



Safe Tractor Operations

Tractors and Rollover Protection in the United States

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Tractors and Rollover Protection

What we will cover:

- Injuries and tractors
- ROPS in the US and other countries
- Social marketing for ROPS retrofitting
- Applied engineering for ROPS retrofitting
- Real-time stability monitoring
- Recommendations for decision makers



Tractors and Rollover Protection

Farming is hazardous:

- From 1992 through 2005, 7,571 have died from farm work; doesn't include non-working children, other bystanders
- Average work death rate: 26/100,000 workers; all-industry average: 3.8/100,000
- Leading causes: tractors (37%), other machinery (18%), and trucks (10%)
- Of the 2,795 tractor related deaths, 1,411 were due to tractor overturns (50%)



Tractors and Rollover Protection

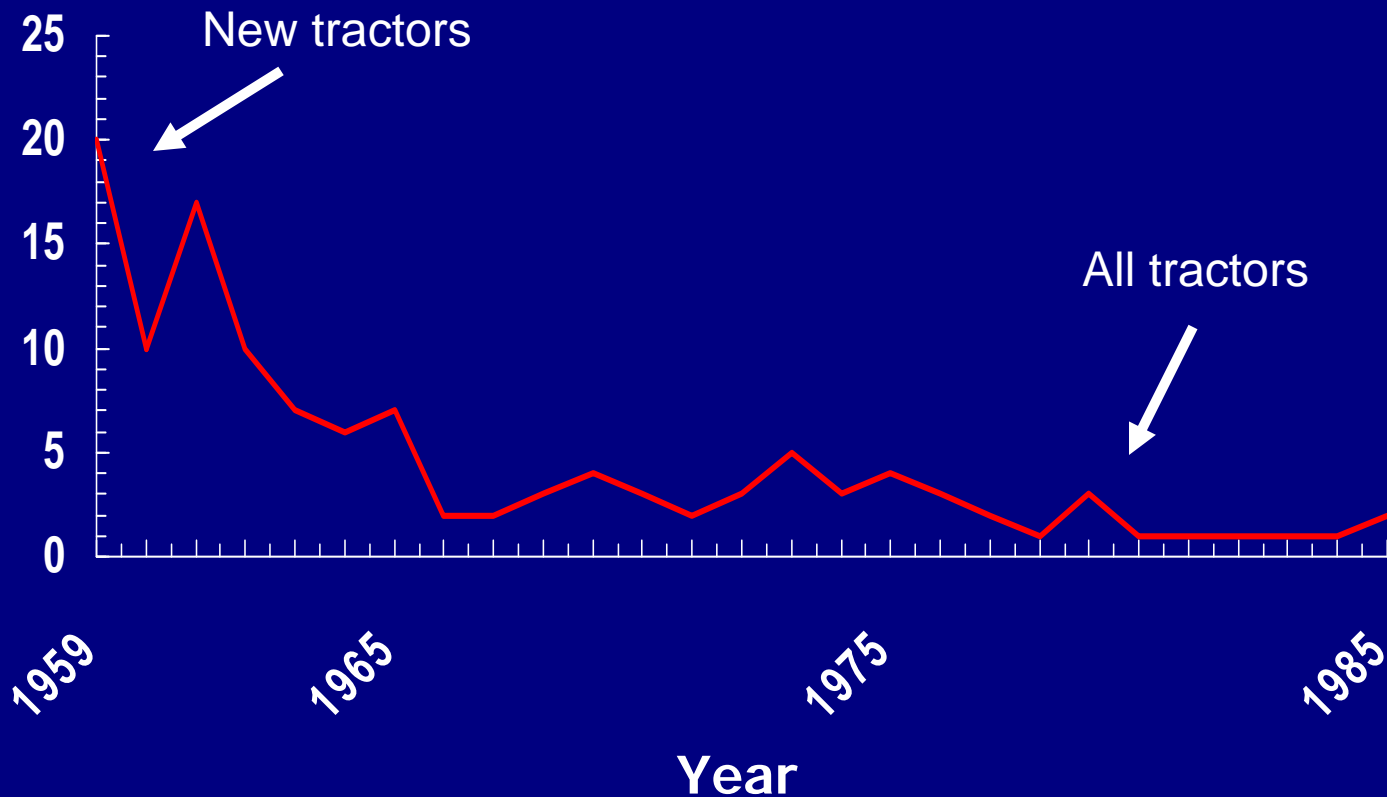
Rollover Protective Structure (ROPS)

- Proven intervention – 99% effective when used w/seat belt
- ROPS prevalent in Europe: overturn deaths reduced to 1-2 per year

Tractor Fatalities In Sweden

Impact of Rollover Protective Cab Structures

Fatalities in Sweden



Tractors and Rollover Protection

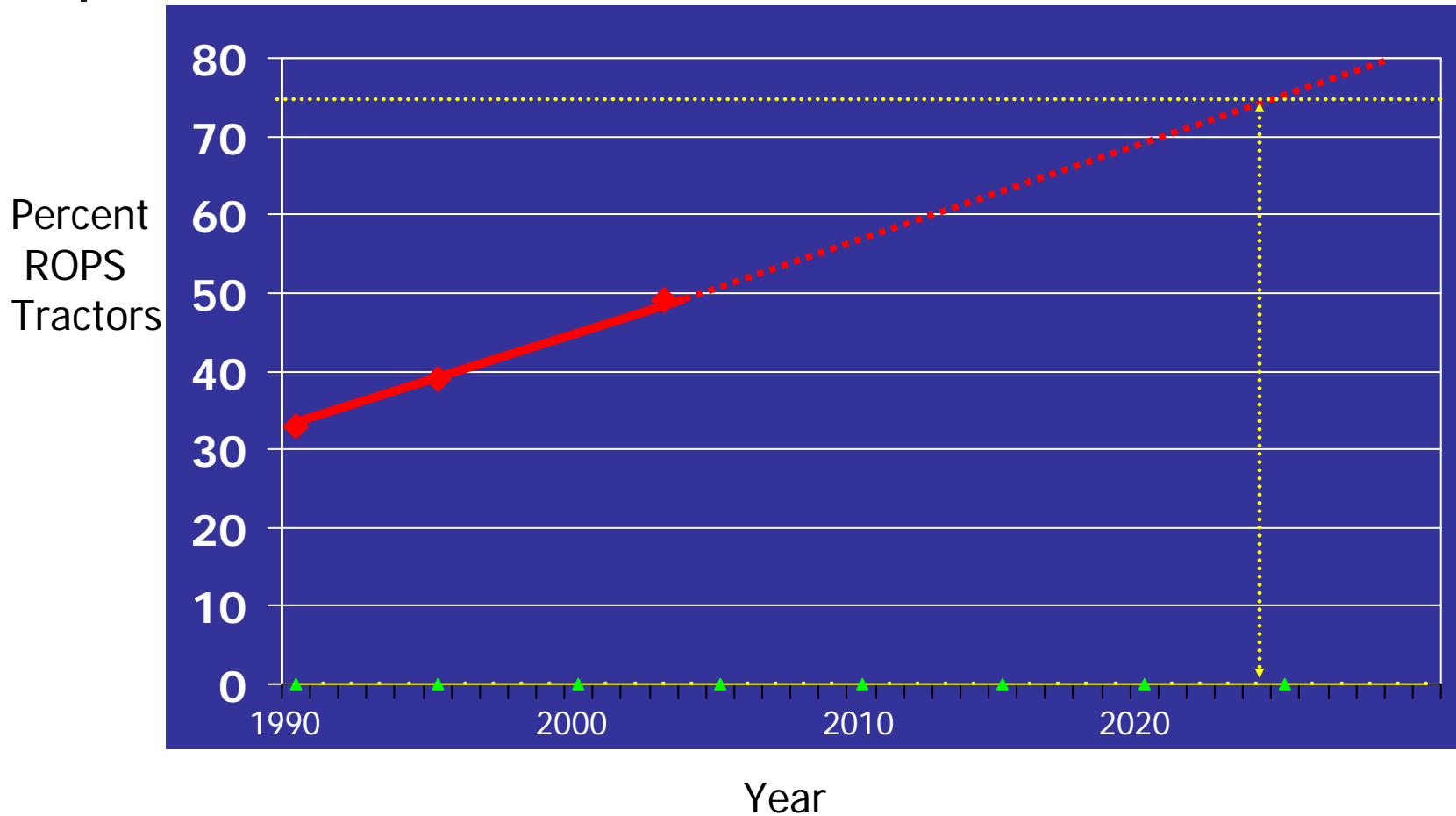
The Situation in the US

Rollover Protective Structure (ROPS)

- ROPS not prevalent in US: 41% (1.7m) of tractors w/o ROPS
- European experience suggest 75% of tractors need ROPS to reduce fatalities near zero
- At current pace will take 13(?) years to reach 75% coverage

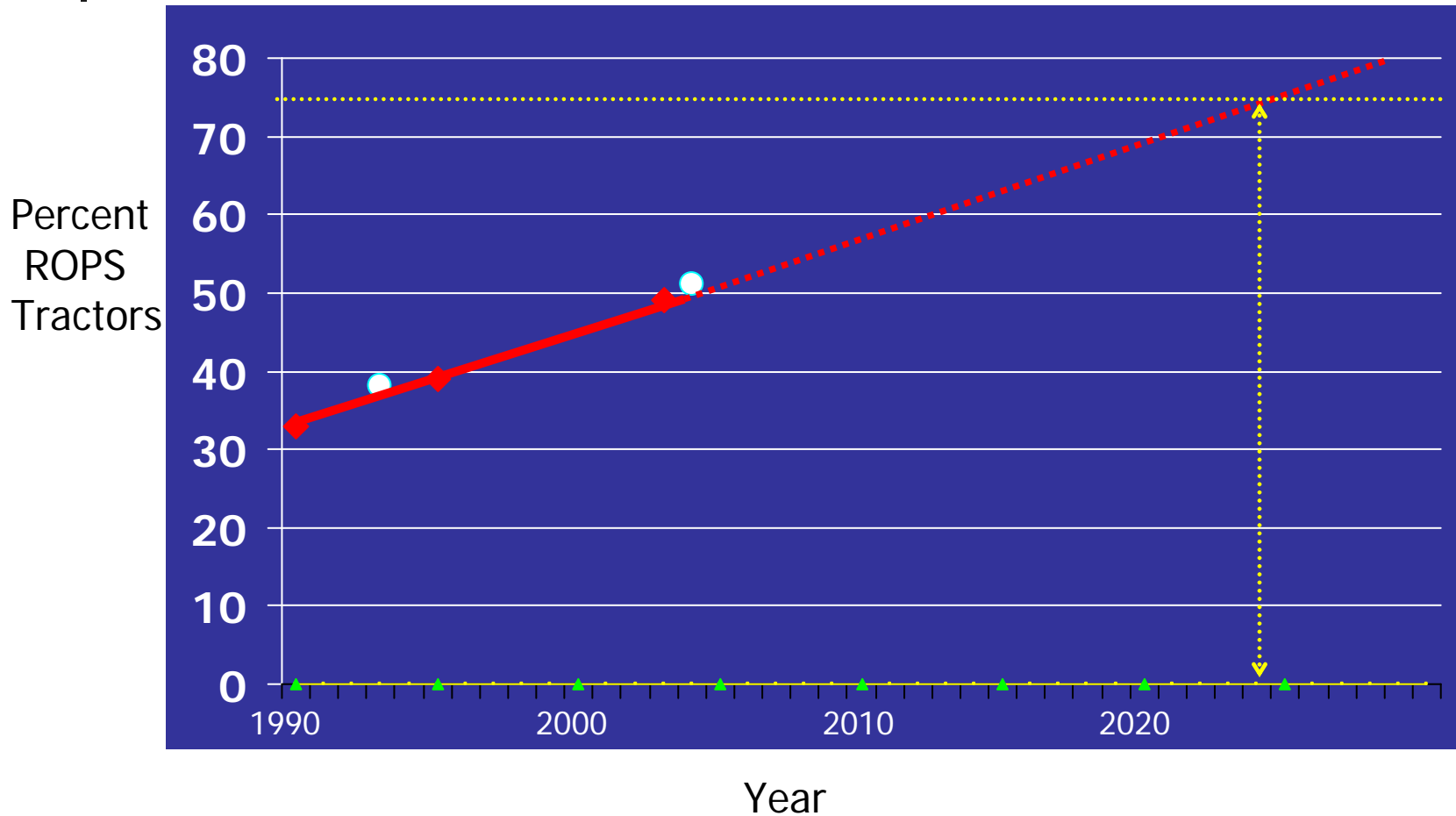
Prevalence of ROPS on NY Tractors

Projection based upon three previous NY surveys



Prevalence of ROPS on NY Tractors

New York and NIOSH Survey Data





Efforts to Promote ROPS Retrofitting

ROPS Sales and Promotions in the US:

- 1966 to the late 1970
- 1985 industry initiative
- Virginia Farm Bureau
- University of Kentucky
- Social Marketing in NY



Efforts to Promote ROPS Retrofitting

Industry Efforts

Farm and Industrial Equipment Institute (FIEI)
aka: "EMI" "Association of Equipment Manufacturers"

"This is one thing we all can agree on"

Case

Deere

Ford

International Harvester

Kubota



Efforts to Promote ROPS Retrofitting

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Virginia Farm Bureau

“the Granddaddy of the incentive programs”

- Funding through VA Farm Bureau Mutual Insurance
- Began 1995 with minor revisions every 3-5 years thereafter
- Total of 306 retrofits - roughly \$60K in incentives
- Incentives of \$150 → \$200 (double for canopy)
- Self-install waiver
- Interest fluctuates with quality of the growing season
- Other state FB programs



Southeast Center for Agricultural Health and Injury Prevention

- Community-based trial of ROPS marketing
 - 2 intervention counties
 - Newspaper, radio, fliers, producer groups
 - Support / fund raising with county organizations
 - Endorsement by community leaders
 - Public raffle for 20 rebate awards \$100 - \$250
 - Considerable interest and increased ROPS retrofits, especially in the second year



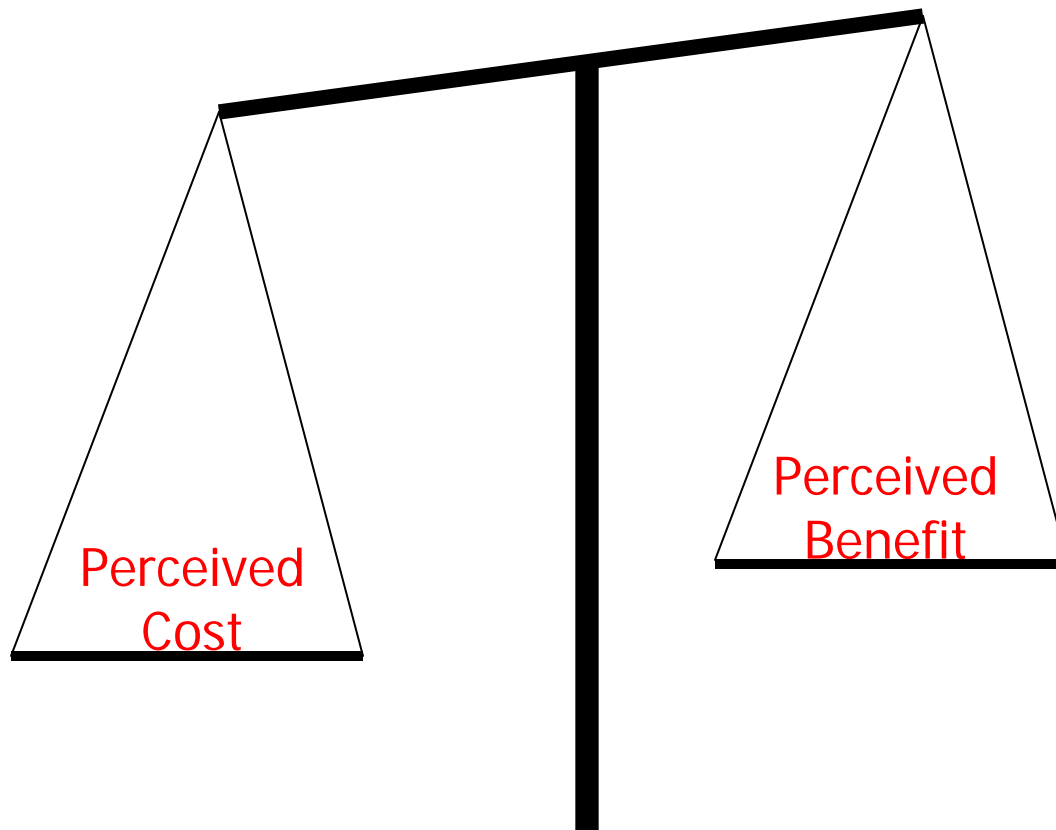
Social Marketing Efforts in NY

“Application of commercial marketing technologies to the analysis, planning, execution and evaluation of programs”

- Not just slick advertisements
- Complete intervention, carefully designed to meet the perceived needs of the target audience
- Impacts and perceptions continually measured

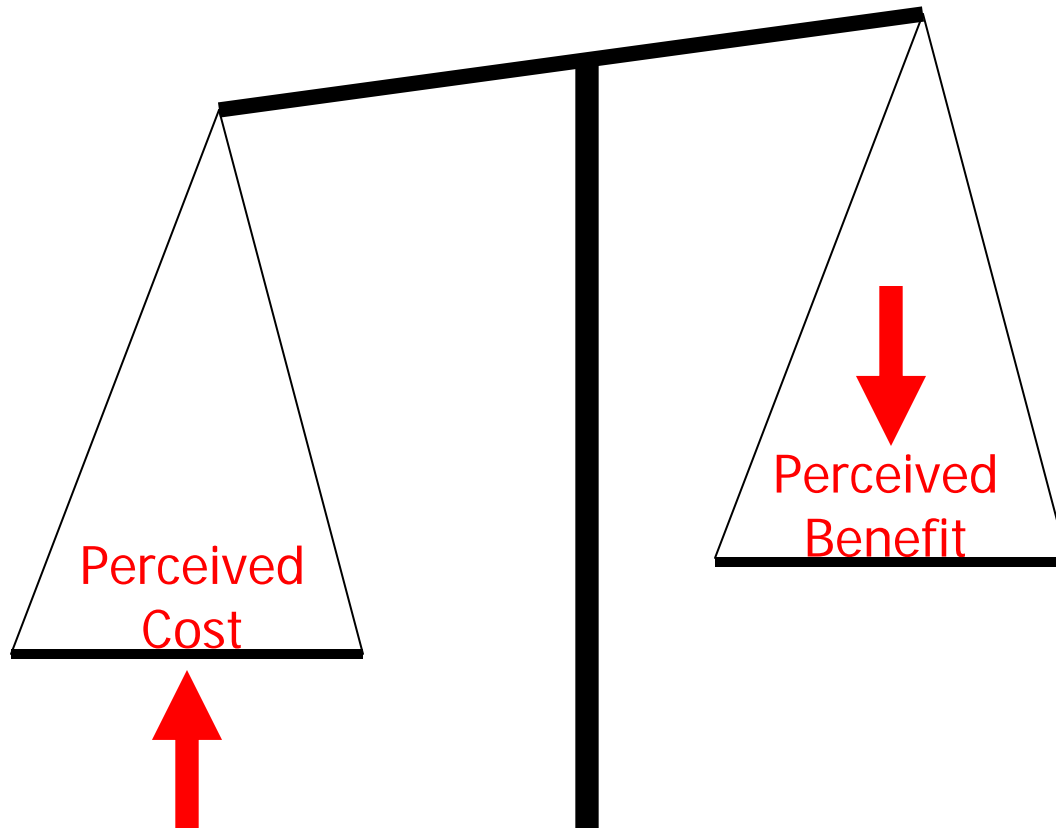


It's about Perceived Cost*



* "Cost" = time, money, effort, aggravation, etc., etc.

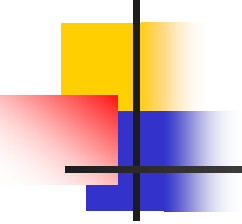
Social Marketing Must Address Perceived Costs and Benefits





Where Does Social Marketing Fit?





New York

Small Crop / Livestock Producers

- Three-fourths of farmers acknowledged value of ROPS; no plans to retrofit tractors
- Barriers: high risk tolerance, personal risk denial, financial concerns, complexity of comparing, selecting, ordering, shipping
- Motivators: concern for family members, hired workers, recognition as a responsible farmer, financial implications of injury



The Intervention in New York

Social marketing intervention:

- Funds obtained from NY legislators
- Rebates of 70% up to \$600 maximum, farmer pays the rest
- Hotline established to reduce hassle factor
- Targeted media messages & appropriate channels



The Impact of Social Marketing in New York

- 12 months: 1,000 calls to hotline, 356 commitments, 268 completed installations and rebates
- 36 months: >700 ROPS installations, 66% self-installed
- Random inspections of self-installations:
 - 34% no problems
 - 57% minor problems
 - Installation guidelines developed



Additional Pertinent Information

Social Marketing

- Current average cost: \$936
- 23% of callers can't be helped
- 2 years: 14 serious injury events prevented
- Cost / benefit analysis: net cost savings in year 3
- Current effort in Vermont and Pennsylvania
- Social marketing: very promising but not the only option for prevention of tractor overturn injury



Tony McKenzie, Ph.D., P.E.

NIOSH - Research Safety Engineer

“The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination of policy.”



Tractors and Rollover Protection in the US

ROPS Engineering: AutoROPS

- Easily adaptable for low clearance situations
- Passive protection – retracted until rollover conditions are detected
- AutoROPS: system with three parts
 - Base (stationary) section containing the latching system
 - Crossbar (deployable) section
 - Electronic deployment control section

Tractors and Rollover Protection in the US

2001: 1st generation AutoROPS

Deployable height
approximately
equal to a
commercially
available ROPS





Tractors and Rollover Protection in the US

1st generation design challenges:

- Reliability of sensors and latching mechanisms
- Material costs
- Ease of resetting with deployment
- Challenges addressed in 2nd through 4th generations by:
 - Eliminating internal hydraulic cylinders
 - Reducing weight
 - Using square tubing (Assimilate to commercial ROPS)
 - Inverting deployable and base sections
 - Transferring the latch and release mechanism to the deployable section

Tractors and Rollover Protection in the US

Current AutoROPS on
zero-turn mower

Currently: ASABE X-599,
*"Standardized Deployment
Performance of an Automatic
Deployable ROPS for
Turf & Landscape Equipment"*





Tractors and Rollover Protection in the US

CROPS (Cost-effective ROPS) – addresses cost issues (shipping, installation)

- Limited weld design with common structural elements and fasteners
- One-person self-installation
- Tested designs for **Ford 8N / MF-135**, Ford 3000, 4000 and Farmall M & H
- Designs meet SAE J2194
- Manufacturing Requirements: bend 1/2 steel plate steel

Tractors and Rollover Protection in the US

Laboratory Testing



Massey Ferguson -135

Field Installation



Ford 4000



Tractors and Rollover Protection in the US

CROPS status

NIOSH Web Site Development (Proposed Fall 2010)

- a) Design Drawings
- b) SAE J2194 Testing Results
 - i. Energy Curves
 - ii. Photos
 - iii. Videos
- c) Installation instructions 2 Types
 - i. Paper
 - ii. Video animations

Public Health Practice Project (3 yrs) Work with NYCAMH
to install CROPS in Pennsylvania and Vermont



Tractors and Rollover Protection in the US

ROPS Engineering

- Existing types: 2-post (solid or fold-down), 4-post, ROPS w/cab
- Performance standard SAE J2194, governed by ASABE
- Slowness of ROPS protection for all tractors has caused researchers to explore other options to increase coverage, including applied engineering
- Three current efforts: AutoROPS & CROPS (NIOSH), and real-time stability feedback monitor (PSU)



Tractors and Rollover Protection

Safety training & education still needed:

- Social marketing and engineering approaches do not prevent overturns—but increased tractor operational knowledge and skills can!
- Education & training needed for: using seat belt, unfolding ROPS, CG & stability baselines, hitching & pulling, new and inexperienced operators, new machines, etc.
- Numerous educational materials exist for safe tractor driving



Tractors and Rollover Protection

Real-time tractor stability/instability feedback monitoring:

- Combines engineering and education to increase tractor operation knowledge and skill
- Operators are not adept at predicting overturn:
 - Cannot reliably interpret all pertinent variables; cannot always react quickly enough; lack training, experience, judgment, etc.
 - Real-time stability/instability status is key missing information

Tractors and Rollover Protection

Stability/Instability Feedback Monitoring

Past research:

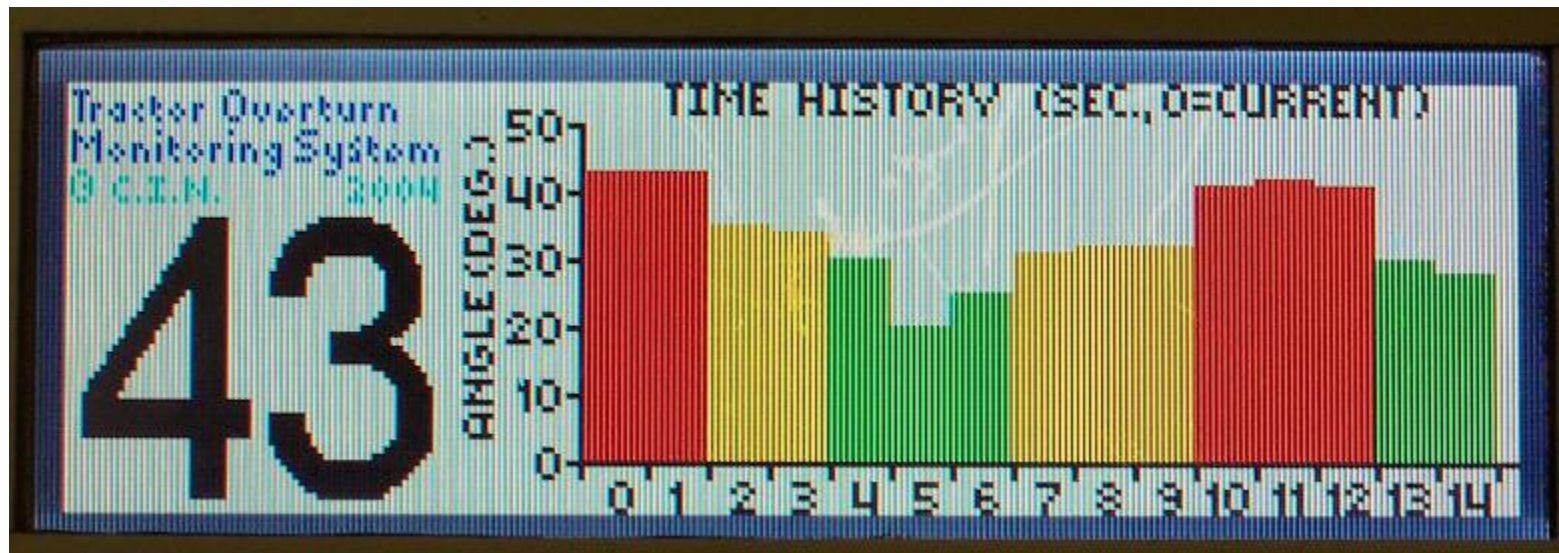
- Successfully monitored tractor stability with inexpensive micro-electromechanical systems (MEMS) sensors, dual-axis accelerometers and roll rate gyros;
- Excellent results in predicting side and rear overturns full-size tractors, with and without an attached implement.



Tractors and Rollover Protection

Stability/Instability Feedback Monitoring

Pitch and roll signals were also combined with a first pass at a color LCD visual display to help inform tractor operators of current and prior stability conditions and alert them of dangerous situations.



Tractors and Rollover Protection

Stability/Instability Feedback Monitoring

Current research: human factors, cognition and psychology for the display unit





Tractors and Rollover Protection

Stability/Instability Feedback Monitoring

Major findings:

- Uncomfortable slope: $12.92^{\circ} \pm .58$
Would Not Drive slope: $19.06^{\circ} \pm .66$
- Participants were less able to accurately estimate angles as slopes became steeper.
- Novice operators were 6.1 times more likely than experienced operators to accurately estimate roll angles, and 96% more likely to properly rank these angles.
- Younger operators were 49% more likely to accurately estimate the angles than older operators.
- The stability indicator influenced angle estimations of novice operators



Tractors and Rollover Protection

Research-to-Practice Recommendations:

- Policy makers...fund research & outreach that:
 - Identifies at-risk populations
 - Facilitates options for retrofitting older tractors
 - Makes newer technologies more available (AutoROPS, CROPS, sensor stability indicators)
 - Provides social marketing toolkits
 - Enhances training and education opportunities