Creating Standards for Winter Terrain Parks

Mont Hubbard

Department of Mechanical & Aerospace Engineering
University of California, Davis, CA

Jim McNeil

Department of Physics
Colorado School of Mines, Golden, CO

Creating Standards for Winter Terrain Parks

- The need for safer parks
- Role of design
- Current practice
- Recent research on safer designs
- Proposed role for ASTM F-27

The Need for Safer Terrain Parks

Deaths: 50 (2007-2008)
39 (2008-2009)

Compiled by California Ski and Snowboard Safety Organization

From NSAA web site (2007)

58.9M skier/snowboarder days (2005-06)

57 "serious injuries"

39 fatalities (31 male, 6 female) mostly young

J. Shealy (2000)

Snowboard injury rate doubled during 1990-2000 from 3.37 to 6.97 per 1000 skier days

The Need for Safer Terrain Parks

F. Tarazi, M. Dvorak, P. Wing, Spinal injuries in skiers and snowboarders ***Am. J. Sports Med. 27,177*** (1999)

~ 40 SCI/10^6-snowboarder-days (4x skier rate)
~ 77% of snowboarding SCI from jumps (4x skier rate)

(2000-01) 16.1 10^6-snowboarder-days
→ 496 SCI from jumps!

Scale of the problem ~100s !

The Need for Safer Terrain Parks

Winter terrain park jumps pose a special risk for death or paralysis:

Charlene Vine – paralyzed
Kenny Salvini – paralyzed
James McLean – death
Asher Crank – death
James Malaguit – paralyzed
Christian Bagg – paralyzed
Steven Rosier – paralyzed
Sam Harrison – paralyzed
Jared Nagel – death
Caleb Szajner – death
Sheree Perez – paralyzed
Ryan Stevenson – paralyzed

James McLean

Role of Design

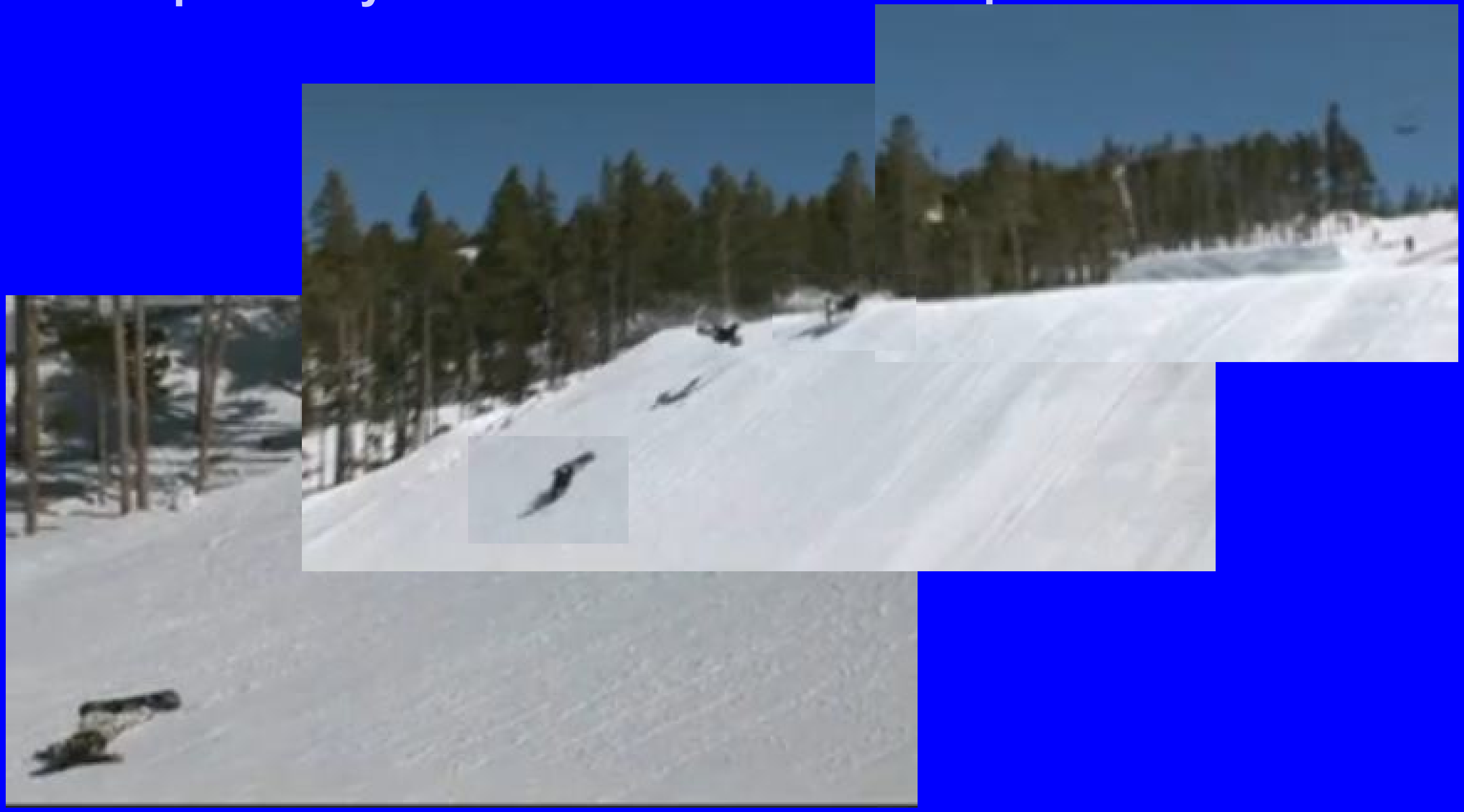
Rider induced

http://www.youtube.com/watch?v=lW9Zg_WSLWg

Role of Design

Design feature exacerbating a rider mistake: Knuckle crash

http://www.youtube.com/watch?v=EHGqETZIv-E



Role of Design: Design Flaws

Curvature in take off can lead to involuntary inversion

Catastrophic Convergence of Design Flaws

Approach too long/steep for landing
Curvature in take off leading to inversion
Landing too short for approach speeds

Spinal Cord Injury --> Death, Parapalegia or Quadraplegia

Current Practice

Most jumps built by snow cat operators and tested by local ski pros

No terrain park jump standards or engineering design

Industry position: rider/snow variability make engineering design impractical if not impossible

Some NSAA guidelines: Terrain Park Manual

Landing slope = take off angle

Landing area 2/3 of total feature size

No “gap” jumps

Why resistance to engineering?

Apparent Liability Concerns:
View terrain parks from frame of liability, not engineering

Result:
NSAA meetings discussing terrain park designs are closed because they are considered part of legal strategy

Shift to engineering frame motivated creation of a 501c(3) non-profit,

USTPC

United States Terrain Park Council

Dedicated to providing an open, transparent, democratic forum for all terrain park constituents to research and share best practices in terrain park design.

“above the fray” – officers/board members barred from involvement in litigation.

http://USTerrainParkCouncil.org

Summary of Recent Research

Muller, et al.(1995)- used EFH* to quantify impact
Wylie(1999)- compared aerial & freestyle with EFH
La Hart(2007)- discussed societal implications
McNeil & McNeil(2008)- showed convex landing surfaces
safer; concave takeoff dangerous
Hubbard(2008)- showed analytic design to limit EFH
Shealy, et al.(2010)- experimentally measured rider variability
Swedberg(2010)- showed large tabletop jumps unsafe

*EHF = equivalent fall height

Some aspects of jump design

In-run steepness and length

Takeoff-ramp surface shape & size

Landing surface shape

And many others

Why design of landing surface shape works

Impact severity can be characterized by Equivalent Fall Height (EFH).

Landing surface shape can be calculated to limit EFH by making landing slope nearly parallel to jumper path.

Newton's Second Law

An object with mass *m*
With velocity *v* that suddenly stops
Sustains impulse I where

$$I=mv$$

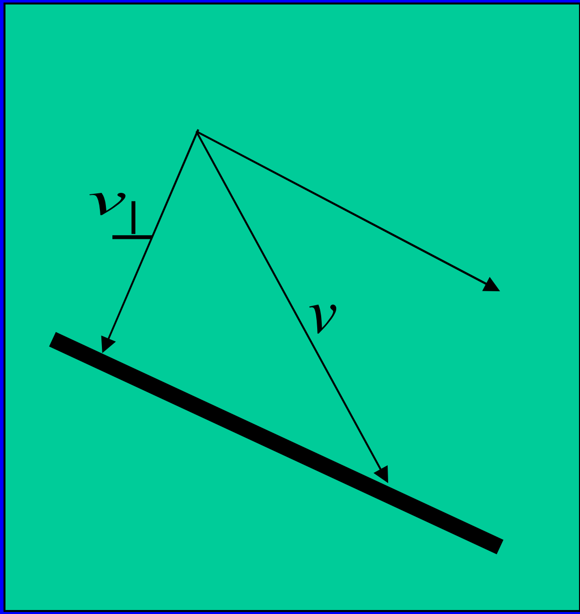
How to measure jump landing impact severity?

Equivalent Fall Height on a slope

$$h = v^2 / 2g$$

becomes

$$h = v_{\perp}^2 / 2g$$

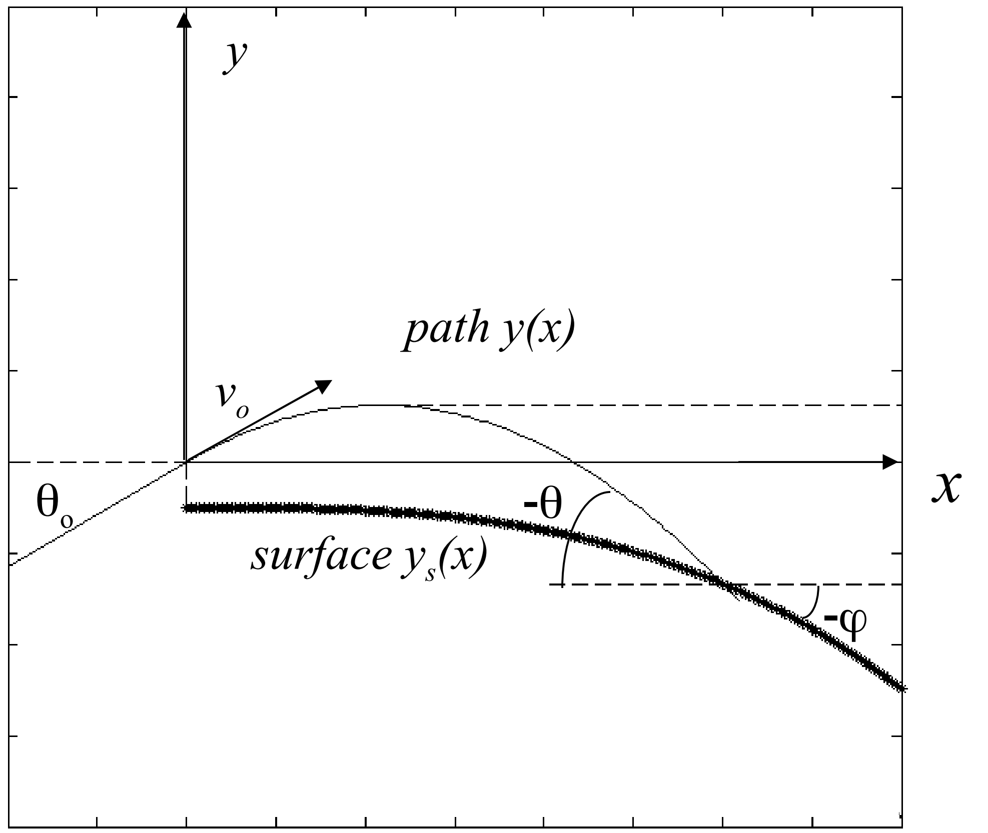


where $v_{\perp}$ is the velocity perpendicular to the landing surface.

Nordic Ski Jumping has EFH = 0.6 meters

Safe landing surface design statement:

Given takeoff angle θ_o
and a safe equivalent fall height h,
calculate the landing surface shape $y_s(x)$ that
limits EFH to h
for any takeoff velocity v_o.

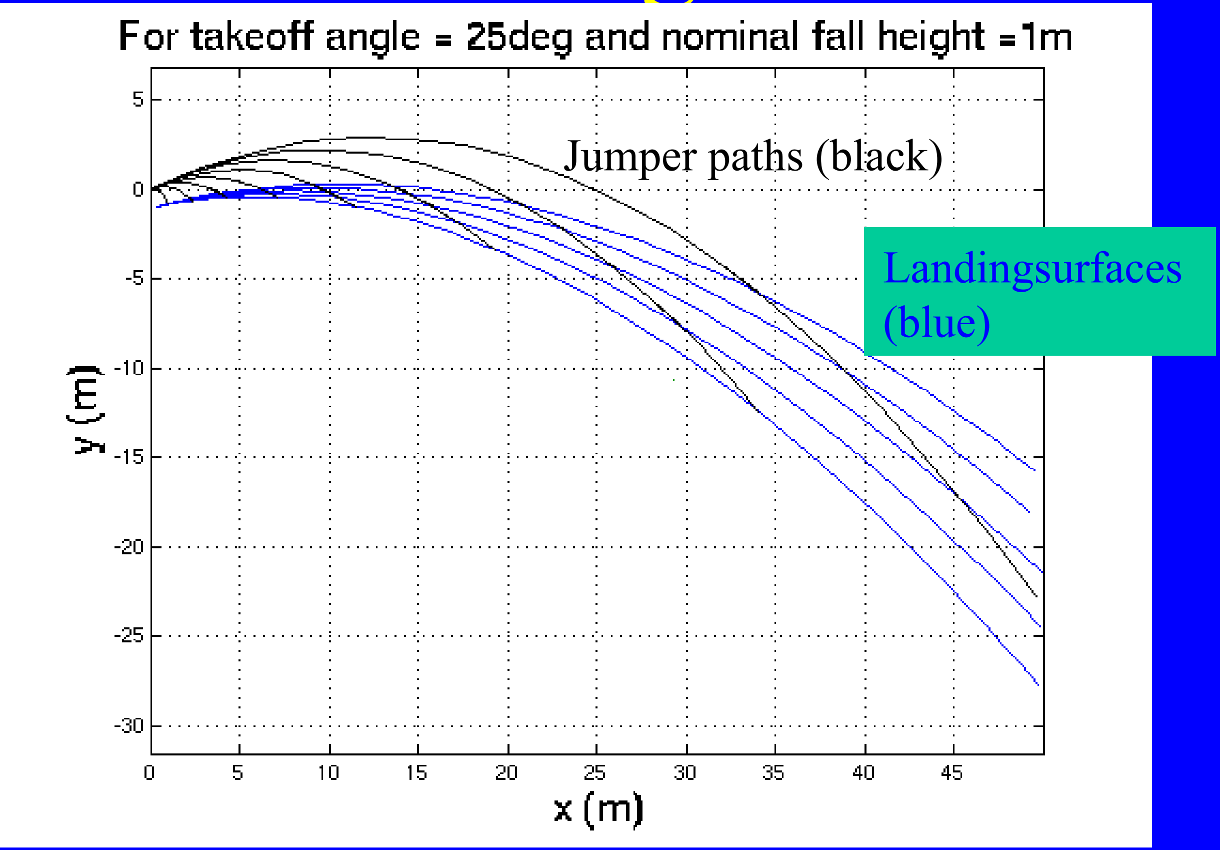


y
path y(x)
v_o
x
θ_o
-θ
surface y_s(x)
-φ

Soft landings have small misalignment θ-φ between path and slope

$$v_{\perp} = \sqrt{2gh} = v\sin(\theta-\varphi)$$

Safe landing surfaces



Monotonically decreasing slope as function of x

Ubiquitous. Entire xy plane below TO line is dense with solutions

All landing surfaces above are equally safe

Design algorithm

Choose h for acceptable safety.

How big should jump be? Fit onto available slope (x_L, y_L).

If fix θ_o can choose safe slope that passes through (x_L, y_L) but overshoot may occur => control of v_o may be needed.

If free θ_o can choose safe slope that passes through (x_L, y_L) at maximum reasonable v_o.

Use ubiquity to find easiest and most economical to build.

Conclusions

Design flaws or lack of design in winter terrain parks contribute to injury and death

Industry eschews design standards as impractical due to variability and relies on liability shield laws to protect them after accidents

Recent research shows that variables are manageable and that engineering design is practical and can save lives

Benefits and consequences that will accrue from standards

1. Better terrain parks will be designed with increased safety for participants.
2. Resorts will incur responsibility to adhere to standards, but
3. Adherence to standards will shield resorts from liability.

Proposed role for ASTM F-27

Create a dedicated F27 subcommittee to research potential technical standards for design of winter terrain parks, including jumps and other features.