AgrAbility and Agricultural All-Terrain Vehicle Safety

Presented by:

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ATVs are only one kind of "other power-driven mobility device" that may potentially be used by individuals with mobility disabilities on farms.

https://www.atvcourse.com

https://www.americantrails.org
Introduction

- All-Terrain Vehicle (ATV) or Quad bike
- In 2016, 97,200 ATV-related, injuries in the United States
- In 2016, 661 ATV-related fatalities
- 22 percent children younger than 16 years of age

http://mvatvr.org/1-person-killed-in-eastern-idaho-atv-crash/
ATV in Agriculture

- ATV in farms
- Three out of five occupational ATV fatalities happen in the agriculture sector (OSHA)
- The second most common injury source in agriculture, across all ages, causing 190 of injuries or deaths
- Leading cause of injury in agriculture among youth (0-17), 2015 and 2016 (National Farm Medicine Center)

http://farmcreditblog.com

https://www.liveabout.com/buying-a-used-atv-4260
Definitions

Sport vs. Utility/Agricultural ATV

An example of a sport ATV
1) No or small load racks
2) No trailer hitches
3) Rear wheel drive (some)
4) Manual transmissions (some)
5) No winch
6) No 12-volt power plug

An example of a utility ATV
1) Front and rear racks for carrying loads or mounting equipment
2) Trailer hitch
3) 4-wheel drive
4) Automatic transmission (some)
5) Winch
6) A 12-volt power plug
Recreational vs. agricultural ATV incidents

<table>
<thead>
<tr>
<th></th>
<th>Agricultural</th>
<th>Recreational</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types of accident</strong></td>
<td>ATV rollovers (85%)</td>
<td>Riding fast, lost control, was ejected, and collided with a stationary or moving object</td>
</tr>
<tr>
<td></td>
<td>Rider pinned under ATV (68%)</td>
<td>Rider pinned under ATV (30%)</td>
</tr>
<tr>
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<td>Death by asphyxia (42%)</td>
<td>Death by asphyxia (11%)</td>
</tr>
<tr>
<td><strong>Injuries</strong></td>
<td>Head injuries (13%)</td>
<td>Head injuries (49%)</td>
</tr>
<tr>
<td></td>
<td>Chest injuries (59%)</td>
<td></td>
</tr>
<tr>
<td><strong>Added load /or passenger</strong></td>
<td>Attachments (≈50-75%)</td>
<td>Attachments (≈25 to 33%)</td>
</tr>
<tr>
<td></td>
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<td>More possible to carry a passenger</td>
</tr>
</tbody>
</table>

There is an obvious need to distinguish and treat the safety requirements for Agricultural ATV differently compared to the recreational ATV.
Solving issue

- Elimination or substitution
- Engineering control: Roll-Over Protective Structure (ROPS), Crush Protection Device (CPD)
- Administrative control
- Training and PPE
Elimination or substitution

• Three-wheeled ATVs: elimination of three-wheelers ATVs which the production of three-wheelers ceased in 1987 due to safety concerns

• Like tractors, banning the four-wheeled ATV is not an option because of its broad acceptance as a useful vehicle on farms

• However, technical advances by Segway may provide a solution to the ATV rollover problem

• The Segway Centaur is conceived as a self-balancing human transporter, but advances could lead its use for utility functions.
Recreational Off-highway Vehicle

- Recreational off-highway vehicles (ROVs or side-by-side vehicles)
- Steering wheel instead of a handlebar
- Bench or bucket seats instead of straddle seating,
- Foot controls for throttle and braking instead of levers located on the handlebar.
- Rollover protective system ROPS
- Seatbelts
- Maximum speed greater than 30 mph.
- Superior static stability, dynamic handling, minimal steering disturbance when traversing a bump
- Rollover crashworthiness of ROVs
Engineering control: ROPS and CPD

- 60% of fatalities were associated with ATV overturns (General)
- Roll-Over Protective Structure (ROPS), Crush Protection Device (CPD)
Crush Protection Device (CPD)

- Seat belt
- Active riding
- Increase the stability by 10% to 30%

NZ T-Bar CPD  HSE U-Bar CPD
Commercial CPD/ROPS

Quadbar
Quadbar Flexi
Quick-fix
Lifeguard
CFMOTO
Israel Army ROPS
Auto ROPS
CPD/ROPS

MTV roll cage

Pro-Tec System ATV
Experimental test to evaluate performance of ATV

- Static Stability tests: static stability angle

- Dynamic Handling Tests
  - Steady-state circular driving behaviour dynamic tests - the limit of lateral acceleration
  - Steady-state circular driving behaviour dynamic tests - scores either the understeer or oversteer characteristic.
  - Bump obstacle perturbation tests.
The Quad Bike Performance Project

17 model of ATV and SSV

- Static Stability
- Dynamic Handling
- Rollover Crashworthiness

The static stability and dynamic handling tests identified that:

- Quadbar and Lifeguard were not detrimental
- Quickfix was found to be detrimental
CPD/ROPS evaluation

- Simulate ATV accidents
  - Experimental test methods
    - Static
    - Dynamic
    - Field-upset test
  - Theoretical simulation methods
    - Simulation programs including MADYMO, ATB and MATD
Static test

Lateral

Longitudinal

Vertical

Dynamic test

Vehicle Accelerator

Tilt table

Field-upset test

University of Southern Queensland

University of New South Wales, Sydney, Australia
Quadbar and Lifeguard are likely to be beneficial in terms of severe injury and pinned prevention in some low speed rollovers typical of farm incidents.

In some specific cases injury risk could be increased although there is currently no real world recorded evidence of this.

Improvements to OPD designs in future.
ATV with & without CPD
Theoretical simulation and Field-upset test

- Dynamic Research Inc. (DRI)
- Field-upset test
- 12 full scale experimental tests for calibrating the simulations
- The motion of the dummy and ATV were correlated
- No correlation regarding the injuries predicted
Theoretical simulation

- Six different ATV ROPS/CPDs
- 113 accidents scenarios.
- Either the ROPS/CPD had no statistically significant net injury benefit, or if there was a ROPS/CPD net benefit, then the risk/benefit percentage was much greater than their presumed allowable limit, in this case 12%.

Criticisms of the DRI research

- *Substantial assumptions that had to be made*
- 17 key variables needed to test or simulate an overturn, the UK/US database had a minimum of 2 variables, and an average of 8 variables
- *Extreme scenarios (speeds and obstacles) caused the rider to be thrown clear of the bike*
Field-upset test

(a) J-turn (Top, base-line ATV, Down, ATV equipped with CPD)

(b) V-ditch and tests (Top, base-line ATV, Down, ATV equipped with CPD),
## A Motorcyclist Anthropometric Test Device (MATD)

### MATD injury measures for J-turn tests

<table>
<thead>
<tr>
<th>Measure</th>
<th>Quadbar ATV Test</th>
<th>Baseline ATV Test</th>
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<tbody>
<tr>
<td>Head AIS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Neck AIS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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</tr>
<tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tibia AIS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maximum AIS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Normalized Injury Cost (Icnorm)</td>
<td>0.006</td>
<td>0.002</td>
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<tr>
<td>Asphyxia</td>
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### MATD injury measures for V-ditch tests

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CPD/ROPS evaluation

- NIOSH recommended installing CPDs and reported that CPDs can decrease the number of deaths by 40% (Helmkamp, 2012).
- The application of a CPD in an Australian resort with more than 100 ATVs and 3,000 tourists, resulted in 90% drop in injuries rate since ATVs were equipped with CPDs (Freund, 2015).
Fleet Managers Survey: a survey of companies (Fleet Managers Survey) with large ATV fleets fitted with CPD, with responses from ATV fleet managers (12 Australian and 4 NZ companies, with a total of 436 ATVs) (Grzebieta et al., 2017).
Global Perspective

The administrative authority: Rules and standards around the world

Australia

- **Rebates program**: New South Wales, Victoria

  WorkSafe Victoria accepts OPDs as a solution to control the risk to operators in the event of a rollover.

  Australia’s Victoria state mandates rollover protection to be fitted to ATVs used in the workplace.

- **Research**

- **Standard**: Australian Consumer and Competition Commission (ACCC): Exposure Draft: Quad bike safety Final Recommendation to the Minister

  “A general use quad bike must have one of the following devices fitted, or integrated into its design:
  
  - (a) ATV Lifeguard
  - (b) Quadbar,
  - (c) A device of a type that offers the same, or better, level of protection for operators from the risk of serious injury, or death, as a result of being crushed or pinned in the event of a rollover.”
Global Perspective

New Zealand

- **Rebates program**: Accident Compensation Corporation (ACC) is the New Zealand: 
  "If you’re self-employed or own a small to medium business in the agriculture sectors with the highest quad bike injury rates, you might be eligible for a workplace injury prevention subsidy to help pay for a CPD for quad bikes at work”.

- **Policy**: WorkSafe is New Zealand's primary workplace health and safety regulator “strongly recommend you have a CPD installed.”

- Currently NZ WorkSafe recommends - buy a CPD that’s professionally designed and manufactured

- **Standard**: Guidelines provided by the Occupational Safety and Health Service of New Zealand for the design of ATV ROPS (after a trial period, standard withdrawn)

Israel

- **Policy**: Israel’s Ministry of Transport requires the mandatory fitting of safety frame on all ATVs.

- **Standard**: “Technical specifications for testing and mounting of safety frames for ATV’s” (2004, Ref:5016203)
Global Perspective

Sweden

- **Research:** Swedish ATV riders already install CPDs on ATVs. A survey was conducted in the Sweden, in which the ATV riders with ATV equipped with CPD were interviewed. “With such prevalent views, it would probably be more effective to focus on passive interventions by targeting the manufacturing side to develop technological safety systems (like ROPS) fitted to new quad bikes. “

- **Policy:** Better Safety on Quad Bikes Joint strategy version 1.0 for the years 2014-2020:
  
  **2013:** We do not feel ready to recommend physical rollover protection structures as there is no research that demonstrates that they have the desired effect in the event of a vehicle overturning.

**2020**

Canada

- **Policy:** No federal policy for CPD and ROPS

An insurance company in Canada is offering a 5% discount on their ATV insurance if they have a quad bar installed.
Global Perspective

United States

- **Upper Midwest Agricultural Safety and Health** (UMASH) offers a farm safety checklist for ATV which includes this point "Does ATV have a Crush Protection Device (CPD) designed to prevent crush injuries in lower speed crashes (<30 mph)?"

- **The National Children’s Center for Rural and Agricultural Health and Safety** (NCCRAHS) offers guidelines for adults to determine the readiness of youth (younger than 16) to operate a utility ATV on farms (NCCRAHS, 2018) one of the requirements is: ATV has a Crush Protection Device (CPD) designed to prevent crush injuries in lower speed crashes (<30 mph)

- **Standard**: Currently ATV standard exist as “American National Standard for Four Wheel All-Terrain Vehicles” ANSI/SVIA 1-2017. Does not address CPDs.

- (SVIA) doesn’t approve mounting roll bars on ATVs.

- **Policy**
The training: Available occupational training programs

- ATV Safety Institute (ASI) is within a division of the Specialty Vehicle Institute of America (SVIA):
  - Offers free hands-on training to any individual who purchases a new ATV (ATV RiderCourse<sup>SM</sup>)
  - Safety information and riding techniques

**Protective Gear for ATVs**

- Helmet
- Eye Protection
- Gloves
- Boots
- Protective Clothing

https://cropwatch.unl.edu/2018/required-youth-tractor-safety-training-12-sites-summer
What to do

- Evaluate agricultural ATV accidents
- Design a new CPD
- Develop technical standards for CPDs
- ATV safety outreach program (social marketing) 3E (Engineering, Enforcing, Education)

An ATV with a bent CPD after a violent frontal overturn

M. L. Myers, 2017
Capabilities and Limitations of Youth Operating Agricultural All-Terrain Vehicles

- Agricultural is the most dangerous industry for youth
- The number of worker fatalities in agriculture is consistently higher than in all non-agricultural industries combined
- ATV is leading cause of fatalities and injuries
- It has been hypothesized that many ATV-related injuries occur because children are assigned ATV-related jobs beyond their physical capabilities

Evaluate 100 utility ATVs of varying age, models, and regarding:
- (a) control force activation requirements
- (b) reachability of each control
Reachability

The angle of lean from vertical (CPSC, 2006), Turning reach (IPCH, 2018).
Evaluate performance of CPD in agricultural ATV rollover accidents

Objectives

(1) Develop a remotely controlled ATV equipped with autonomous direction control for rollover tests

(2) Evaluate the performance of the remotely controlled ATV

(3) Conduct ATV rollover tests

4x4 Honda FourTrax Rancher 2018 with Dual Clutch Transmission (DCT), independent rear suspension (IRS), and electric power steering (EPS)
Objective 3: Rollover Simulation

- **Rear-upset test** and **side-upset test** will be conducted.
Objective 3: Rollover Simulation

- A tilt table is built for the **rear-upset test** (tilt of 60±5°), and the rollover tests will be conducted at the **UCD Pavement Research Center**.
Objective 3: Rollover Simulation

- Other instruments /considerations for rollover tests:
  - **Dummy** with instrumental devices
  - **High speed camera** for rollover crushes analysis
  - **Handlebar** enhancement / replacement
  - Crash protection (**impact barrels or sandbags**) in terrain
Evaluation of CPD for Agricultural ATV

- 4 Operational criteria
- 5 Safety criteria
- Quadbar, Lifeguard, and Air-Quad
- Mounted on 13 ATV models

Factors include:
- The shape and volume of the rear and side CPZ
- The increase in the height of the center of gravity height when the ATV is equipped with a CPD
Crush Protection Zone

- rear and side roll

The blue volume shows the rear CPZ of an ATV in the overturned position (left) general trapezoid shape of CPZ and (Right) CPZ of Lifeguard which is deformed in the overturned position.
Comparison of rear CPZ For Three Designs of CPD

CPD resulted in an average rear CPZ increase of 0.34 m$^3$ (80%).
The AIR-Quad was the most effective CPD in increasing the CPZ, with an average increase in CPZ of 0.48 m$^3$ (111% increase).
QB: increases by 0.39 m$^3$ (92% increase)
The flexible design of the lifeguard had the lowest increase in CPZ among those analyzed, with a 0.15 m$^3$ increase in CPZ (35% increase).
Questions