels for transit to site and installation with heavy plant without impact to the integrity of the components
- Faster installation – the simpler arrangement means that this time on the critical path can be reduced when undertaking turnout renewals. This will pave the way for the future for possessions of shorter duration or restricted track access.
- Future proofing for turnout renewals – the torsion bar can be combined with the other efficiencies within the turnout design space in order to improve installation times (such as leaving the motor on the switch panels)



***Waterfall 58 Backdrive Transportation on Tilt Wagon***

In response to a constructability issue, signals mechanical design was able to create a solution that addressed not only the initial problem statement but also increased efficiency in construction as well as improving safety on site, quality and ease of maintenance. The collaboration with the Major Works delivery teams to implement this during 48 hour possession windows is also a credit to the individuals involved. In construction, the benefits of the use of the torsion bar backdrive are already being actualised with reduced installation times allowing for additional scope to be achieved in weekend possessions. During the renewal of Waterfall 58pts, the full track, signals and overhead scopes were able to be completed during the possession weekend to the required standard.

### *iii) Technical Input*

The torsion bar backdrive uses a torsion bar installed outside the rail gauge to transfer the force from the point machine to the rear of the switch blades, ensuring that the blades are driven to the correct position and secured with each point movement. The torsion bar replaces earlier designs which used more complex arrangements of cranks and rodding to achieve the same result.

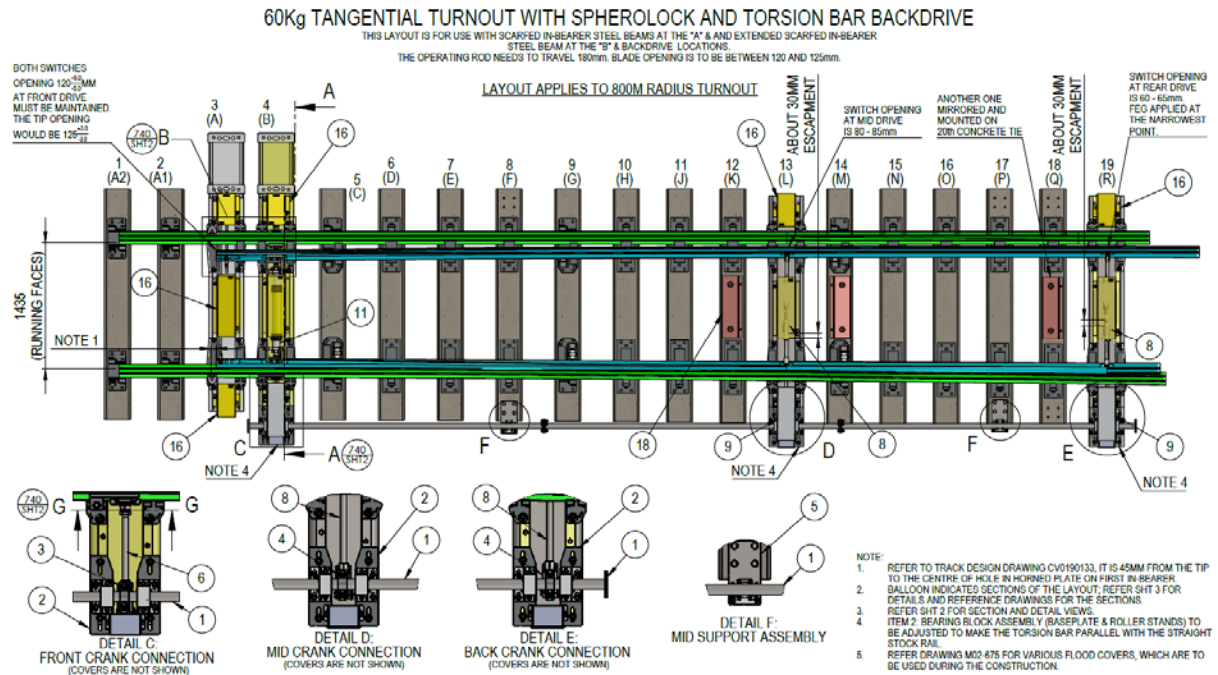
In order to effectively design and implement this arrangement, a huge number of stakeholders from the Engineering and Maintenance Directorate in Sydney Trains were consulted:

- Signalling Mechanical Design: providing design, support and driving type approval
- Major Works Signals Commissioning Engineers
- Major Works Turnout Construction delivery teams – constructability of design, access to site and utilisation of approved heavy plant for construction of concrete turnouts
- Major Works Signal Mechanical Project Operations
- Major Works Planning Teams to identify clearance issues in concept phase

Based on the advice and expertise of the stakeholders above, Sydney Trains developed an engineering instruction and test plan to ensure the strict requirements of the new system were met. Reports on the trial are ongoing to document learnings from the installation and subsequent performance under service.

The torsion backdrive design required significant consultation between signalling mechanical and track experts from Sydney Trains, Asset Standards Authority and Voestalpine Australia to ensure that the design was compatible with and compliant to the requirements set out in:

- ESG 100.14 Signal Design Principles – Points.
- SPG 1588 Point Mechanisms.
- ESG 003 Signalling Equipment Configuration Standard
- ESG 004 Signalling Equipment Strategy.
- ESC 250 Turnouts and Special Trackwork
- ASA standard tangential turnout designs
- Sydney Trains Asset Strategy



**Sydney Trains Design Drawing M10-740 - 60Kg Tangential Spherolock with Torsion Backdrive Layout**

#### *iv) Degree of Innovation in Rail Aspects*

With a completely in-house design, Sydney Trains was able to leverage a clearance issue into the development of a more robust backdrive system for use with concrete tangential turnouts. The improvements for constructability will pave the way for further innovation in order to respond to pressures to reduce installation time as the overall organisation reviews the operational impact of large configuration possessions.

Pre-assembly off site of the backdrive and proven durability during the installation of concrete switch panels combined with the use of the jointed bearer system will assist in the progression of a completely modular turnout renewal construction methodology, resulting in faster installation. This was successfully trialled in its totality in March with the installation of Waterfall 58A&B, providing the final piece of the puzzle for review of the currently utilised track installation methodologies.

Further, this design innovation was progressed to Type Approval from the Asset Standards Authority in July 2020, the first of its type in Sydney Trains, which will provide opportunities for the rollout of similar systems beyond the Sydney Trains Network.



***Waterfall 58 Switch Panel in Transportation***



## **v) Contribution to Safety**

The use of the torsion backdrive has multiple benefits from a safety perspective.

- Manual handling is reduced due to the ability to pre-assemble and leave points rodding on concrete switch panels for transport and installation on site.
- The reduced footprint reduces trip hazards on site for both construction and maintenance.
- The reduction of time to build points means less congestion on site due to delivery weekends, allowing for greater access for other disciplines and eventually the final commissioning of the asset into service.
- The torsion bar eliminates or isolates a number of pinch points.
- In addition, the torsion bar offers both reduced likelihood of and additional resilience to damage caused by being run over or struck by plant or dragging equipment.



***Torsion Backdrive Pre Assembly***

The torsion backdrive system allows for fully pre-assembled switch panel construction with only minor mechanical adjustments. This reduces the need for resource intensive in situ assembly during the weekend construction works, reducing people plant interaction and associated risk of safety incidents.

Multiple risk workshops were held to consider the risks and controls applicable to the introduction of the torsion bar backdrive. In addition to these formal meetings a large number of ad hoc discussions with other personnel contributed to the identification of risks and controls. For the installation of Waterfall 58A&B points, the construction risk reviews also considered the new methodology of installing directly off the tilt wagons, with the safety benefits identified above also materialising during this review.

## *vi) Systems Assurance*

The Sydney Trains Signalling Mechanical Design team that developed the torsion bar backdrive considered the full life cycle of the system. There were a number of management and engineering activities factors considered in order to obtain the appropriate performance data to progress to ASA type approval:

### Reliability

The reduction in installation time directly influences the critical path, resulting in opportunities to complete additional scope. This can directly translate into the minimisation of defects, rework and also the completion of the full scope of works during the delivery weekend. Thus far, the torsion bar backdrive with a Spherolock operating mechanism has proved reliable, with no failures of the points reported during or since the trial. The pre-assembly ensured components fitted together as required by design, and functioned in the manner required to ensure the switches were able to close and open to the tight tolerances required for commissioning into service

### Maintainability

There have been no maintainability concerns reported. Lubrication and general maintenance requirements are less than required for previous backdrive arrangements. The torsion bar backdrive design eliminates four of the five operational adjustment points in the T crank design. This improves maintainability, and reduces the potential for incorrect adjustment and consequent reliability issues, which have been previously seen in T crank installations. Finally, the torsion backdrive simply has fewer parts to be maintained, meaning fewer failure points and increased maintainability.

### Availability

The reliability and maintainability benefits offered by the torsion bar backdrive represent an improvement in availability. Availability is also likely to be improved with improvements in construction methods, enabled by the use of the torsion bar backdrive, potentially allowing a reduction in total track closure time. A number of improvements in turnout installation methodologies are being investigated and trialled by Sydney Trains Major Works division, one of which is installing the turnout with the points equipment including the torsion bar backdrive fully fitted. This improvement was proved viable with the installation of Rhodes 52 and Waterfall 58points.

A further improvement in availability is likely to be provided by greater resistance to damage caused by external factors. The T crank backdrive has been proven in service to be susceptible to impacts from plant, particularly when run over by vehicles, and this has on several occasions resulted in late possession handbacks and disruption to services caused by failures following possessions. The design of the torsion bar backdrive reduces the likelihood of this type of damage through its reduced footprint and increased tolerance to vertical loads. No testing has been carried out on this, however desktop analysis and CAD simulation suggests that the backdrive is unlikely to suffer any permanent damage as a result of a single wheel impact of a light vehicle and that any damage caused by a larger vehicle would be less likely to significantly affect the operation of the backdrive.

### **vii) Commercial Benefits**

As discussed above, there are a number of benefits associated with the use of the torsion bar backdrive. These benefits translate into commercial benefits:

- **Reduced Clearance** – means that complete redesign of junctions will not be required in order to upgrade life expired assets which can result in opportunity cost, loss of budget, and increased maintenance to existing asset whilst searching for an appropriate (often bespoke) solution.
- **Constructability and faster installation** – The design makes the adjustment simpler, and enables pre-assembly in a controlled environment. The reduction in installation time directly influences the critical path, resulting in opportunities to complete additional scope. This can directly translate into the minimisation of defects, rework and also the completion of the full scope of works during the delivery weekend. Its simpler profile also assists with resurfacing operation, ensuring that the switches can be adequately tamped, particularly during maintenance resurfacing



***Waterfall 58A Points During Construction Tamping***

- **Reliability** – the improved reliability and failure recovery provided by the torsion bar backdrive reduces both the probability and severity of service delays and consequent loss of revenue and reputational damage.
- **Maintainability** – again, simpler adjustment for maintenance resulting in less time spent in adjustment as well as fewer parts to be maintained and/or replaced as required.



- Availability of materials – ability to leverage internal skills within the Sydney Trains workshops as well as external procurement agreements in order to supply the relevant components. The modular design also allows for minimal holding of spares and simplifies supply chain management.

## Conclusion

The torsion bar backdrive is a step change in the operation, construction and maintenance of points in the Sydney Trains network. The design offers substantial improvements in safety, reliability, maintainability, constructability and availability of points assets. Improvements in constructability create opportunities for further innovation in turnout installation to significantly reduce both track possession requirements and project risks caused by critical path delays, while reliability and maintainability improvements offer reduced disruption to services.