AERIAL FEATURES FOR BICYCLES: DESIGN PRINCIPLES AND GUIDELINES

1. Overview

This document is intended to provide design principles and guidelines for aerial features intended for bicycle use, including mountain bikes (including rigid, hardtail and dual suspension mountain bikes) and BMX bikes. Such features may be incorporated into jump lines, trail networks, bike parks, and skills areas. Concepts detailed herein should assist in constructing such facilities in a manner that is appropriate for a given expected user group, taking into considerations such as rider ability, desired feature difficulty and purpose, site limitations, and risk management.

A primary objective of this document is to assist in understanding factors that lead to risks of rider injury, and how those can be managed without necessarily detracting from rider enjoyment. This facilitates the construction of aerial features enable users to progress their skills in a safe environment.

This document is not intended to restrict creativity on the part of trail designers. Various feature types and configurations not considered herein may still be entirely appropriate, and may be designed using corresponding underlying principles. For example, other common feature types include “satellite dishes”, “whale tails”, “wallrides”, “elevated step-up platforms”, and quarterpipes.

2. About the Author

The primary author of this document, Matt Ward, holds a Bachelor of Science majoring in mathematical physics, a Bachelor of Laws, and has been building aerial features for over ten years. This brings together knowledge and understanding of the underlying physics, the practical applications, and aspects of risk management. Matt has spent considerable time visiting bike parks and other facilities internationally in recent years, including discussing construction techniques and rider experiences.

(details of review process and reviewers to be completed)

3. Important Caveats

This document is intended to assist in the understanding of risks only, and does not in any way guarantee that riders will not suffer injuries riding features constructed based upon guidelines set out herein. The author does not accept any personal responsibility for injuries or other damage/loss that occurs from use of teachings set out herein. Bicycling is an inherently dangerous sport, and injuries are common.

Any facility including aerial features should be reviewed, tested, and approved by persons having appropriate knowledge and riding experience prior to being opened for use by members of the public.

Diagrams are not drawn to scale, and are representative only.

4. Elements of an Aerial Feature

Whilst aerial features vary widely in shape and size, all share the following key elements:

- *Approach:* This is a section of trail along which a rider travels immediately before reaching the takeoff of an aerial feature.

- *Takeoff:* This is a portion of trail that prepares a rider for an airborne trajectory. It is also at times referred to by the terms “lip”, “ramp”, “kicker” or “jump”. Characteristics of the takeoff determine trajectory and influence feature difficulty.

- *Lander:* This is a portion of trail upon which a rider, having followed an airborne trajectory following the takeoff, is intended to land. Landing before a functional portion of the lander is referred to as “undershooting”, landing beyond a functional portion of the lander as “overshooting”.

- *Middle:* This is a region between the takeoff and the lander. There are various different configurations that may be present, including gaps, tabletops, rolled doubles, and combinations thereof.

- *Margin for Error:* This defines a region in which a rider is able to land relatively safely. The margin for error is affected primarily by the configuration of middle, and the horizontal length of a lander.

These elements are illustrated in the figure below.

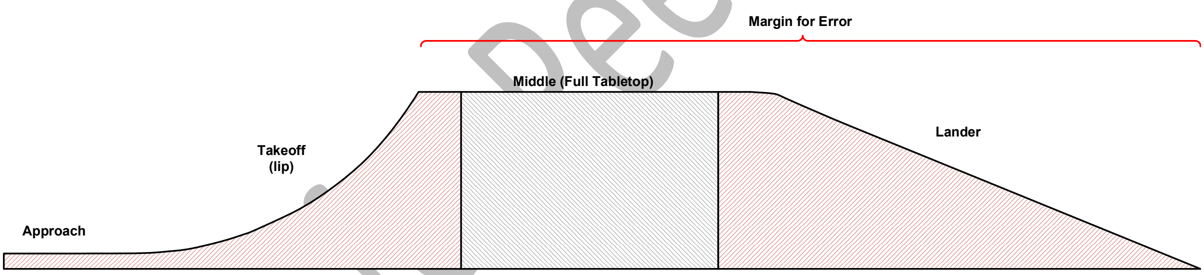

FIG. 4.1: Basic Feature Elements

Feature operation, performance, difficulty and risk are each influenced by configuration of these basic elements, as discussed in detail further below.

Diagrams provided herein show features in cross section. In practice, features may be of substantially any width, and as width increases so does margin for error (and hence safety). As a general rule, a lander should always have a width greater than or real to the width of the takeoff.

A feature may be either “straight” or “hipped”. In the case of a hipped feature, the lander is angularly offset with respect to the axis of the takeoff.

5. Approach: Design Considerations

The approach portion, whilst often overlooked, is of substantial importance when designing a feature. In particular, appropriate approach design is crucial in terms of ensuring a rider is appropriately positioned and balanced when entering a takeoff. There are two preferred options:

(i) A horizontal approach, which should be at least 1.5 metres in length. Such a length of flat ground enables any preceding effect of slope angle change to subside, allowing a rider to enter a lip radius in a balanced manner (as shown in FIG. 1).

(ii) A curved approach, which is curved at a radius matching the takeoff radius. This, in essence, means that a rider commences along a path defined by the takeoff radius on a downslope preceding the takeoff

The diagram below shows a curved approach.

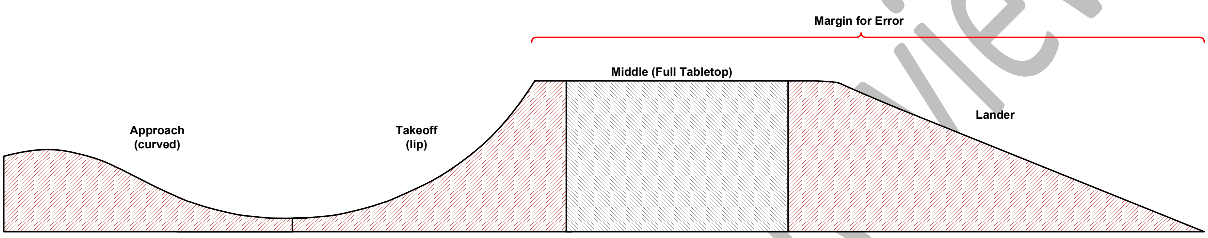

FIG. 5.1: Approach curved to match takeoff radius

It is preferable to avoid the sudden changes in radius between a preceding downslope and a takeoff. This reduces the likelihood of a rider being thrown off balance.

More generally, risks are most effectively managed by ensuring that an approach is relatively smooth and predictable, avoiding uneven ground, bumps and/or other obstacles.

6. Takeoff: Key Elements

The takeoff determines a rider's airborne trajectory. The diagram below illustrates key components characterising any takeoff:

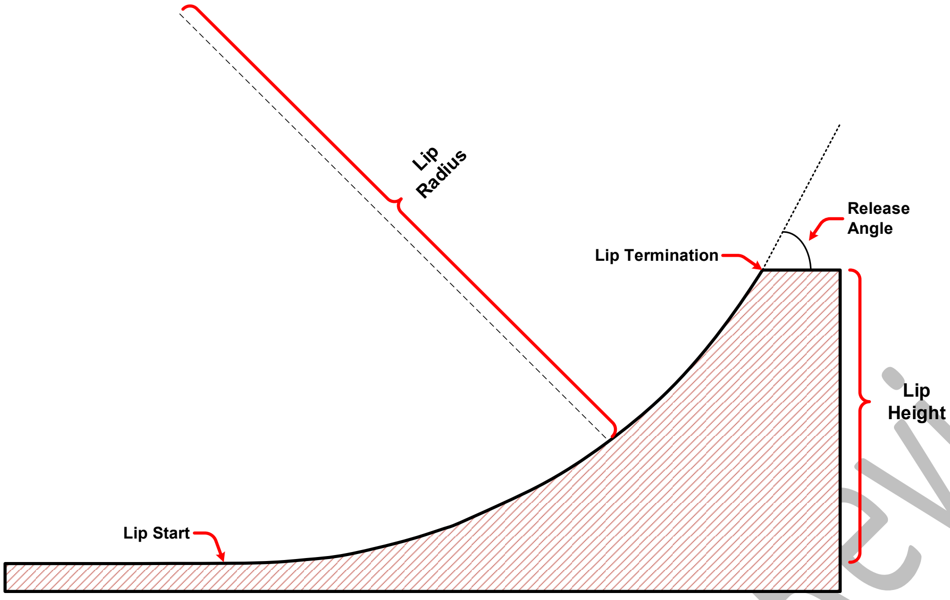

FIG. 6.1: Key Components of a Takeoff

The "lip start" is defined by a point at which the approach and lip meet, being a point at which the ground leaves horizontal and begins to slope upwardly.

The "lip radius" defines the curvature of the takeoff. A takeoff should have a constant radius; this is crucial providing a predictable rider experience (and hence reducing rider injury risks). The lip radius combined with rider approach velocity are primary factors in defining feature difficulty.

The "lip termination" is a point at which the constant radius ceases. This defines a "release angle", being an angle defined between the takeoff riding surface and horizontal at the point of the lip termination. This release angle is a primary contributing factor in the context of rider trajectory.

The "lip height" is the vertical distance from: (i) the horizontal level of the riding surface at the lip start to (ii) the horizontal level of the lip termination. The lip height is what determines the release angle for a given lip radius.

7. Takeoff: Lip Radius

As noted above, a takeoff should, as a general principle, adopt a constant lip radius. The following diagram more clearly illustrates the concept of a lip radius, by showing the full circle upon which the radius is defined:

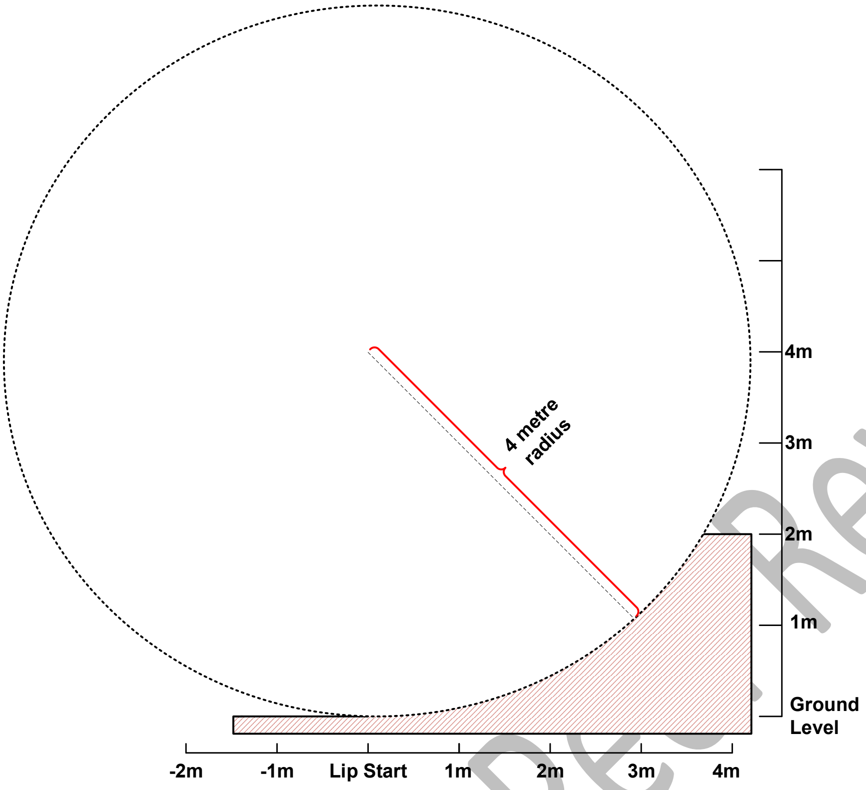

FIG. 7.1: Understanding Lip Radius

Varying the lip height, whilst maintaining a common lip radius, will affect the release angle, as shown below:

The lip height combined with the lip radius define the release angle. The diagrams below illustrate relationships between lip height and release angle for a given lip radius, in this case being a 4 metre radius.

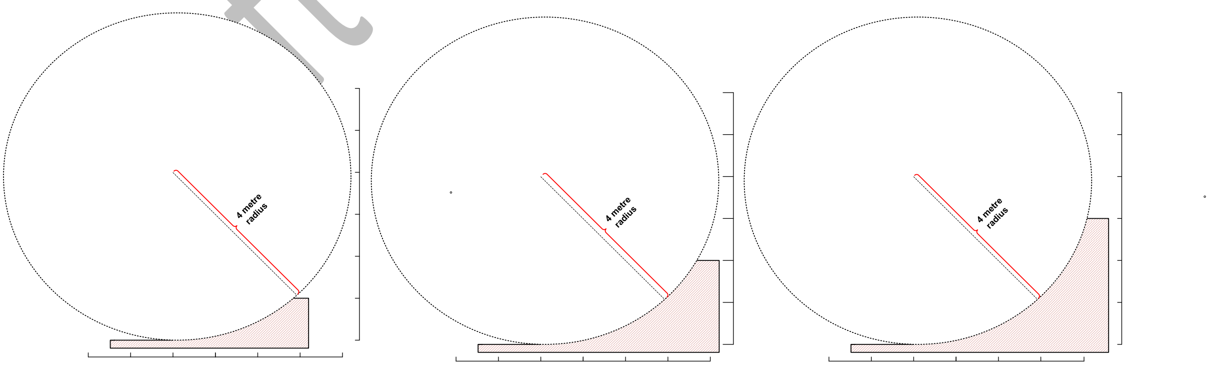

FIG. 7.1: Lips of Constant Radius, but Varying Lip Height

The examples above illustrate, working from right to left, what can be regarded as "relaxed", "moderate" and "aggressive" release angles.

As explained below, lips of a common lip radius will have a similar "feel" and level of technical difficulty.

When constructing a takeoff from dirt, obvious imperfections, such a bumps, and exposed rocks (or other foreign matter), and ruts (for example due to erosion) should in all cases be avoided. These have potential to adversely and unpredictably effect rider trajectory, and hence contribute significantly to rider danger. It will be appreciated that ongoing maintenance is often necessary thereby to ensure takeoff integrity and manage ongoing safety concerns.

Ensuring a constant takeoff radius when building from dirt may be achieved by a trained eye (for example it is possible to readily identify where a take-off increases/decreases in curvature along its length from a side-on inspection). Alternately, specially adapted tools may be used. For example, a set of arcs having known radii may be constructed from wood (or other suitable materials) thereby to provide lip radius templates:

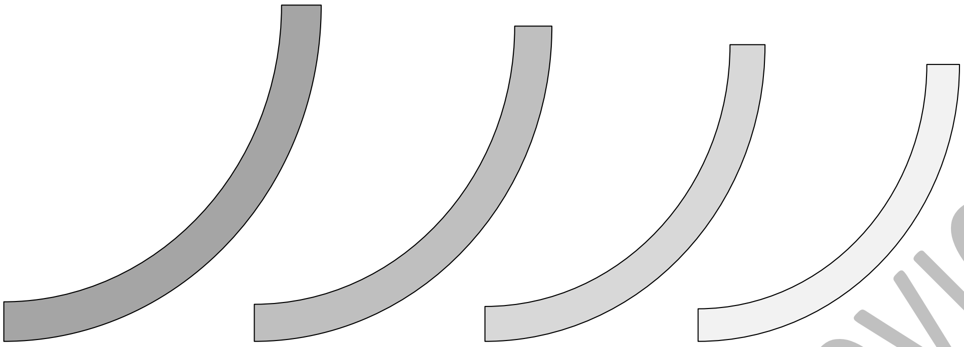

FIG. 7.2: Lip Radius Templates

When using other construction materials to construct takeoffs (for example wood, steel, and the like), conventional engineering techniques are able to be used thereby to achieve a desired constant lip radius.

8. Takeoff: Lip Radius and Difficulty

It is a common misconception that the release angle ("steepness") of a takeoff is a key factor in the technical difficulty of a takeoff. In fact, the technical difficulty of a takeoff is primarily based upon the lip radius and approach velocity, which affect the rate of change of rider direction as a function of time. The release angle is only of substantial relevance to trajectory, discussed in the following section.

A rider, in order to traverse a takeoff successfully, must be able to adapt to a change in direction from horizontal (at the lip start) to the release angle (at the lip termination). That is, there is a change in direction as a function of time: a rate of angular change. A rider's ability to successfully adapt to a given rate of angular change will depend on reflexes, ability and experience.

There are two factors which combine to define the rate of angular change for a given takeoff: approach velocity and lip radius. In particular:

- For a given lip radius: as approach velocity increases, so does the rate of angular change. That is, the amount of time over which the rider's direction changes from horizontal to the release angle decreases for higher velocities.

- For a given approach velocity: as lip radius increases, the rate of angular change decreases. That is, the amount of time over which the rider's direction changes from horizontal to the release angle increases for large lip radii.

With a constant radius, this change in direction at least occurs in a predictable manner (it is significantly more difficult to adapt to a progressively tightening radius). For this reason, progressive lip radii should be avoided.

The diagram below illustrates a general relationship between lip radius, approach velocity, and degree of technical difficulty.

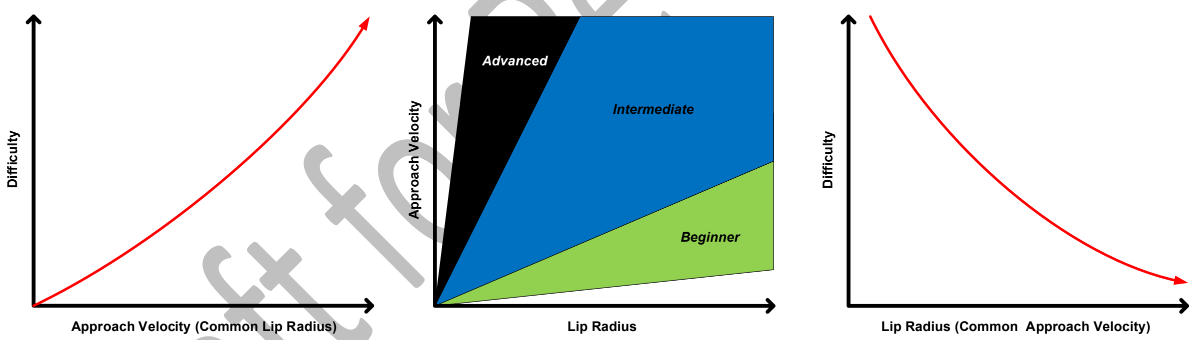

FIG. 8.1: Lips of Constant Radius, but Varying Lip Height

It will be appreciated that these are representative charts only. Furthermore, this is representative of takeoff difficulty; overall feature difficulty will be dependent on additional factors (for example fall height, margin for error, feature width, and hip angle)

In practice, approach velocity is often predetermined based on a preceding section of trail. Accordingly, the feature design process is often based upon determining an appropriate radius based on that velocity and the desired technical difficulty, and then defining a desired trajectory (by way of lip height selection).

Takeoffs may be constructed from substantially any material that allows adequate control over takeoff radius. Dirt and wood are by far the most common, however successful results have also been achieved using concrete or asphalt coatings (which may be helpful in reducing wear and tear).

9. Takeoff: Release angle and Trajectory

The release angle is a primary factor affecting rider trajectory. Selecting the correct trajectory is crucial in ensuring that, at a given expected approach velocity, a rider will land in an intended location on a lander.

As shown below, for a given lip radius, release angle increases with lip height.

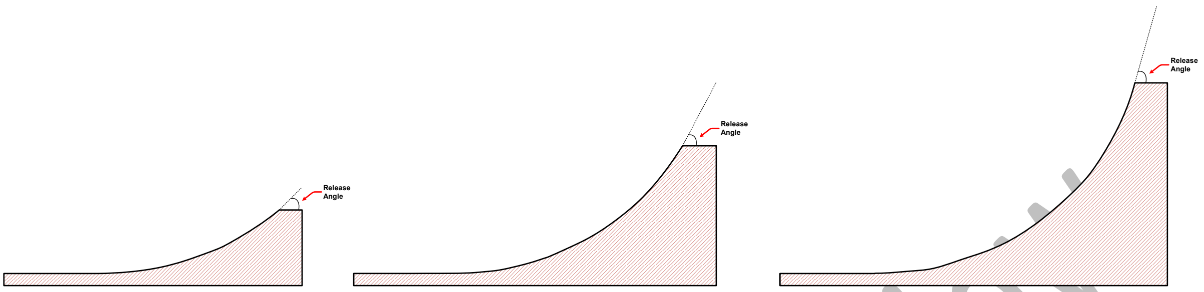

FIG. 9.1: Release Angle Increase with Lip Height

A basic principle from physics is that a release angle of 45 degrees will maximise horizontal travel. In practice, a rider will not leave a takeoff precisely at a release angle, and accordingly the optimal release angle for horizontal travel is typically around 50 to 60 degrees, depending on factors including rider momentum and lip radius. The following diagram provides a visual understanding of how release angles affect trajectory in practice:

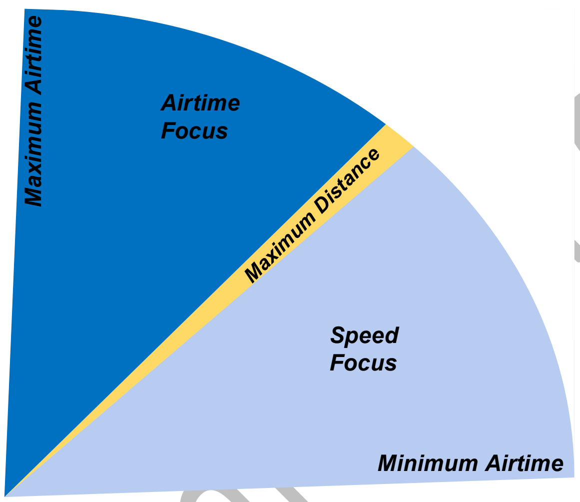

FIG. 9.2: Release Angle Effect on Trajectory

From this, it can be seen that where aerial features are being designed for the purpose of enjoying airtime, release angles in excess of 45 degrees (and preferably in excess of 60 degrees) should be used. Release angles of under 45 degrees in essence mean that a rider's velocity is greater than necessary for a given feature length, potentially increasing risk of injury in the event of a fall.

An additional artefact with of consideration is horizontal velocity. The horizontal component of a rider's velocity reduces as release angle increases. The horizontal velocity can be returned to the rider by appropriately shaping a lander to smoothly meet the rider's expected angle of trajectory upon meeting the lander. Alternately, by intentionally mismatching release angle and lander decline, such that the lander is flatter than the rider's anticipated trajectory upon landing, horizontal velocity is lost and the associated energy dispersed via landing impact. This is discussed in more detail further below.

10. Takeoff: False Lip Regions

Although a takeoff should, as a general principle, adopt a constant lip radius, in some cases it is appropriate to use a “false lip region. A false lip region is a region of reduced (or regressive) lip radius, which defines a rising surface following the lip termination. This region does not affect release angle (and hence does not affect trajectory).

The diagram below illustrates one common example of a takeoff having a false lip region, being a linear false lip region:

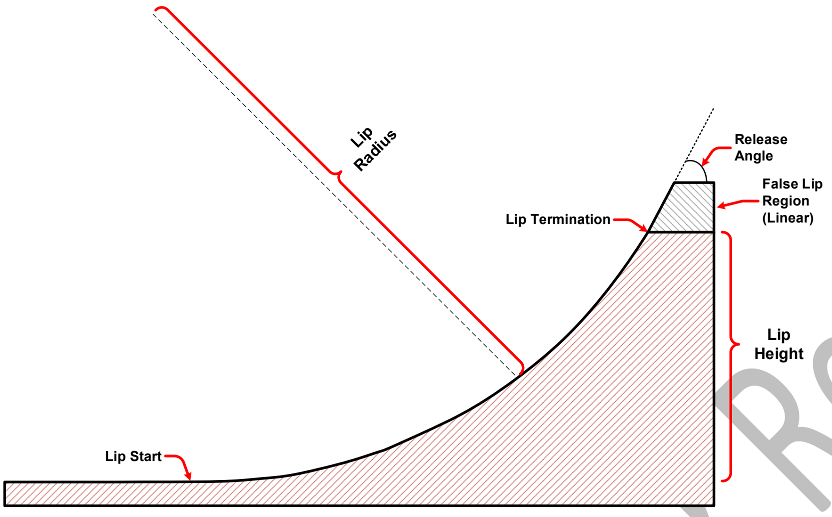

FIG. 4: Takeoff with Linear False Lip Region

A linear false lip region follows the release angle defined at the lip termination. Provided this false lip region is less than about 20% of the lip height, it should have substantially no adverse effects on rider experience (and some may argue it provides benefits to rider experience). Furthermore, for lips constructed from dirt, a linear false lip region may provide beneficial effects in terms of riding surface longevity (due to decreased rider force through the terminating edge of the takeoff).

Another common example of a false lip region is illustrated below, being a rolled lip region:

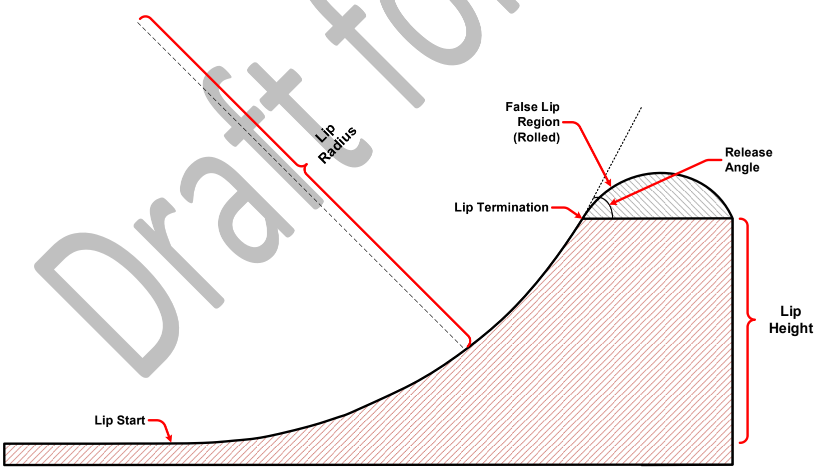

FIG. 5: Takeoff with Rolled False Lip Region

A rolled false lip region regresses the release angle defined at the lip termination, thereby to define a rollable surface. However, there are disadvantages in the sense that a rider has a reduced ability to visually assess the lip termination and release angle, as compared with other takeoff designs. Furthermore, there are challenges from a maintenance perspective; it is difficult to maintain a desired lip radius and provide a smooth transition into the regressive radius of the rolled false lip. Accordingly, it is generally advisable to avoid use of rolled false lip regions.

11. Common Feature Styles

As noted above, various configurations may be used for the middle of a feature. Several of the most common examples are discussed below:

- Traditional Gaps.
- Tabletops.
- Visual Gaps.
- Rolled Doubles.

These are each described and illustrated using the same configuration of takeoff and lander.

Firstly, the diagram below shows a traditional gap.

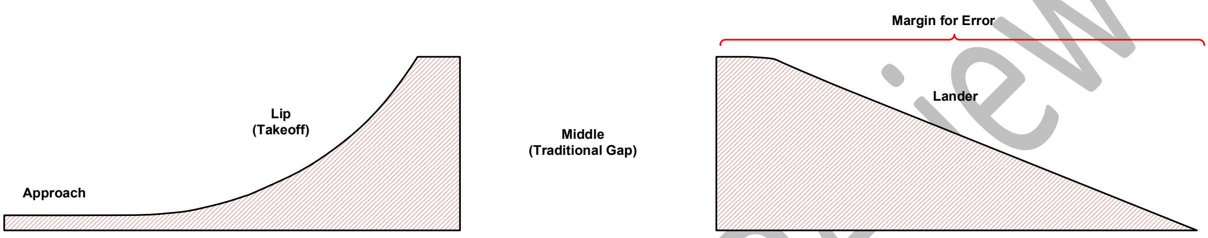

FIG. 11.1: Traditional Gap Feature

A traditional gap is characterised by a middle in which a rider cannot safely land. The lander generally includes a small (for example <1m) flat portion at its proximal edge, which may be rolled into the lander downslope, or alternatively meet the downslope at a defined corner.

Practical advantages and disadvantages are discussed below:

Advantages	***Disadvantages***
Reduced construction material	Low margin for error
Visual deterrent for unskilled riders; feature cannot be rolled (preserves takeoff integrity)	High consequence for undershooting (leading to increased potential for overshooting.

Table 1: Advantages and Disadvantages of Traditional Gaps

Traditional gaps are often favoured, particularly in informal facilities, as they assist in minimising required construction materials and construction effort. Additionally, they are favoured by some riders due to the "excitement" of traversing an intimidating gap, and due to subject elements of aesthetics arising from fashion/culture within the sport. However, the gap itself provides little or no real benefit from a risk management or rider safety perspective.

The diagram below illustrates a tabletop feature.

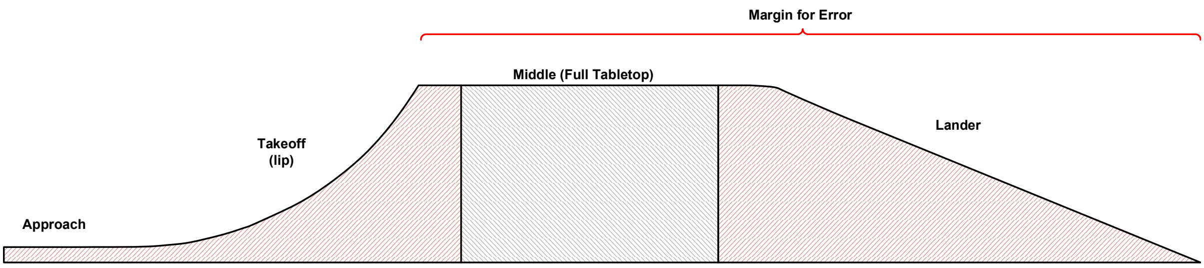

FIG. 11.2: Standard Tabletop Feature

A tabletop feature is characterised by a flat (or in some cases slightly downwardly sloped) middle portion, which meets the lander at a smooth junction. This maximises margin for error by eliminating the potential for undershooting.

Practical advantages and disadvantages are discussed below:

Advantages	***Disadvantages***
Maximum margin for error	Requires considerable construction materials
No possibility of undershooting (which also reduces likelihood of overshooting)	Takeoff integrity can rapidly diminish due to riders rolling over takeoff, adversely affecting trajectory
Able to be rolled by riders of substantially all skill levels	Risk that inexperienced riders may come to a stop in unsafe location having rolled over takeoff

Table 2: Advantages and Disadvantages of Tabletop

Traditional gaps are often favoured in bike parks and public facilities due to their high margin for error. However, disadvantages relating to short-lived takeoff integrity should not be ignored; regular maintenance should be performed to rectify takeoff deterioration thereby to prevent the feature from becoming dangerous to riders traversing the feature in the intended aerial manner.

A balance between the preceding options is provided by a visual gap, as illustrated below:

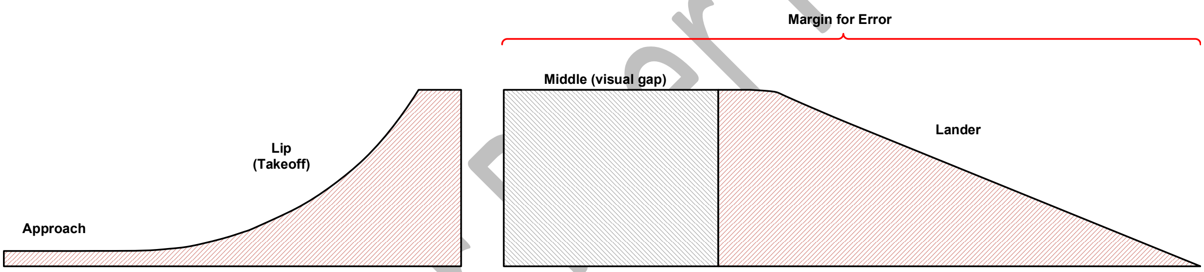

FIG. 11.3: Visual Gap Feature

A visual gap feature is characterised by a middle portion including a relatively small gap (which need not extend to ground level as illustrated), followed by a flat (or in some cases slightly downwardly sloped) portion, which meets the lander at a smooth junction. The gap is "visual" in the sense that it is sufficiently small relative to the size of the feature as to be insignificant to a rider possessing a threshold degree of skill. For example, the gap is preferably ~1-2 bike lengths, meaning that it is very unlikely that a rider would land with both wheels in the gap (provided the rider's front wheel reaches the flat portion, risks of injury are relatively low). The flat portion (sometimes referred to as a "case pad") should be a minimum of one full bike length, and should allow a rider to roll onto the lander downslope with adequate sprocket/bottom bracket clearance.

Practical advantages and disadvantages are discussed below:

Advantages	***Disadvantages***
High margin for error	Requires considerable construction materials
Low possibility of undershooting (which also reduces likelihood of overshooting)	Feature cannot be rolled by inexperienced riders
Visual deterrent for unskilled riders; feature cannot be rolled (preserves takeoff integrity)	

Table 3: Advantages and Disadvantages of Visual Gap

This style of feature is optimal for providing a low-risk experience for riders of intermediate standard and above, whilst reducing the likelihood that beginner riders will put themselves in a dangerous position by rolling over the feature. Additionally, takeoff deterioration concerns associated with tabletops are conveniently alleviated.

Finally, a rolled double is illustrated below.

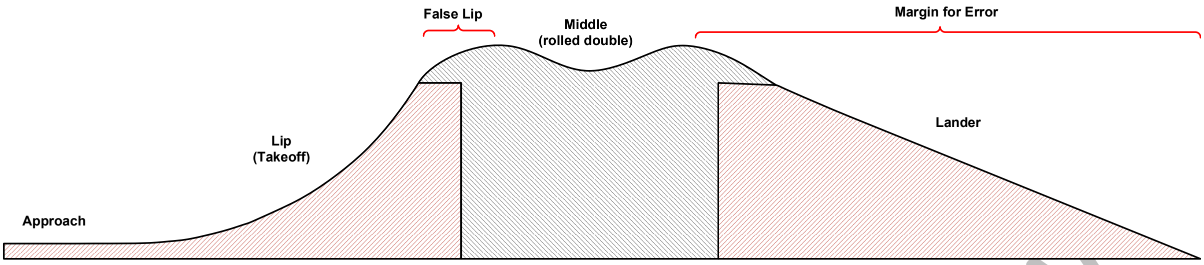

FIG. 11.4: Rolled Double Feature

A rolled double feature is characterised by a middle portion including a pair of rollers (defined in part by a rolled false lip). This allows a rider to either jump or roll the feature.

Practical advantages and disadvantages are discussed below:

Advantages	***Disadvantages***
Able to be rolled by riders of substantially all skill levels	Requires considerable construction materials
	Rolled false lip can be misleading, and is difficult to maintain
	Feature appears safer than it is in practice
	High consequence for undershooting

Table 3: Advantages and Disadvantages of Rolled Double

This style of feature has historically been popular in many public facilities, perhaps due to its safe appearance, and its resemblance to features used in BMX race tracks. However, it has a number of drawbacks. For example, the roller creates a "false lip", being an upwardly extending region adjacent the takeoff which functionally does not actually affect trajectory. This makes it more difficult for a rider to judge precisely where they will leave the ground, and also renders a gap visually smaller than it is in practice. Additionally, the upwardly sloping portion of the second roller does not present a safe landing region, and the margin for error is hence substantially similar to a traditional gap.

12. Basic Feature Types

There are three basic feature types, defined by reference between the relative heights of the distal end of the takeoff and the proximal end of the lander. These are:

- Standard jumps, where the distal end of the takeoff is at substantially the same height as the proximal end of the lander.

- Step-downs, in which case the distal end of the takeoff is higher than the proximal end of the lander.

- Step-ups, in which case the distal end of the takeoff is lower than the proximal end of the lander.

Diagrams providing examples of the latter two are provided below (noting that previous examples show standard jumps.

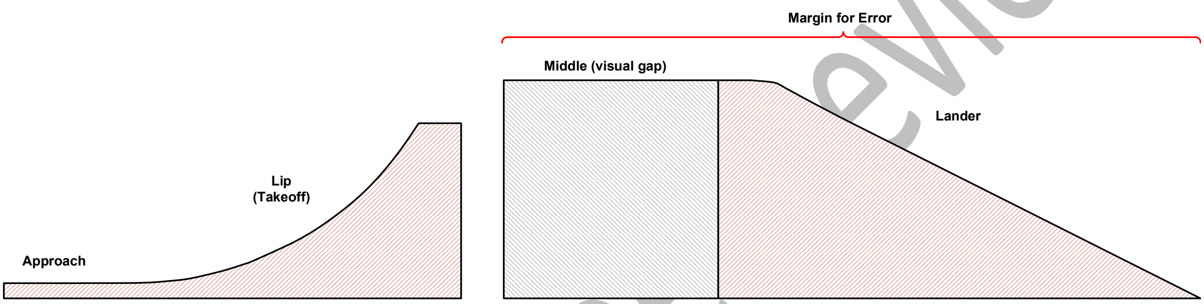

FIG. 12.1: Step-Up (with visual gap)

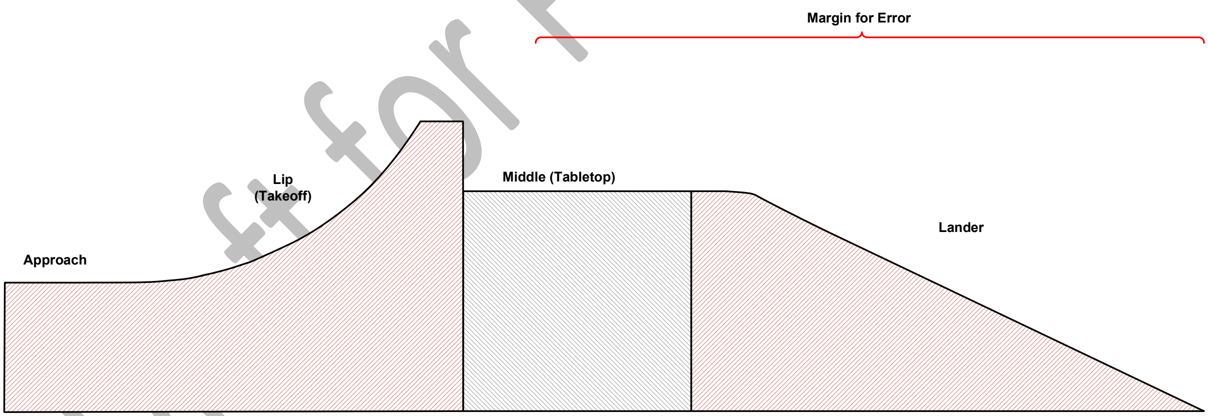

FIG. 12.2: Step Down (with tabletop)

From a risk management perspective, the main difference between these feature types is the fall height, being the expected average height from which a rider falls (from the highest point in their trajectory) when successfully completing the feature[1].

An important point to note is that risks associated with an aggressively upward trajectory can be mitigated by using a step up (for example in the manner shown n FIG. 12.1), as risks stem from the rider's maximum height above a landing point, as opposed to maximum height above the takeoff.

[1] It is appreciated that different riders will achieve different actual fall heights based on their body motions (and other factors such as weight and bicycle type); this is a general approximation based on trajectory physics principles.

13. Lander Design Principles

When designing a lander, the main parameter with which to work is lander decline angle. As a general principle, a more gradual decline angle will (i) increase margin for error; (ii) decrease feature exit velocity; and (iii) increase landing harshness. This is diagrammatically illustrated below:

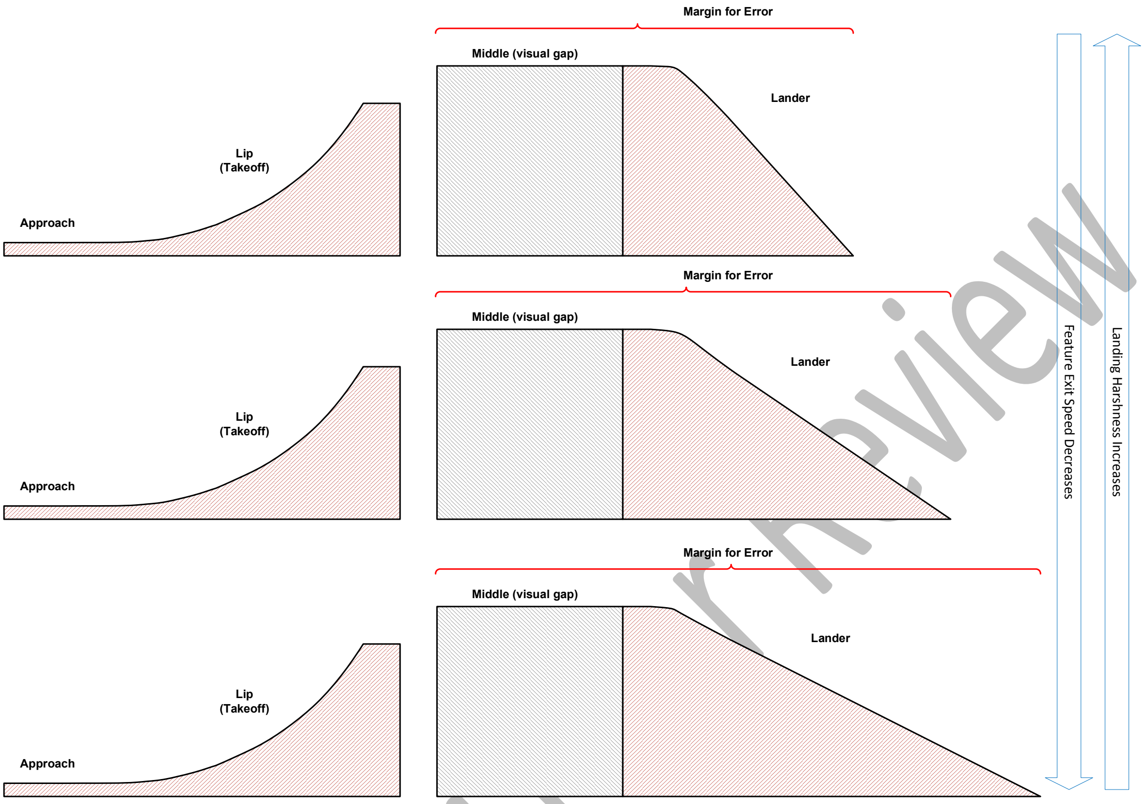

FIG. 13.1: Landers with Varying Decline Angles

In practice, lander design is in essence a task of balancing margin for error with velocity conservation. Landing harshness is typically less of a concern (assuming an angle of at least 20 degrees is achieved), unless the fall height is considerable and landing trajectory angle particularly steep.

If there is a need to maximise feature exit velocity, this is able to be achieved by matching a lander decline angle at an optimal landing location (typically the top metre of the lander) with an anticipated landing trajectory angle (which will be dependent on the takeoff release angle). If those are closely aligned, then the landing will be particularly low-impact, allowing maximum redirection of a downward velocity component back into a horizontal velocity component.

Although landers shown herein are linear, it is often preferable to design a lander that decreases in decline angle along some or all of its length (i.e. a concave curved lander). This allows for closer matching of lander decline and landing trajectory at the optimal landing location, without necessarily sacrificing margin for error, as shown below.

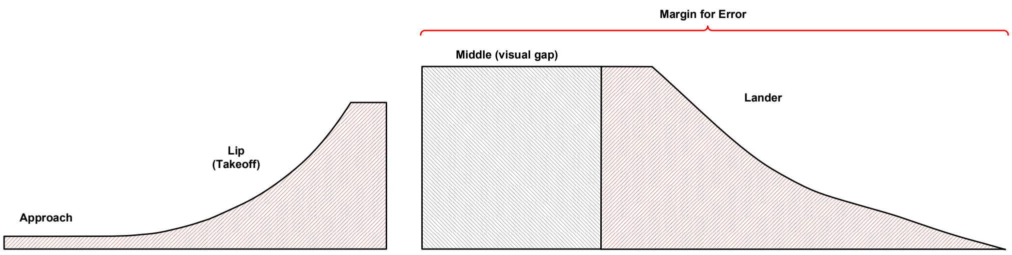

FIG. 13.2: Concave Curved Lander

14. Line Design: General Principles

The diagram below shows an exemplary line of aerial features, showing a number of common line components, including components illustrated in previous sections.

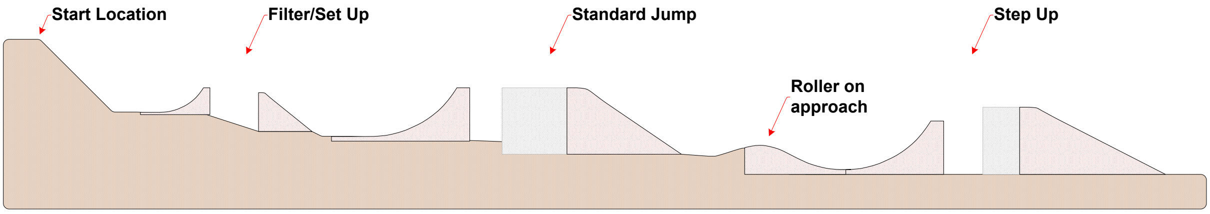

FIG. 14.1: Sample Jump Line

Lines need not be linear, as illustrated, and may include various direction changes including switchbacks, berms, banks, hips, and so on.

A start location should provide clear line of sight to at least the first feature of the line, and preferably over the majority (or all) features in the line. In an ideal situation, the start location provides adequate downslope preceding a first feature to provide a rider with substantially the correct velocity for that first feature. If pedalling is necessary, that should be limited to two, or at most three, pedal cranks (and these should preferably be possible prior to a downslope).

Filter features and set up features should be considered. Often, and as shown in FIG 14.1, a single feature serves a purpose as both a filter feature and a set up feature.

A filter feature is a feature configured to deter insufficiently skilled/confident/experienced riders from attempting a line. This may be achieved by either or both of the following techniques:

- Providing a filter feature that is more technically challenging, but of lesser consequence, than other features in the line.

- Providing a filter feature that is visually intimidating, for example using a gap and/or other visual deterrents.

It is crucial that the filter feature is positioned relative to its following feature such that it is not feasible for a rider to attempt that following feature without first navigating the filter feature.

A set up feature is a low-consequence feature that is configured to assist a rider in checking their velocity prior to attempting features of higher consequence. A rider should not have to pedal or apply any brake between a set up feature and its following feature. Multiple set up features may be spread throughout a line, particularly in the event that there are reasons for which rider velocity should be periodically checked (for example due to sections in which braking is unavoidable, sections where riders are likely to stop to rest, and the like).

As a general rule, when designing a line containing aerial features, attempts should be made to configure the individual features and linking sections such no pedalling is required between features, and at most light braking (ideally the need for braking should be eliminated). This is important from a risk management perspective; it provides predictability to a rider. In particular, when a line is built in that manner, a rider can confidently know that, having successfully traversed a given feature, the exit velocity for that feature will set them up appropriately for a subsequent feature, greatly reducing the likelihood of overshooting and undershooting.

Appropriately managing line flow thereby to substantially eliminate braking is not only valuable from a risk management perspective; it also assists in reducing trail degradation (for instance by preventing the formation of “braking bumps”.

There are also inherent environmental factors, such as afternoon sun direction, predominate wind directions (and wind effects), which should be taken into consideration when designing a line containing aerial features. These may be managed through directional design, and in some cases through the use of shades, buffers, and the like (both natural and artificial).

15. Rider Velocity Management Techniques

As noted, when designing a line containing aerial features, attempts should be made to configure the individual features and linking sections such no pedalling is required between features, and at most light braking (ideally the need for braking should be eliminated). This section described techniques that may be applied to tune features and linking sections thereby to assist in controlling rider velocity.

A primary technique is the use of rollers. Rollers (such the one shown in FIG. 15.1) are features that are able to be rolled in a relaxed manner (which has little effect on velocity), “pumped” thereby to cause an increase in velocity, or “anti-pumped” thereby to cause a decrease in velocity. Rollers are often provided in sets of two or more. Generally speaking, the size of a roller (in height and length) is a primary factor affecting its capacity to enable velocity management.

Techniques for increasing feature exit velocity:

(i) Increase lander decline angle to match expected landing trajectory angle. This will both decrease the amount of kinetic energy lost through landing, and additionally increases “drive” effects by which a rider is able to maximise velocity upon landing.

(ii) Increasing takeoff release angle. This may necessitate adjustments in lip radius, lip height, distance from takeoff to lander, lander height/position, lander decline angle and/or other artefacts. Such adjustments account for limitations associated with a predetermined approach velocity. This increase in release angle is combined with (i) above thereby to allow additional increase to lander decline angle, and a still more effective transfer of gravitational potential energy and downward components of kinetic energy into horizontal kinetic energy.

Techniques for decreasing feature exit velocity:

(i) Decrease lander decline angle. This will cause loss of kinetic energy through a more harsh lading impact.

(ii) Raising lander height, optionally in combination with a decrease in lander angle. This has advantages in that is mitigates harsh landing feelings, whilst nevertheless assisting in velocity management.

(iii) Increasing takeoff release angle (which again may necessitate adjustments in lip radius, lip height, distance from takeoff to lander, lander height/position, lander decline angle and/or other artefact). The rationale is again to increase the angle of trajectory relative to the decline angle of the lander/

Techniques for managing velocity between features (other than the use of rollers):

(i) Unnecessary direction changes (for example banks and bermed corners) can be used to assist in containing rider velocity.

(ii) Introduction of additional aerial features which are tuned to have desired velocity effects.

Skilled trail designers will readily recognise options for trail modification to achieve desired effects in given practical situations.

16. Erosion Management

For facilities that include features and/or linking trail constructed from dirt, there is a need to manage erosion. Water, for example from rainfall, will cause loss of dirt and feature degradation. Erosion effects, both on features and in linking trail portions regions, can cause unpredictable conditions and irregularities that increase the likelihood of rider injury.

A primary technique for erosion management is to minimise water flow on a trail and trail features. This is achieved, for example, by utilisation of drains and the like thereby to prevent water flow across a trail. Where a trail is constructed across a sloped hill, an approach such as that shown below may be used.

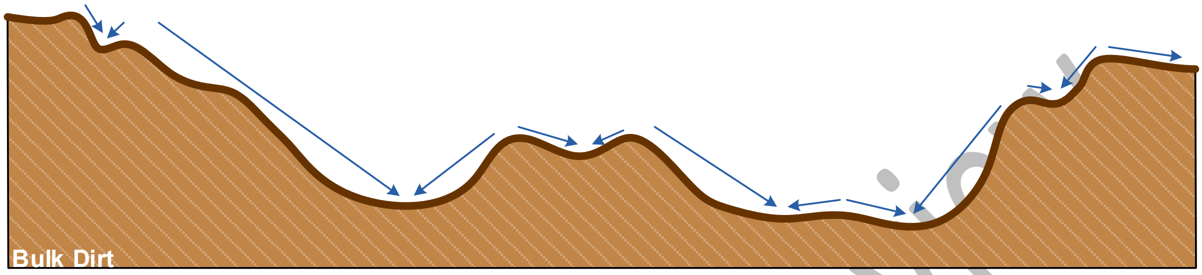

FIG. 16.1: Side View of Trail

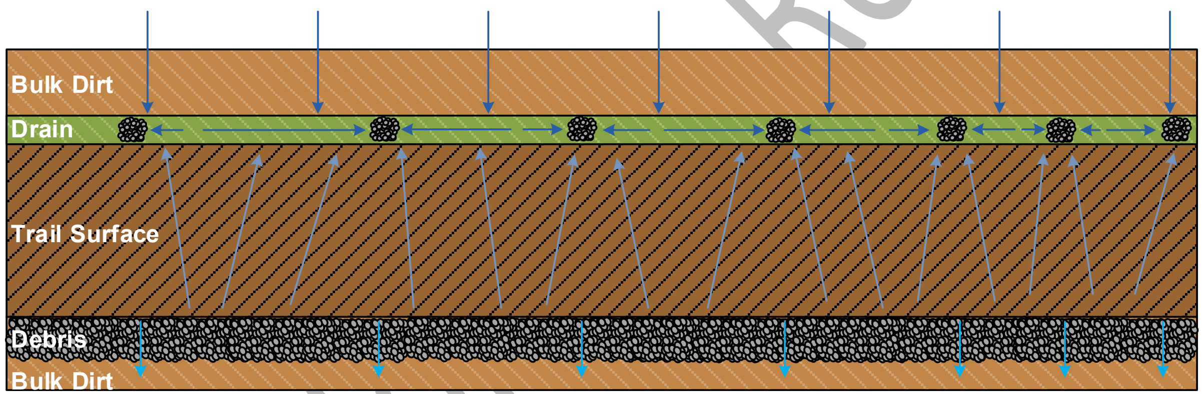

FIG. 16.2: Plan View of Trail

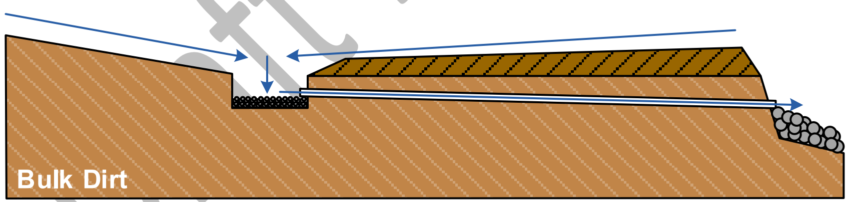

FIG. 16.3: Cross Section of Trail

In overview, regular reverse grades are provided by trail features. These reverse grades, combines with a slight inward bevel of the trail surface, direct water into a drain and towards sediment traps (which are located at low points). Each sediment trap contains an elevated drain opening, with the drain extending beneath the trail surface, distributing water onto debris on the low side of the trail. Blue arrows indicate general rain water dispersion movement.

Feature degradation may additionally be mitigated for dirt features by covering takeoffs (and in some cases landers). A common approach in informal facilities has been to use second-hand carpet and rugs as such coverings, and this has proven to be quite effective. General household and commercial carpets tend to be effective in greatly reducing the rate of lip and landing degradation due to both rain and prolonged dry periods. Materials displaying corresponding advantageous qualities might be commercially sourced.

17. Ongoing Maintenance

Features, particularity those constructed all or in part from dirt, will require ongoing maintenance.

A first form of maintenance is preventative maintenance. This includes regularly sweeping and moistening riding surfaces (for example a hose or watering can may be used). This assists in maintaining dirt plasticity, and reduces wear and tear effects during normal use.

A second, and more substantive, form of maintenance involves re-surfacing and repairing trail features. This involves application of replenishing dirt, with appropriate moisture levels, to return a feature to its intended shape.

Any facility should have a maintenance plan which accounts for both of these, thereby to reduce risks associated with a facility becoming dangerous due to lack of maintenance. This plan should take into consideration:

- Availability of water (e.g. rainwater collection, town water access, hoses, etc.).
- Availability of suitable tools (e.g. a storage locker or the like).
- Availability of stockpiled dirt (for maintenance purposes).
- A maintenance management structure (for example responsible persons).

Many risk factors are heavily increased in situations where features become degraded (and otherwise are in need of maintenance).

Utilisation of wooden and/or steel-framed structures, along with surface coatings (for example concrete/ asphalt, carpet, and other materials), and utilisation of dirt stabilising agents may be helpful in reducing maintenance requirements.

18. Risk Factors and Management

The table below sets out major risk factors which may lead to rider injury, and preventative options that may assist in reducing/managing those risks.

Risk	***Preventative Options***
Rider fall due to complete undershoot (>50% of bike misses margin for error zone)	• Use tabletops or visual gaps. • Ensure speed/flow matching of line and adjacent features. • Make use of set-up feature.
Rider fall due to partial undershoot (<50% of bike misses margin for error zone)	• Use tabletops or visual gaps. • Ensure speed/flow matching of line and adjacent features. • Make use of set-up features. • Use higher release angles to reduce horizontal component of velocity upon landing.
Rider fall due to overshoot	• Use tabletops or visual gaps. • Ensure speed/flow matching of line and adjacent features. • Make use of set-up features. • Set lander decline and position angle for increased margin for error.
Rider fall due to landing	• Maximise lander size and margin for error. • Remove or manage danger of obstacles in likely rider path when exiting lander without bike control. • Use higher release angles to reduce horizontal component of velocity upon landing. • Perform regular maintenance
Rider fall due to imbalance upon takeoff	• Maximise takeoff radius (decreases takeoff technicality) and user release angles above optimal trajectory (increased airtime provides increased opportunity to correct position). • Use filter features to ensure threshold rider ability. • Ensure speed/flow matching of line and adjacent features. • Ensure approach is suitable for feature. • Perform regular radius assessments, maintain as required. • Use step up features to decrease landing force.
Rider fall due to insufficient skill for feature	• Use visual gaps (or gap) to discourage attempts. • Use filter features.
Rider injury due to collision on lander	• Use visual gaps (or gap) to prevent rolling of features.

19. Feature Difficulty Ratings

A wide range of factors contribute to assessing difficulty ratings for aerial features and lines containing aerial features in practical situations. For example, average rider standards in a given region may impact on what is regarded as “beginner” as opposed to “expert”.

The following sections provide a range of sample feature templates to provide general guidance. These are not intended to be in any way prescriptive; they are for high-level guidance only. Although the templates range from “novice” to “advanced”, it is anticipated that additional skill designations bat be defined beyond either end of that scale.

It should be recognised that each illustrated template covers a wide range of possible feature designs. For example, the diagram below illustrates multiple step up configurations that may be appropriate based on a common one of the templates:

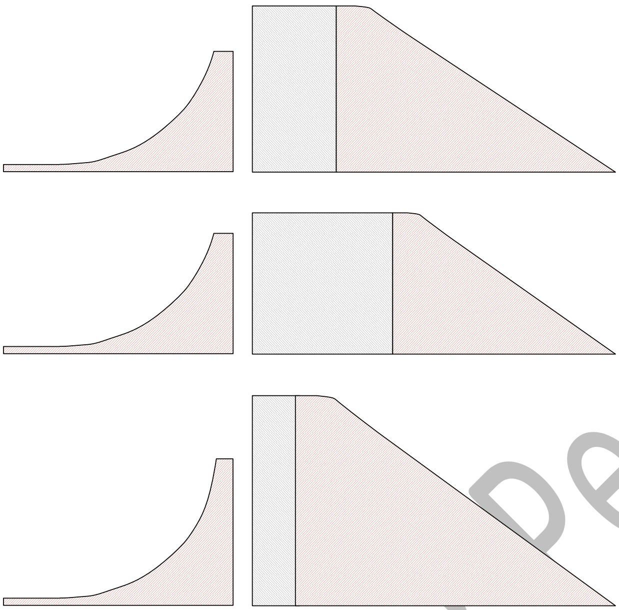

FIG. 19.1: Multiple Step-Up Designs with Similar Difficulty Levels

When designing skills parks, and other facilities with a focus on progression, it is often advisable to include multiple features in a side-by-side manner, with incrementally increasing levels of difficulty. The smaller the increments, the safer the environment provided for riders to progress their skills (leading to risk management advantages).

As a general rule, the technical difficulty of a feature can be affected by margin for error. For example, the following approaches may be used to reduce risks associated with features, thereby to make them more safely accessible to developing riders: use of visual gaps (as opposed to traditional gaps), use of effective set-up features, maximizing lander width, and designing landers with gradual declines (significantly-below-optimal trajectory angle).

20. Example Novice-Level Features

As a general rule, novice level features should be rollable, and tabletop configurations are preferred. Hip angles should not exceed approximately 20 degrees.

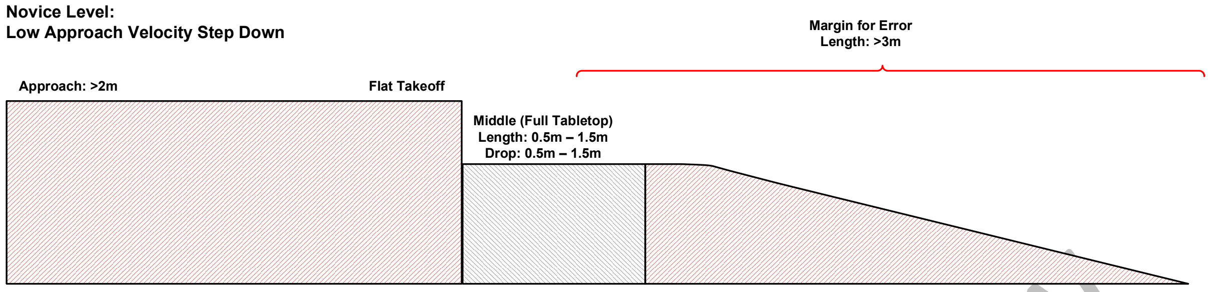

FIG. 20.1: Low Approach Velocity Novice Step-Down

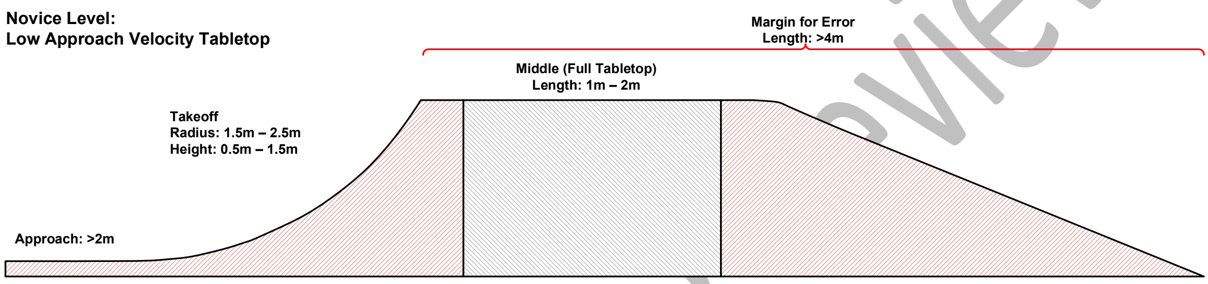

FIG. 20.2: Medium Approach Velocity Novice Tabletop

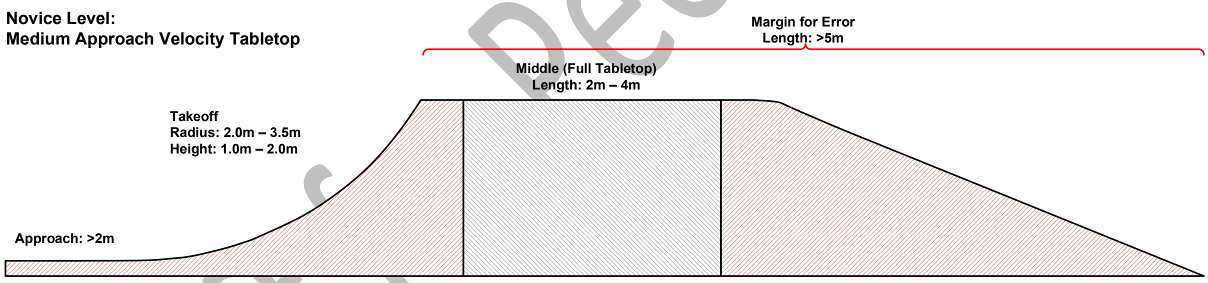

FIG. 20.3: Medium Approach Velocity Novice Tabletop

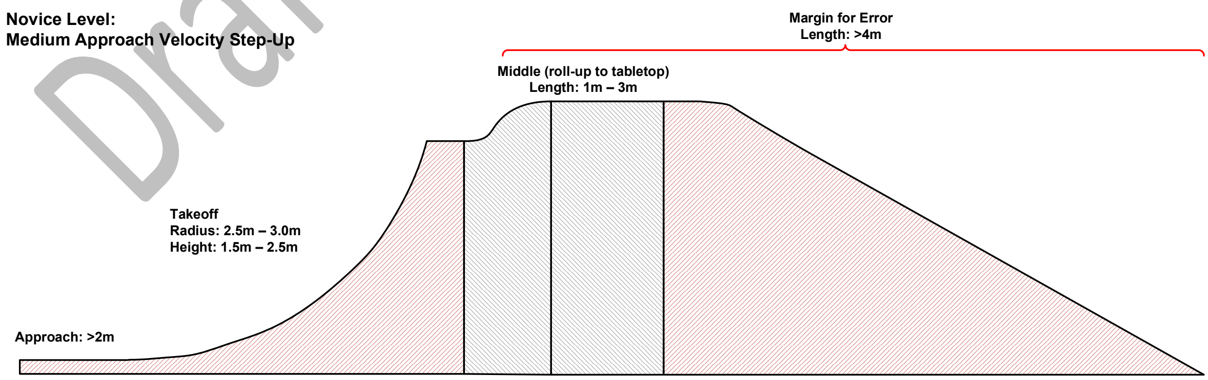

FIG. 20.4: Medium Velocity Novice Step-Up

21. Example Intermediate-Level Features

Intermediate level features need not be rollable, but should include ample margin for error (for example via the use of visual gaps). Traditional gaps may be used for low-consequence features, for example filter features. Hip angles should generally not exceed approximately 45 degrees.

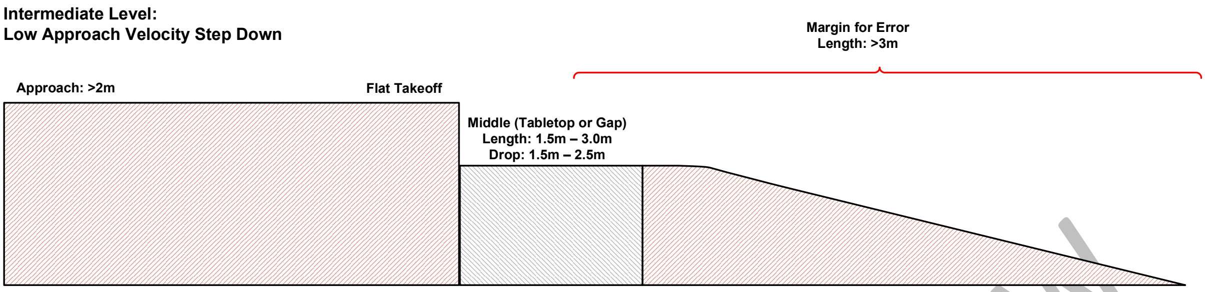

FIG. 21.1: Low Approach Velocity Intermediate Step-Down

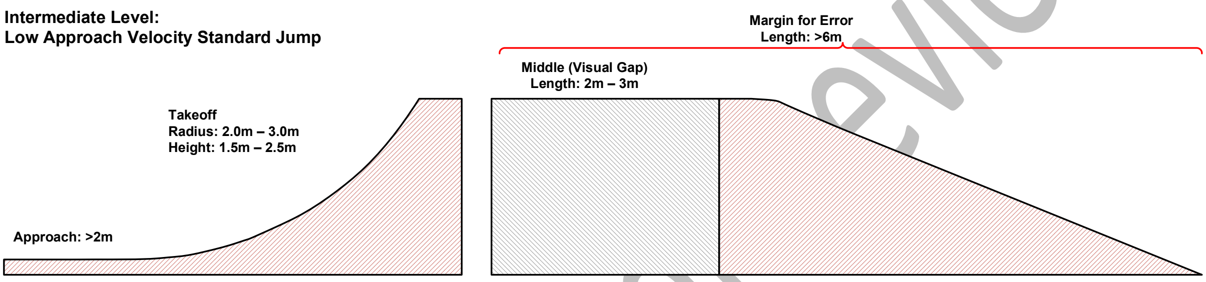

FIG. 21.2: Medium Approach Velocity Intermediate Standard Jump

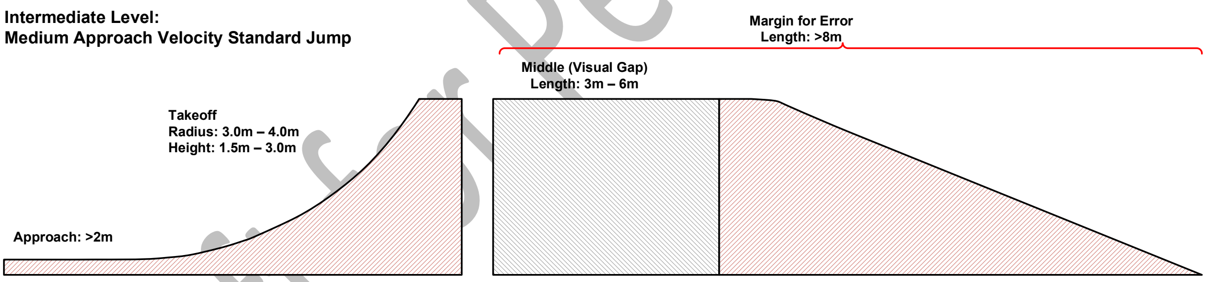

FIG. 21.3: Medium Approach Velocity Intermediate Standard Jump

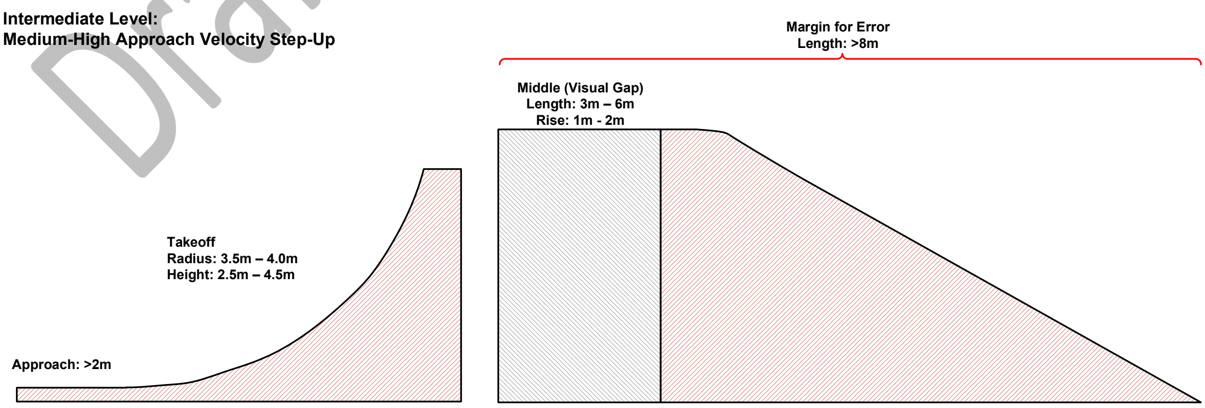

FIG. 21.4: Medium Velocity Intermediate Step-Up

22. Example Advanced-Level Features

Intermediate level features need not be rollable, but should include ample margin for error (for example via the use of visual gaps). Traditional gaps may be used for low-consequence features, for example filter features, and may be considered for other features also. Hip angles may approach 90 degrees.

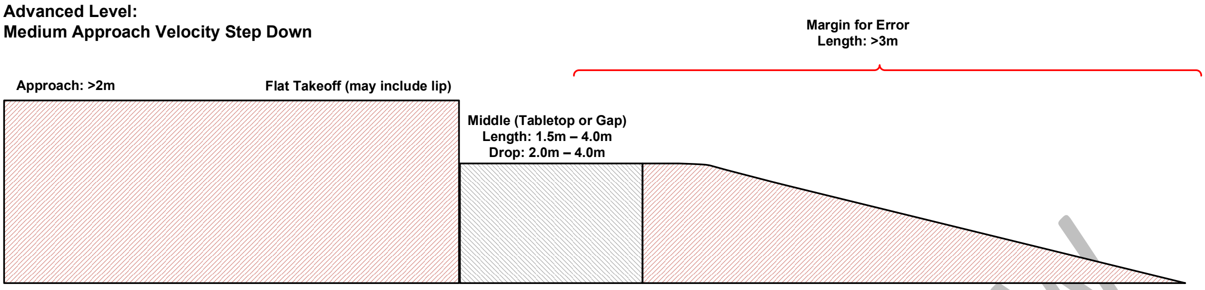

FIG. 22.1: Medium Approach Velocity Advanced Step-Down

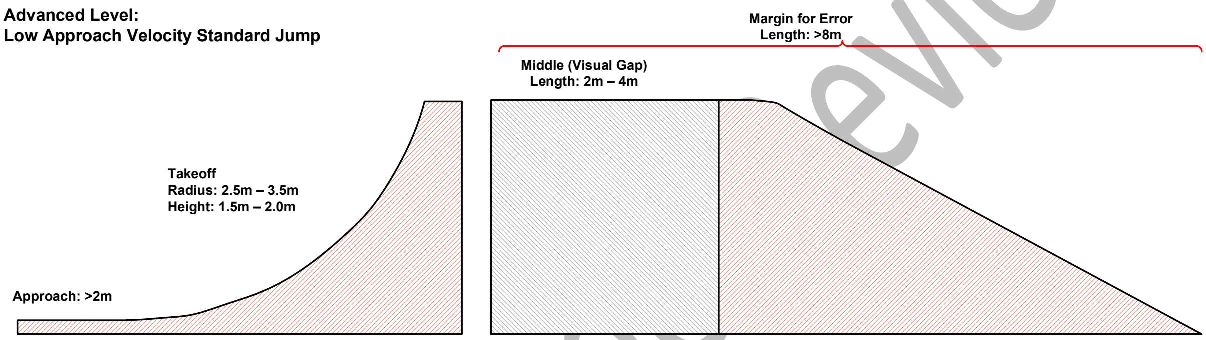

FIG. 22.2: Medium Approach Velocity Advanced Standard Jump

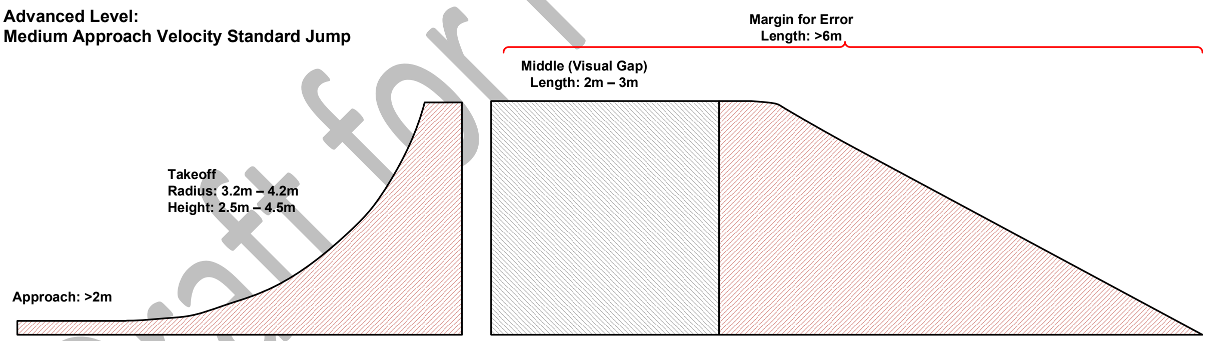

FIG. 22.3: Medium Approach Velocity Advanced Standard Jump

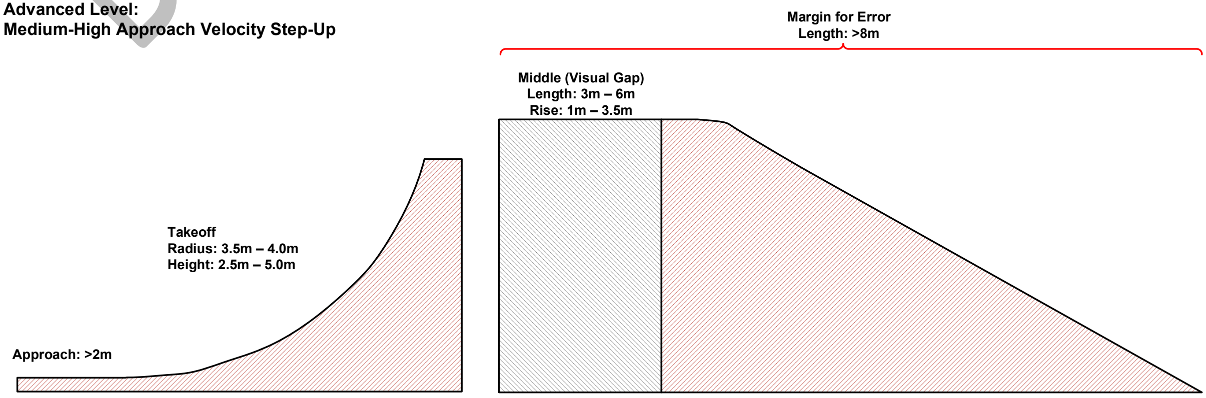

FIG. 22.4: Medium Velocity Advanced Step-Up