Dear TRB Committees,

Please consider reviewing the following draft TCRP Problem Statement (for June 2010 submission for 2011 TCRP).

Air Bag System to Reduce Railway Pedestrian Fatalities

I. TCRP PROBLEM TITLE

Air Bag System to Reduce Railway Pedestrian Fatalities

II. RESEARCH PROBLEM STATEMENT

In the US in 2006, there were 500 fatal collisions between trains and pedestrians. Of these 500, about 360 were suicides. Psychologically speaking, these are “dramatic” suicides where less-dramatic suicide methods would not be substituted. These fatalities are devastating to families and to rail transit personnel. Rail transit systems experiencing frequent fatalities include: Caltrain, Amtrak Capitol Corridor, Washington DC Metrorail, and others. Rail pedestrian fatalities are also an international problem. The UK Rail Safety and Standards Board estimates the total cost of suicides (trackside and at stations) to the UK rail industry in 2003 was more than 11M GBP at 61,000 GBP cost per suicide. This cost includes delay to trains and lost working time as a result of trauma suffered by staff. Each year the UK experiences about 200 rail suicides. In 2008, there were 2,000 rail suicides in Japan. Germany experiences roughly 936 railway suicides per year. Australia has called for improved crashworthiness of trains.
A front-of-train air bag system shows promise in increasing rail safety. When inflated, the air bag system might be 15 feet long and 7 feet high. The system will be able to safely handle a collision between a pedestrian and a 60 mph locomotive, grabbing and holding the pedestrian until the locomotive comes to a stop. Collision physics calculations have been validated for a constant 20g deceleration. Such an air bag system will necessarily have a more complicated design than current in-vehicle automotive air bags. States a Principal Engineer at TRW Automotive: "I believe that this concept is possible. I believe that it would take quite a bit of development due to the volume of the 'bag' and the volatility of the propellants commonly used in air bag systems. We would need to perform a lot of experimentation but I overall I think it can be developed." In early 2010, the Federal Railroad Administration undertook a small study with somewhat promising results. A crash test dummy was collided with a steel plate with three automotive airbags reducing the damage.

Proposed is a two-phase research study. The first phase covers design and feasibility. The second phase creates an implementation plan.

III. OBJECTIVE

Save a significant portion of the 500 US lives per year lost to railway pedestrian collisions, providing an annual value in lives saved of $1B (based on low $2M value of a human life) and an annual rail operating cost savings of $49.5M (based on UK Rail Safety and Standards Board cost estimates). In Phase I, design the air bag system and validate feasibility. In Phase II, create an implementation plan.

IV. RESEARCH PROPOSED

December 2009 Air Bag System Specification

- Goal: “meet” the pedestrian in front of the train, cushion the impact of a 60 mph locomotive collision, and hold onto the pedestrian until the train safely comes to a stop. Maximum Caltrain commuter rail speed is 79 mph. A fully loaded 100-car freight train doing 79 mph (which is generally the top speed in non-urban areas) takes over a mile to come to a stop; even a relatively light-weight light rail train will take more than 800 feet from 55 mph (the usual top speed for most light rail systems that have the types of non-street-running alignments that allow speeds higher than street speed limits).
- Lower-capacity air bag versions may be adequate, at lower cost, for lower-speed trains, such as light rail vehicles that rarely exceed 55 mph in service to the public and have a lower common range of collision speeds.
- The solution should substantially increase the chances of surviving a head-on collision with a 60 mph railroad locomotive (particularly because there is generally some braking prior to collision). The pedestrian may be standing or laying on the tracks.
- Before a prototype is built, independently-verified collision calculations and "design narrative" should convincingly predict a substantial survival rate increase.
- The solution is not intended to address commuter rail collisions with cars that are stuck on the tracks. There is some possibility that this system could mitigate train-vs.-vehicle collisions to some extent and, if so, there may be some benefits in this regard. It is believed that such systems would be unlikely to increase the severity of train-vs.-vehicle collisions except in freak circumstances. If this system proves valuable in train-vs.-pedestrian collisions, it may be possible to later revisit this with train-vs.-vehicle devices, but this would obviously be more difficult by literally orders of magnitude.
• The first prototype should be testable on a common rail test track. Such prototype testing might also be accomplished on a road by attaching the solution to a truck and then crashing into a crash test dummy.
• If the solution is detachable (there are arguments for permanently attaching the solution to locomotives), the solution must meet the needs of rail operators to rapidly configure trains. IE the solution might need to attach and detach in two minutes or less with a small amount of labor.
• Suggests one rail staff member, "A per-locomotive cost for a safety device of $10,000 might be acceptable for passenger railroads operating over limited distances. A $100,000 cost per locomotive would probably be prohibitive. For freight and long distance passenger operations, the acceptable cost per locomotive would probably be even lower than $10,000."
• The device should not push pedestrians or objects up towards the locomotive’s cab, as that will endanger railway personnel.
• The solution should work in the heavy rail station track "trenches" of systems such as BART and Washington DC Metrorail.
• There are about 25,000 locomotives in the U.S. (Counting for non-locomotives that would have to be so fitted for complete coverage, such as the "cab end" passenger car at the end of a commuter rail train with controls that allows “push-pull” operation). If these bags cost $10,000 each – that’s $250M. Additional costs would include annual maintenance, inspection, and repair, plus replacement over time. If full US deployment cost is believed to be excessive, then the cost-effectiveness and feasibility should be studied for a subset of systems that have higher incident rates.

Phase I: Design and Feasibility
• Beginning with the "December 2009 Air Bag System Specification" above, develop a refined specification encompassing rail operating constraints including operator line-of-sight requirements. Cover requirements for commuter rail, intercity rail (except for grade-separated HSR), freight rail, metro, and faster-than-35 mph light rail. Specify a series of "use cases" based on actual incidents that encompass the posture, size, angle, location, and speed of collisions between pedestrians and locomotives.
• Identify whether advanced air bags are truly the only direction to follow in solving this problem, or are their other technologies worth considering?
• Working with advanced airbag design experts, develop a detailed design. Report on the feasibility and practicality of that design. Report on the expected efficacy under the range of use cases. Report on human factors implications for train operators. Should the air bag be permanently attached to locomotives or should the device be a standalone device capable of being attached and removed rapidly? Should the device be pre-inflated or should it inflate “just in time?”
• Hold a design review workshop with outside experts, where the detailed design is critically analyzed.
• Coordinate work with the Australian rail safety effort to reduce damage from locomotive collisions. Identify any other compatible international efforts to liaise with, such as the UK Rail Safety and Standards Board (RSSB), German Railways Deutsche Bahn, European Railway Agency, and Japanese rail interests.
• A talented, multi-disciplinary oversight panel with a mix of rail operations and collision expertise will aid the research. The research team should regularly report in to the oversight panel so that the panel can ensure the research activities meet the complicated needs and stay grounded in practicality.
Rail suicides in Palo Alto, CA were prominent in the national news in 2009. The City of Palo Alto has offered a small amount of staff time to project if desired, to give input to the research based on experience with Caltrain suicides.

Phase II: if Phase I provides a feasible, practical design, then develop an implementation plan:

- Analyze implementation insurance and product liability considerations. Is new liability-limiting legislation required to enable implementation?
- Rank US rail systems (commuter rail, freight rail, metro, faster-than-35 mph light rail) in terms of cost-effectiveness of implementation, i.e., the more expected lives saved per locomotive, the more cost-effective. Is it fair to assume that an air bag safety solution is not required for slower forms of rail transit such as streetcar, and slower-than-35 mph light rail? (Opines Jerry Roane: “The data I have heard indicates that 35 mph light rail is even more important than regular freight trains for pedestrian deaths. I also feel it is important that the cost be low enough to get the final solution attached to all trains that have long stopping distances.”) Is it fair to assume that grade-separated systems (HSR, PRT, APM) do not require this solution? As of 2006, there were 19 US commuter rail systems. Explain the ramifications for Push/Pull rail service (where a single locomotive on one end of a train pushes and pulls the passenger cars) versus Multiple Unit trains (where every car is powered and has the capability of leading a train).
- Develop a prototyping and implementation plan, with expected costs and a roll-out timeline.
- Some Japanese rail companies charge surviving family members of rail suicide victims for cleanup and other costs. In addition, the development of a very safe rail air bag could motivate thrill seekers to seek out rail collisions. Should intentional collisions result in a financial penalty? If so, should supporting legislation be developed? Is it a crime to intentionally cause the deployment of a rail air bag?
- Develop a narrative about historical inertia of safety regimes for different transit technologies. New transit technologies such as HSR, APMs, and PRT are held to a new safety standard. With older transit technologies, frequent fatalities are an accepted part of the paradigm.
- Explain how Phase I and II research fits with TCRP 137 "Improving Pedestrian and Motorist Safety Along LRT Alignments" and TCRP A-32 "Operation of LRT through Ungated Crossings at Speeds over 35 MPH."

V. ESTIMATE OF THE PROBLEM FUNDING AND RESEARCH PERIOD

Recommended Funding:
Phase I (12 months): $300,000
Phase II (12 months): $150,000

VI. URGENCY AND PAYOFF POTENTIAL

Quantified payoff from achieving project objectives:
Save 500 US lives per year lost to railway pedestrian collisions, providing an annual value in lives saved of $1B (based on $2M value of a human life) and an annual rail operating cost savings of $49.5M (based on UK Rail Safety and Standards Board cost estimates).

VII. RELATIONSHIP TO FTA STRATEGIC GOALS AND POLICY INITIATIVES and TCRP STRATEGIC PRIORITIES
Per the Jan 7, 2009 TCRP memo from Christopher Jenks:

- Supports FTA strategic research goal #2, specifically because “FTA strives to make SAFE public transportation available to all Americans.”
  - “What new knowledge, technology and practical solutions can help transit agencies increase SAFETY?”
  - “How can we improve the SAFETY of transit workers?”
- Supports TCRP’s strategic priorities:
  - II. The proposed air bag system uses “state-of-the-art technology”
  - III. The proposed system “improves public transportation.”
  - V. By reducing cost, the proposed system allows transit organizations to “Work Better – Cost Less.”

VIII. FEDERAL RAILROAD ADMINISTRATION 2010 RESEARCH

Federal Railroad Administration’s R&D Division undertook a small simulation study in early 2010. The results were somewhat encouraging:

Sent: Wednesday, March 31, 2010 1:44 PM
Subject: FRA “Quick Look” at Pedestrian Airbags

FRA’s R&D division commissioned a small simulation study of collisions of a moving plate (used to represent the front of a locomotive) and a standing anthropomorphic test device (dummy) to look for a potential effect of airbags on pedestrian safety. To keep the simulation simple, a vertical stack of three automotive airbags was used. They were mounted on a flat plate with none of the complexities of the front of an actual locomotive such as couplers and safety appliances (which are necessary, but which could defeat the effectiveness of an airbag system.) The simulations represented only a narrow sliver of time surrounding the impact and indicated that the dummy would be thrown in front of the locomotive, but did not follow it to its final resting place, nor simulate the effects of it hitting the ground or being impacted a second time and perhaps being dragged by the locomotive.

From this study it was noted that:

- Airbag deployed between plate (locomotive) and dummy can potentially offer a significant reduction in peak accelerations of dummy’s head/chest/pelvic
- Airbag more effective at the lower impact speeds (20-30 mph)
- In the simulation, a steel plate traveling at a constant speed was used to represent locomotive. Therefore, simulated results only qualitatively show the difference between cases with and without using airbags
- Airbags chosen here are commonly used in automotive applications. Special airbag should be designed for future applications, such as airbag size, shape, inflation rate and locations

No follow-up is planned at this time.

C. B., FRA Motive Power and Equipment Staff

VIII. RELATED RESEARCH
• Investigation of an air bag device to reduce railway pedestrian suicides, including input from air bag experts, transit engineers, psychologists, Federal Railway Administration, and light/commuter rail operators. [http://www.cities21.org/cow_catcher.htm](http://www.cities21.org/cow_catcher.htm).

• US Patent #6106038: "System for Collision Damage Reduction:" [http://www.google.com/patents/about?id=SCoDAAAEBAJ&dq=6106038](http://www.google.com/patents/about?id=SCoDAAAEBAJ&dq=6106038). The inventor believes that his 5-foot-long, front-facing exterior air bag system allows a driver to survive a 45-mph collision between the driver’s 3,000 lb car and an immovable wall. The inventor's patent document hints at a longer air bag system with higher crash capability. The inventor envisioned his invention being applied to trains and buses, as well as cars. The inventor appears to have considered and addressed many design challenges. A special, extra-strong air bag fabric is used. The venting system is clever: the “collidant’s” velocity drops off exponentially with each additional foot of air bag compression. To ensure that the air bag doesn’t pop, blowout patches relieve the pressure. An inside-the-vehicle air bag fills and deflates rapidly. The inventor’s external air bag stays inflated until the collision occurs. A radar or sonar sensing system is used to detect an imminent collision and initiate inflation of the air bag. The inventor creates downward pressure to keep the air bag from hinging upward. A system of air bag compartments is used.

• TCRP Report 137 "Improving Pedestrian and Motorist Safety Along Light Rail Transit Alignments," available Feb 2010. The report addresses pedestrian and motorist behaviors contributing to light rail transit (LRT) safety and describes mitigating measures available to improve safety along LRT alignments.

• TCRP A-32 "Operation of Light Rail Transit through Ungated Crossings at Speeds over 35 MPH," is an active research project scheduled for completion in 2011. One portion of the work scope is: "Identify potential supplemental safety measures for use with traffic signals in lieu of highway-light rail grade crossing flashing lights and gates where LRVs could operate at speeds in excess of 35 mph in a semi-exclusive public right-of-way."

• TCRP A-35 "Defining and Implementing a Transit Safety Culture" is scheduled to start in 2010.


• Road Safety Committee Inquiry into Improving Safety at Level Crossings, December 2008, Parliament of Victoria, Australia, pg 119. "Improving crashworthiness of trains: Change to the design of trains could provide protection for train crew and passengers, as well as road users, against injury or loss of life in the event of a crash. These types of technologies, or design changes have a similar purpose to passive technologies found in vehicles, such as seatbelts, air bags, and the vehicle crumple zone which compress and absorb energy in a crash. In submissions to the Inquiry, Dr Wigglesworth and DVEExperts International suggested that research be undertaken into energy attenuating systems, such as air bags on the front of locomotives to reduce the severity of a crash."

IX. PERSONS DEVELOPING THE PROBLEM

• Steve Raney, Principal, ULTra PRT North America, Palo Alto, CA, [http://www.ultraprtnet](http://www.ultraprtnet); Transportation Research Board Committee Member: AP020 and AP040; Executive Director, Cities21. E-mail: cities21 at cities21 dot oh arr gee.

• Thomas A. Rubin, Oakland, CA, [http://reason.org/authors/show/thomas-a-rubin](http://reason.org/authors/show/thomas-a-rubin)
• Walter Brewer, Lockport NY. A retired Vice President of a concepts and management center supporting military missile and space programs in Southern CA.
• Jerry Roane, CEO, Roane Inventions Incorporated, Georgetown, TX. Designer, high speed Tri-Track dual mode PRT.
• David Maymudes, formerly: Software Developer, Taxi2000 (PRT), Seattle, WA, currently working for Google.

X. PROCESS USED TO DEVELOP PROBLEM STATEMENT

Steve Raney led development of this problem statement using a collaborative investigative process, utilizing web-based research and advice/brainstorming from experts.

XI. DATE AND SUBMITTED BY

Re-state the persons in Section IX above.
Provide date of submission.

Submit to: tcrp@nas.edu
Christopher W. Jenks
Director
Cooperative Research Programs
Transportation Research Board
500 Fifth Street., N.W.
Washington, D.C. 20001
202/334-3089
December 18, 2009

Dear Mr. Raney,

This is a letter to express the City of Palo Alto’s support in concept of your submittal of a Federal Research Proposal for Transit Cooperative Research Program (TCRP) regarding a Shock-absorbing Air Bag System to Reduce Railway Pedestrian Fatalities (information available at http://www.cities21.org/cow_catcher.htm).

According to your research, there were 500 fatal collisions between trains and pedestrians in the US in 2006. These fatalities are devastating to families, schools and communities as well as to rail transit personnel. Your concept of a front-of-train air bag system shows promise.

There is an active commuter/freight railway that passes through Palo Alto and carries numerous speeding trains each day along a route close to homes, businesses and schools. The City of Palo Alto is in support of any effort to improve pedestrian and vehicle safety along railroad corridors and right of ways.

Sincerely,

Steve Emslie  
Deputy City Manager  
City of Palo Alto  
(650) 329-2354