PRIORITISATION OF SH5 SAFETY IMPROVEMENTS

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ABSTRACT

SH5 is the primary connection of Hawkes Bay with the upper North Island and carries around 4,500 vehicles per day of which around 19% is HCV's. Given the taxing topography of the road, transforming the road to reinstate a 100km/h speed limit is extremely costly and, although improvements are needed from a resilience perspective (a separate business case), the SH5 corridor investigations have indicated that significant investment is needed, which may take some time to design and construct.

In the interim, a multitude of low-cost, low risk treatments have been identified to improve the overall safety of the road. In order to prioritise the projects, WSP developed a prioritisation tool to assist in the decision-making process. The tool also has an in-built ability to quickly adjust the treatment priority based on a range of factors.

This paper outlines the development of a prioritisation methodology and the various criterion used. Initially focussed on improved safety outcomes (death and serious injury reduction), several criteria such as community acceptance, the deliverability / timing of the project and quantifying construction difficulty as well as duration of construction were all included in the assessment. This provided decision makers with a 'total risk' for each treatment and provides an improved holistic view of each treatment, rather than focussing purely on road safety.

This approach aligns well with three focus areas of the conference; namely working with the natural world rather than against it, being people focussed through minimising delays to road users during construction, as well as improving road safety.

This work was completed in 2022 and formed the basis of the conceptual and detailed design work, which was completed at the end of 2023. Construction of the work is to be completed mid-2024 and should provide a noticeable improvement to approximately 10km of the corridor.

INTRODUCTION/BACKGROUND

The Taupo to Napier corridor comprises State Highway 5 (SH5) from its intersection with SH1 at Taupo, to its intersection with SH2 at Eskdale, just north of Napier (refer to Figure 1). SH5 is a critical lifeline corridor connecting Hawke's Bay to the central and upper North Island. It has a daily traffic volume of up to 4,500 vehicles per day, of which 19% are heavy vehicles. SH5 currently serves as the primary route for freight between the upper North Island and Napier/Hastings as well as providing access to several communities (e.g. Te Pohue, Te Haroto) and forestry plantations. The terrain through which the road passes varies substantially; comprising relatively straight and flat sections for about a third of its length, with the remaining two-thirds winding through hilly and mountainous terrain. The speed limit through the winding section of SH5 was reduced from 100km/h to 80km/h in February 2022 as part of the Speed Management Programme (Urban Connection, 2020). This was largely opposed by the Hawkes Bay community at the time, primarily due to a perception of longer travel times. As of 2024 the 80km/h speed limit remains in place.

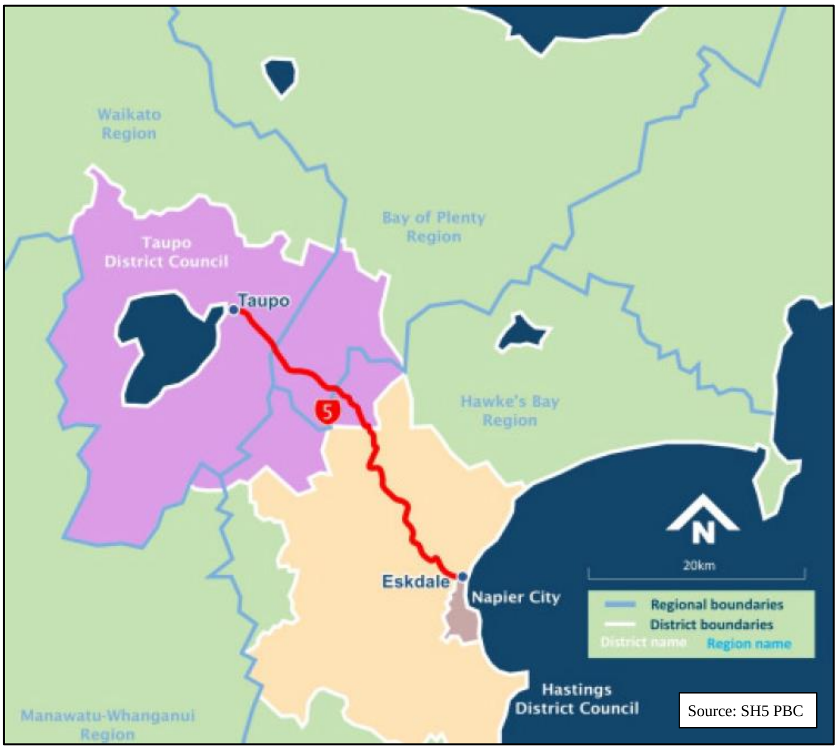

Figure 1: SH5 Location

In 2019, the New Zealand Government released their road safety strategy, Road to Zero (Ministry of Transport, 2019), with the target of reducing deaths and serious injuries (DSi's) by 40% by 2030 when compared to 2018. The national road authority, NZ Transport Agency Waka Kotahi (NZTA), developed five focus areas to achieve this target. One of these areas was "Infrastructure Improvements and Speed Management" and involved implementing improvements to the top 10% high-risk rural roads in the country.

The SH5 corridor (Napier to Taupo) was identified as one of these high-risk corridors and was investigated in 2021/2022 as part of a feasibility investigation funded under the Speed and Infrastructure Programme (SIP). The investigation developed a range of investment scenarios with expected DSi reductions of between 10% and 60%. However, the report findings demonstrated that in order to achieve the targeted DSi reduction of 40%, the project would require a significantly higher programme of investment than the $100M originally allocated to the project (Randall, et al., 2022).

The feasibility investigation did include investment scenarios that could be delivered within the allocated project funding, but this only allowed treatment of approximately 30% of the corridor. Other options also explored secondary treatments (e.g. wide shoulders, guardrails, etc) rather than primary treatments (e.g. median barrier) and these appeared to show reasonable safety benefits for far lower investment.

While the SH5 Programme Business Case (PBC) (Evis, et al., 2023) for the corridor provided the long-term vision, the Low Cost Low Risk (LCLR) funding stream provided a mechanism to realise short-term safety benefits at the most critical areas.

THE PROBLEM

The project team needed the ability to easily rank a multitude of low cost safety projects in a dynamic way that would allow decisionmakers to make informed decisions. A priority list needed to be produced using an unbiased approach and with the ability to amend the budget dynamically as well as compute the safety benefits. The project team researched how historical projects might have tackled similar problems in the past, but the majority of processes appeared to focus on risk mitigation rather than optimising safety benefits. To this extent, the project team developed their own bespoke tool to assess and prioritise options, as explained under the methodology section.

Based on the findings of the initial investigation, it was recognised that a significant scale of investment (both time and funding) would be required to improve road safety to achieve the desirable safety outcomes. An ancillary concern was the ongoing exposure to road safety risks for communities and travellers in the interim whilst funding is secured for a longer-term programme of investment. The ability to implement ‘quick wins’ through a LCLR delivery model was therefore desirable as road users could immediately benefit from these safety gains, despite only a percentage of the corridor being treated. These treatments formed the basis of the Do-minimum option for the PBC.

METHODOLOGY

The project essentially followed three stages:

1. Site Identification – creating an initial list of treatment sites;
2. Assessment Criterion – developing a list of criteria against which the sites and preferred treatments would be measured against; and
3. Tool Development – development of a spreadsheet to prioritise sites and options, with the ability to quickly conduct sensitivity tests of different budgets and weightings.

Site Identification

The first stage of the project was to develop a list of the treatment sites. Given that SH5 (Napier to Taupo) corridor is approximately 120km in length, the project team used a multitude of data sources to help generate the initial list. This leveraged any historical work done previously. The main sources included:

- SIP Feasibility Design report for SH5. Some key areas of concern had been identified and investigated at a high level;
- NZTA’s Crash Analysis System (CAS). A 10-year crash period (2012-2021) was obtained to identify the crash hot-spots;
- Areas of concern from the Road Safety Audit (commissioned for the SIP project) (Urban Connection, 2022).
- Known deficiencies identified by the contractor from the Network Outcome Contract (NOC). This information came from two contractors given the SH5 (Napier to Taupo) corridor is split between two NOC regions: the northernmost 40km from Taupo being within Central Waikato NOC region, with the remaining 85km in the Hawke’s Bay NOC region.
- Known deficiencies the public had identified to NZTA via customer queries.

The crash history provided the initial identification of high-risk sites, with clusters more often composed of minor injury and non-injury crashes. Interestingly, when identifying sites from the other sources, there was a significant overlap between the crash history, the concerns raised by the NOC contractor and the concerns raised by the public.

More than 40 sites were initially identified as locations of interest, each ranging in length from 200m to 1.5km. A range of treatments were proposed for each site depending on the crash types observed, the existing road geometry and terrain. NZTA has developed a DSi Calculator, which includes a range of proven safety interventions and the likely safety benefits associated with them. Some treatments include:

- Median Barriers;
- Wide Centreline;
- Roadside Barriers;
- Shoulder Widening;
- Audio Tactile Pavement Markers (ATP); and
- Sign and Linemarking improvements.

It is noted that when reviewing the individual sites collectively, several sites were observed to be geographically close to each other (within 1km). In addition, when looking at other sites with greater separation (up to 5km), there appeared to be little differentiation in the form/feel of the road environment. This treatment of isolated areas could potentially lead to crash migration. Crash migration is a term used to describe a hypothesis that crashes may increase surrounding the treated site due to changes in the drivers' assessment of risk (Austroads, 2021). To reduce the degree to which this phenomenon might have an effect, several of the sites were combined into sections (termed "Route Consistency"). These longer sections ranged between 5km and 10km in length with the goal of enhancing longer sections of the corridor to create a uniform environment that the user could understand.

The method of input is to initially capture some general details of each site such as type of treatment, the start and end positions, followed by the DSi, which is obtained from the DSi Calculator. An example is shown in Table 1 below.

Site	NOC area	Considered for Priority List (Noc Region)	Issue Description	Start RP	End RP	Length (km)	Corridor Section No. (SIP Feasibility Report)	Source of Issue	Actual DSI per year	DSI Equivalents per year
SM001	HBNOC	No	Sequence of sharp curves. Minimal barriers / signs currently along the curves.	249/5.200	249/4.200	1.00	5	CAS	0.2	0.10
SM002	HBNOC	No	Long blind curve with dense vegetation. No signs/barriers present.	249/1.500	249/0.800	0.70	5	CAS	0.2	0.06

Table 1: Example of data entered into Input Table

In order to address the tortuous sections of the corridor, a treatment type entitled "Speed Management" was also added. This treatment sought to introduce lower speed limits of 60km/h where appropriate.

A fourth category was also introduced, termed "Corridor Transformation". This category consisted of one of the lower cost SIP scenarios and was to provide a comparison when determining the relative ranking of the treatment sites and sections. This was needed as a benchmark as, once the benefits of doing multiple isolated sites reaches a comparable level, it would be more beneficial to treat the whole corridor, rather than a series of individual sites.

In the end, approximately 44 projects were evaluated comprising 33 for Safety Management, seven being Route Consistency, three being Corridor Transformation, and one being Speed Management.

Assessment Criterion

Several criterion were agreed upon with NZTA Subject Matter Experts (SME) to evaluate the relative benefits of each treatment site. This allowed for a consistent evaluation of a large number of sites with varying length as listed below:

- Safety Outcomes. This criterion used the same evaluation factor that other SIP projects adopted; namely the number of DSi's saved per $100 million spent.
- Community Acceptance. Broadly, this criterion evaluated impact on highway users and likely community acceptance. It is noted no community engagement was undertaken during the investigation, largely due to the speed at which the project progressed.
- Duration of Design (Pre-Implementation). This criterion concerns the time taken before construction can start (e.g., planning, consenting, property acquisition and design).
- Construction, Maintenance and Operation Difficulty. This criterion evaluates the extent to which any constraints exist at the location that could impact the construction, maintenance and operation of the road, including geometric and geotechnical challenges (e.g. winding road, steep embankment/drop off close to the road).
- Duration of Construction (Implementation). This criterion concerns the time taken to complete construction.
- Likelihood of Sunk Costs. This criterion was included to consider whether the site fell within an area where future infrastructure treatments (in the form of Corridor Transformation) might be implemented and whether the treatments proposed could be 'future proofed'.

It is worth noting that any treatment proposed is not a simple Yes/No answer but rather includes an approximate treatment length. Although at an early concept stage these values may not be known, the inclusion of a length helps to quantify the benefit of the treatment, which is beneficial for both the Safe System Assessment Framework as well as comparing the benefits against other SIP projects. For the purposes of the assessment spreadsheet, treatment lengths are only required for median barrier, wide centreline, roadside barrier and wide shoulders.

The scorable criteria were also refined, with the final scoring ranges listed below with their respective scoring methods:

- DSi equivalents saved per $100M spent
    - Top 30% have a score of 3
    - Next 30% have a score of 2
    - Next 20% have a score of 1
    - Bottom 20% have a score of 0
- Community Acceptance
    - Community backing has a score of 2
    - Neutral community has a score of 0
    - Community opposing has a score of -2
- Pre-Implementation (Deliverability / Timing)
    - Less than 1 month has a score of 1
    - Between 1 and 3 months has a score of 0
    - Between 3 and 6 months has a score of -1
    - Between 6 and 12 months has a score of -2
    - More than 12 months has a score of -3
- Construction, Maintenance and Operation Difficulty
    - Easy / Neutral constructability (no significant issues) has a score of 0
    - Hard constructability (a couple of significant issues) has a score of -1
    - Very hard constructability (many significant issues) has a score of -2
- Implementation (Construction)
    - Less than 1 month has a score of 1
    - Between 1 and 3 months has a score of 0

    - Between 3 and 6 months has a score of -1
    - Between 6 and 12 months has a score of -2
    - More than 12 months has a score of -3
- Likelihood of Sunk Costs (i.e. site lies within an area that could reasonably be transformed in the future)
    - 'Likely' to have sunk costs has a score of -2
    - 'Unlikely' to have sunk costs has a score of 0
    - 'No' sunk costs from site has a score of 2

Weightings were included for each of the assessment criterion depending on the user and the focus area. The weightings are user-defined, quickly varied and allow for different scenarios to be sensitivity tested.

Post analysis, it was observed that despite having six criteria to score, the crudeness of the scoring meant that it was possible for more than one site to return the same total score as another site. To prevent this, the inverse of the treatment cost in the total score has been used. Therefore, if multiple options had the same scores from the weighted criterion, the lower cost options would be prioritised over a higher cost option.

An example of the output table is shown in Table 2 below.

Corridor Start	005-0137-B/0	**No. sites treated**	**6**
Corridor End	005-0249-B/12466	Dsi equiv. (proposed)	8.46 per annum
Corridor Length	122.400 km	DSI equiv. Saved	0.61 per annum
AADT	3,656 vehicles per day	DSI equiv. Saved / $100M Spent	3.06 per annum
Dsi equiv. (existing)	**9.03 per annum**	**% DSI equiv. Saved**	**6.8%**
		Length of Primary Treatment	
NOC Region Assessed	**All**	Median Barrier	0.00 km
Weighting Scenario	**Scenario 1 - Default**	Wide Centreline	6.05 km
Budget	**$ 20,000,000**	Roadside Barriers	5.30 km
		Shoulder Widening	6.35 km

Priority Order	Site ID	NOC Area	Start RP	End RP	Override to exclude from priority list	Issue Description	Treatment Description	Dsi Equivalents Saved	Cost Estimate	Included in Budget	Cumulative $	Remaining Budget $
2	SM011	HBNOC	204/8.000	204/4.900	Yes	Te Haroto.	1.5 m wide centreline through section. Extend existing guardrail through section. Shoulders to be 0.75 m (both sides). Install ATP through section. Advisory curve signs requied + linemarking	0.19	$ 10,153,000.00	Yes	$ 10,153,000.00	$ 9,847,000.00
3	SM004	HBNOC	233/2.350	233/0.400	Yes	Sharp curve preceeding two intersections (sight distance severely restricted). Additional sharp curves present with no signage. Hazards with no barrier protection.	1.5 m wide centreline through section. Guardrail through curves. Shoulders to be 0.75 m (both sides). Advisory curve signs required + linemarking improvements.	0.10	$ 5,691,000.00	Yes	$ 15,844,000.00	$ 4,156,000.00
6	SM029	CWNOC	150/19.500	150/18.000	Yes	access location does not meet requirements (sightline)	1.5 m wide centreline. Install guardrails. Increase shoulders to 0.75 m. Install ATP along the section.	0.30	$ 2,925,000.00	Yes	$ 18,769,000.00	$ 1,231,000.00
9	SM009	HBNOC	220/7.350	220/7.100	Yes	Sharp curve with no hazard protection.	Guardrail through curve. ATP installed.	0.01	$ 221,000.00	Yes	$ 18,990,000.00	$ 1,010,000.00
10	SM008	HBNOC	220/8.850	220/8.300	Yes	Curves with dropoffs along passing lane.	Guardrail through curves. Advisory curve signs required. Extend ATP coverage.	0.02	$ 589,000.00	Yes	$ 19,579,000.00	$ 421,000.00
21	SMP01	HBNOC	190/6.500	190/3.800	Yes	Torturous road alignment	Localised reduction to 60km/h	0.00	$ 95,000.00	Yes	$ 19,674,000.00	$ 326,000.00

Table 2: Example of Summary Table

The pertinent information is shown in the information box, which indicates to the user the number of sites that can be treated, the total length of the treatments, as well as the percentage reduction in DSi Equivalents. This is particularly important due to the original SIP projects all needing to demonstrate their anticipated DSi reduction.

APPLICATION OF THE TOOL

For the SH5 project, an initial budget for LCLR investment of $20M was agreed, and the prioritisation tool indicated that a total of eight high-risk sites could be implemented, along with some line marking and signage consistency treatments. However, following Cyclone Gabrielle, the line marking consistency treatments were dropped in favour of increasing the extents of three sites to include remediation or increased resilience (slips or flood damage was found through or adjacent to several of the shortlisted sites). The construction estimates for the 8 sites came to $14M ($4M higher than their initial estimates used in the shortlisting, but $6M below the original budget allocation).

Following agreement of the eight priority sites, all have been designed and in the process of being constructed utilising the Transport Resilience East Coast (TREC) alliance for delivery. Construction is due to be complete by July 2024.

BENEFITS OF USING THE TOOL

Prior to the development of the tool, the Multi-Criteria Analysis (MCA) approach was considered. However, this approach was deemed to have limited application due to the need to include more diverse criteria such as construction duration and complexity bands. The inclusion of the DSi Calculator, developed by NZTA, was also seen as a major incentive as this allowed the user to compute DSi reductions with great accuracy, which an MCA could not do.

Another benefit of the tool is that each project could easily be plotted geographically within readily available excel functions. Figure 2 shows an example of this for project cost being displayed spatially. Alternatively, the sites could have been incorporated into a Geographical Information System (GIS) which could then be combined with other project specific constraints (e.g. wetlands, property boundaries, utilities, etc).

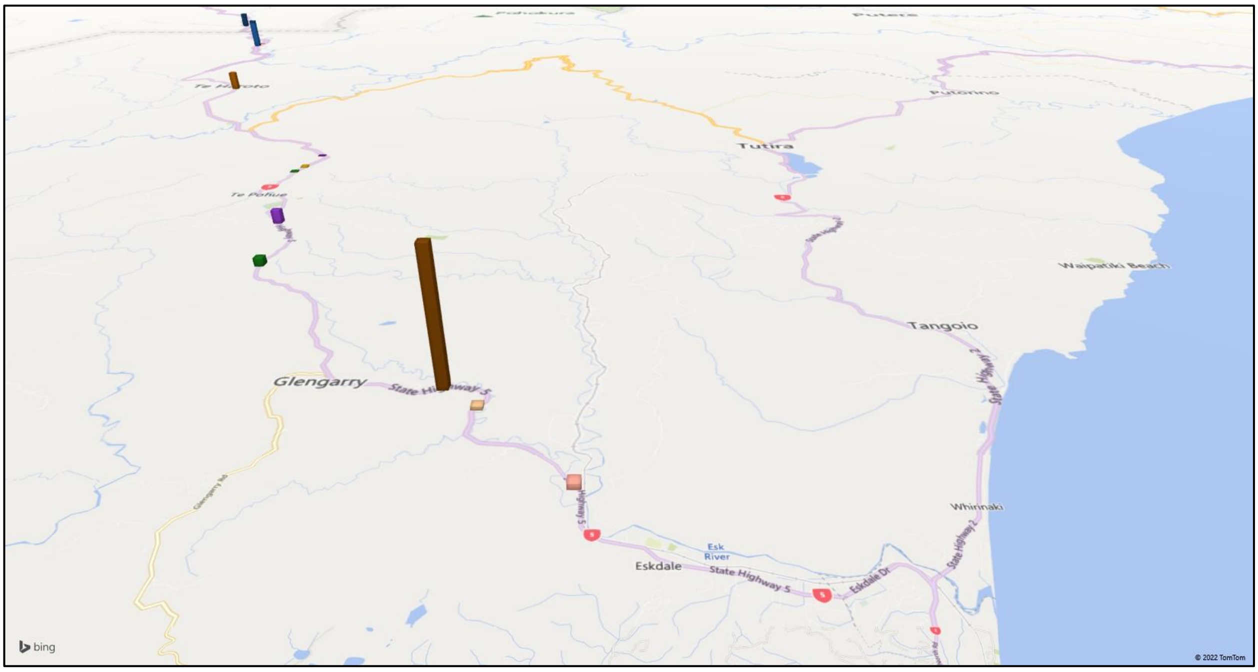

Figure 2: Site Locations and Cost

A third benefit is the ability to easily apply a scenario that amends the weightings for each criterion. In the case of the SH5 (Napier to Taupo) project, the scenario that favoured a quick delivery was typically preferred and therefore scored with a positive weighting, while a project that required land purchase or was located close to a wetland triggering a resource consent was scored with a negative weighting or reduced priority. This information is best derived from the SME’s who have local knowledge, which helps provide a level of confidence.

Fourthly, this tool could be applied to other projects or programmes, such as business cases, to identify where programmes of work are identified and need prioritisation, or where the benefits of investing in safety across programmes/scenarios needs to be quantified quickly and easily.

Finally, the tool serves as a helpful audit trail. Now that construction has commenced, NZTA have received queries from landowners to understand why certain sections of the corridor are not being treated as, in their opinion, their concerns are perceived to be of greater safety risk or importance to treat. The tool can therefore easily be used to demonstrate what treatments have been considered, and provide justification/rationale for prioritising investment in certain sites. This feedback could be helpful to future customer queries.

KEY LEARNINGS

Overall, the tool was effective in developing a shortlist of safety projects. However, a number of observations were made through developing the tool.

- Options to improve Route Consistency did not perform well due to the higher cost and increased time for design and construction. As a result, there project team could not eliminate the possibility of crash migration occurring in the future.
- The tool currently relies on comparing treatment sites along the same corridor, with the summary relying on the corridor being relatively consistent in both road form (alignment, stereotype) and function (traffic volume, speed limit).
- The design stage required more time and effort than originally anticipated when developing the shortlist, primarily around new planning requirements (ecology assessments and resource consents for work near wetlands/water bodies).
- Although attempts were made to constrain the improvements to the existing road reserve, the existing fencelines are rarely accurate or follow property boundaries. For a couple of sites, the existing road is partially/fully constructed within private property, requiring discussion with the adjacent landowners. This is a known issue and although currently being investigated as part of the Digital Parcel Improvement (DPI) project, it potentially adds time, complexity and cost to the project.

CONCLUSION

This tool has been developed due to a perceived lack of documented methodology to prioritise safety improvement projects based on ease of delivery, costs and safety benefits. While the tool can provide useful outputs, it is recognised that it is largely dependent on the accuracy of the inputs, which does require some knowledge of the corridor and the adjacent environment through which it passes. The tool also utilises freely available data sources such as NZTA Crash data and property boundaries.

The tool proved to be invaluable to the decision-making process, providing an agile framework to quickly assess and prioritise a range of high-risk safety sites and treatment options along the corridor. The tool provides a robust and defensible assessment process, which enabled a programme of LCLR projects to be identified and quickly progressed to pre-implementation and implementation phases that will enable safety benefits to be recognised by the community as soon as possible.

It is hoped that this tool could be further developed to be used for wider applications such as prioritising culvert replacements or mitigation of roadside hazards. It also could be applied on other corridor studies, feasibility studies, business cases, etc. as it can provide an easy way to assess individual sites and options against safety outcomes and deliverability considerations.

AUTHOR CONTRIBUTION STATEMENT

Glen Randall has had multiple roles on this project, namely Safety Engineer, Design Manager and Project Manager. Contributions include review of data, chairing progress meetings and client workshops and principal author of technical reports.

Robert Ball was involved in the data collection and compilation, data analysis, tool development and preparation of the paper.

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