

ADVANCED GUIDEWAY SYSTEM (AGS) FEASIBILITY STUDY

HIGH-SPEED TRANSIT TECHNOLOGY FORUM

December 13, 2012 – Golden, CO



About the Technology Forum

The Technology Forum is designed to provide stakeholders with an opportunity to learn more about a range of technologies that have qualified for the Colorado Department of Transportation's (CDOT) Advanced Guideway System (AGS) Feasibility Study. Technology providers from around the world have elected to participate in the study by providing detailed performance and operational information. Participating technology providers that met six preliminary criteria (travel time, grade, safety, weather/wind, light freight and ability to be operational by 2017) have been invited to participate in the Technology Forum.

Qualified Technology Providers (alphabetical order)

- American Maglev Technology
- Flight Rail
- General Atomics/Colorado Maglev Group
- MegaRail
- Owen Transit Group*
- PPRTC
- SkyTran
- Swift Tram
- Talgo
- Transrapid*

Each technology provider was asked to submit a paragraph describing their technology. They are provided in the following pages of this packet. Please note that the paragraphs were provided directly by each technology provider and do not reflect the opinions of CDOT.

**Note: Owen Transit Group and Transrapid met the six preliminary criteria but have elected not to participate in the Technology Exhibition.*

About CDOT's AGS Feasibility Study

The Colorado Department of Transportation's Division of Transit and Rail is conducting the Advanced Guideway System (AGS) Feasibility Study to determine the feasibility of a high-speed transit system in Colorado's I-70 Mountain Corridor. The \$1.8 million study began in April 2012 and is expected to be completed in Fall 2013. TYP SA|AZTEC and Jacobs Engineering are the lead consultants for the study that will evaluate technology, alignment and funding/financing options for a potential AGS in the 120-mile corridor from C-470 in Jefferson County to Eagle County Regional Airport. This study is a critical next step identified in the Record of Decision for the I-70 Mountain Corridor Programmatic Environmental Impact Statement.

American Maglev Transit (Booth 1)



With a strong focus on sustainability, AMT's transit technology is based on optimized magnetic levitation and linear induction propulsion that is entirely electric and non-polluting. This technology is well suited for Colorado, as it is designed to traverse steep grades of up to 10% and is extraordinarily compatible with wintry climate conditions since the traction is frictionless and is inherently not affected by moderate levels of ice or snow. Daily passenger demands will be accommodated with vehicles that will

comfortably carry approximately 200 passengers as well as their luggage and recreational equipment, while offering an excellent level of service with wireless internet and restroom facilities. Traveling by AMT technology will reduce trip times between DIA and Vail; the trains will operate faster than a car with no traffic atop a grade-separate, dedicated guideway within the I-70 corridor -- no additional rights-of-way are needed. The technology is fully automated and requires little maintenance, therefore featuring very low capital and operating costs that can be recovered by reasonable transit fares and revenues. AMT technology is fully compliant with the US FTA Automated Peoplemover Code and all applicable regional standards as well. Since its inception in 1994, AMT has invested millions of dollars in research and development of its advanced zero-emitting, next-generation transportation technology, which has attracted world-class strategic partners and significant corporate investment. In April 2010, AMT signed a 10-year exclusive partnership with Grupo ACS for joint development of transportation projects worldwide. In August 2012, the team contracted with Lockheed-Martin to add tremendous value in manufacturing and technical expertise to the team. Rather than simply provide rail technology components, AMT, ACS and Lockheed-Martin specialize in the broad capability to design, finance, build, operate and maintain transportation systems over a project lifetime. Most importantly, the team has the ability to bring private financing packages and create sustainable Public-Private-Partnerships that create transformative change in the development and management of transportation infrastructure.



Flight Rail (Booth 2)



The VECTORR™ is a high-speed, light weight atmospheric transportation system that uses vacuum/air pressure to move passenger modules along an elevated guideway. Stationary power systems create vacuum/pressure inside a continuous pneumatic tube located centrally below rails within a truss assembly. As these power systems pull the air from the tube, they create a vacuum in front of a free piston that is rail guided inside the power tube. The free piston is magnetically coupled to the passenger modules above. Additionally, air enters the tube behind the free piston to create a differential pressure. The magnetic coupling allows the interior of the power tube to be a closed system to maintain the desired pressure differential in the tube. The transportation unit operates above the power tube on a pair of parallel, steel rails which receive, support, and guides the wheels of the truck assemblies. The passenger modules feature independent wheels angled at 45° that are locked onto the rails. This wheel configuration allows the system to operate in severe weather conditions. Since traction conditions are not required, the guideway can be lubricated for reduction of friction and noise abatement. Flight Rail Corp. currently has a 1/6 scale pilot model operating on an outdoor test guideway. The guideway is 1500 feet long and incorporates 2%, 6%, and 10% grades. The pilot model

operates at speeds up to 25 m.p.h. which equates to a scale speed of 150 m.p.h. Preparations are being made to extend the guideway an additional 700 feet to include a 180° curve with a 48 foot radius. This equates to a full size train operating on a 288 foot radius or 20° curve (at restricted speeds). The foregoing characteristics would fit well with the requirements of the I-70 Corridor. The power tube and supporting structure are very adaptable to enabling ice and snow removal and also serve as a power distribution platform related to power requirements between major power stations.

General Atomics/Colorado Maglev Group (Booth 3)



More than 30 firms and financial institutions, in close concert with the Federal Transit Administration (FTA), have collaboratively developed the technology we are proposing for installation along the I-70 mountain corridor. The Colorado MAGLEV Group is prepared to commence immediately to finance, design, build, operate, maintain and own or lease an advanced guideway transportation system that serves the

needs of corridor communities. Research that shaped this technology started in 1990 and more than \$40 million from, private, federal, and state coffers have been spent during its development. We believe it to be the most advanced, American designed MAGLEV technology currently available for transporting freight and passengers. The \$14 million test track constructed by our team at the General Atomics campus in La Jolla, California, has demonstrated that the following performance characteristics would serve the unique service demands of the I-70 corridor: (1) no right-of-way purchases would be required as the technology can be placed entirely within the existing I-70 envelope, (2) the system can be deployed on an elevated structure supported by 30 to 60 foot columns holding 80 to 100 foot double track guideway platforms (22 ft. in width) that can be produced locally and placed with light cranes deployed from completed sections, (3) capital costs of the guideway are only a third those of light rail or rubber tired alternatives, (4) operating and maintenance costs will be a fourth those of rail systems, (5) environmental impacts (esp., noise and emissions) are minimal as the MAGLEV technology is friction free and relies on a linear synchronous motor for propulsion which is embedded in the guideway, (6) the system should operate reliably (99+%) in all but the most extreme weather conditions and command grades of as much as 15% without a degradation in speed or performance, (7) the esthetics of columns and structures supporting the vehicles, including stations, can conform with community preferences, (8) speeds of 150 mph are possible with headways of as little as 20 seconds between consorts, (9) 100 passenger cars in four car trains would be standard, and (10) it has been demonstrated that this technology will carry standard truck containers using the existing guideway configuration. Levitated with Halbach permanent magnet arrays installed in the guideway, control systems are greatly simplified and largely limited to providing appropriate electrical inputs to the linear synchronous motor.

MegaRail (Booth 4)



High-speed **MegaWay** systems provide electrified, all-elevated, maintenance-free stainless steel **SuperWays**™ and a family of electrically powered, rubber-tire vehicles that operate in a similar manner to that of road vehicles on standard freeways. It is a multi-purpose system capable of transporting passengers, people in their own, standard cars, and both light and heavy cargo intermixed on the same **SuperWay**. It offers a high-speed, low-cost, electrically powered, low air pollution, *all-weather* alternate to cars and trucks on roads with traffic capacity equivalent to that of a six-lane

freeway. Passengers ride seated in comfortable cabins or in their own standard cars. Light and heavy cargo is carried in enclosed, weatherproof containers fully compatible with standard flatbed and box trucks. Factory-built **SuperWays** include enclosed wheelways that contain traction surfaces, wheels, power pickups, power and steering rails, position references, digital communication links and failure-tolerant guideway control systems. The unique wheelways protect all functional items from weather. Full operation is possible in

all weather including 150-mph winds. The exact 600-vdc power used by vehicles is generated by small, natural gas powered generators on **SuperWay** support columns. Welded, stainless steel gas supply lines are supported below the **SuperWay**. Standard grid power lines or substations are not required.

PPRTC (Booth 5)



The PPRTC template for urban efficiency starts with a Personal Rapid Transit (PRT) system, or pod-cars on a fixed guideway that deliver 1 to 4 passengers at-a-time or freight container(s). The vehicles use an air lifting mechanism integrated with magnetic induction propulsion. The cushion of air generated underneath the pod-car takes the place of maintenance-intensive wheels effectively eliminating friction; sequential application of electromagnets between the guideway and vehicle accelerate, brake and stop the vehicle. The elevated guideway, which preserves grade level spaces, also serves as the conduit of system power and telecommunications. Housing the power and fiber-optic communications components inside the PRT's carbon-fiber pylons and guideway makes them impervious to extreme weather or other attack both physical and virtual. The generation of system power occurs onsite at each PRT station using Hydrogen Fuel Cells (HFCs) initially fed by natural gas, eventually migrating to a diversity of renewable sources of Hydrogen. With a Microgrid Power Management (MPM) scheme, real-time data and keen predictive formulae are used to control generation with surgical precision. HFC generation and MPM together make it possible to achieve a zero carbon footprint while having zero impact on the grid. PRT is the ideal choice for an I-70 AGS because whether at high or low velocity, a trip experience is "Rapid" due to never waiting for transit per schedule and never stopping en route, that is, point-to-point and on-demand. These two features, intrinsic to the PRT model, plus the fact that it is a driverless medium (50-75% of the cost of transit), make it significantly more efficient than conventional modes saving time, energy and money for the operator and the rider. Moreover, untold efficiencies are to be had in the building and maintaining of 1 construct versus 3 with a deployment schedule measured in months versus the years that traditional solutions take. Finally, by generating multiple revenue streams from the various components of the template the operation can achieve economic sustainability.

SkyTran (Booth 6)

SkyTran is an Automated Transit Network (ATN) technology that provides on-demand, point-to-point, non-stop service. These characteristics boost ridership by providing a level of performance, convenience and comfort that meets or exceeds an automobile ride. SkyTran uses a fleet of two-passenger automated electric vehicles (AEV) that travel on a network of slim, elevated guideways. The AEV uses a breakthrough maglev-linear motor powertrain that delivers high-speeds (100 mph), high reliability (no wheels to fail) and a comfortable ride (seats wider than a first-class airline seat). SkyTran technology is designed for building scalable networks. This capability is ideal for the AGS as SkyTran can provide direct feeder service to mountain communities by making a no-transfer connection to the main I-70 alignment. SkyTran's vision is to deliver the ultimate customer experience: a one seat ride from Denver International Airport to the ski resort of your choice.

Swift Tram (Booth 7)



Swift Tram is in business to manufacture a new rapid transit system based on the century-old concept of the hanging train. Swift Tram is a people-mover and freight-mover that's electrically powered and elevated. It's a fully automated fixed guideway transportation system featuring coaches in two sizes suspended from the guideway by a hinge. Drive bogies traveling inside the guideway at speeds that can exceed 100 miles per hour provide 'swarm computing' intelligence, system diagnostics, and routine system maintenance. System operation will be available on both a scheduled and an on-demand 24/7 basis. Swift Tram is a Boulder Colorado-based startup in design and engineering stage, currently applying for patents on 12 technology patents for the system. Swift is successfully addressing the issues of grid power outage and emergency & ADA passenger evacuation. This right-sized, light-footprint system is considerably less expensive to install than light rail, and is considerably less expensive to

operate than BRT. The company is creating the safest, cleanest, most cost-effective, and most energy efficient rapid transit system in the world.

Talgo (Booth 8)



Talgo offers a unique combination of innovation and proven technology that assures a high degree of satisfaction among all concerned, passengers, owners and operators. Furthermore, the equipment Talgo will propose will be fully compliant with US DOT, Federal Railroad Administration regulations and fully* compatible with the US railway network, eliminating regulatory uncertainty while providing unexcelled flexibility for years to come. Talgo's "independent wheels" and "natural tilting" system will reduce wheel wear and permit faster speeds within the I-70 right-of-way than will be possible with conventional railroad equipment, yet the technology used to produce this result has proven itself over nearly three decades' of

continuous service. Propulsion energy will come from the commercial electric grid and be applied to the rail using frame hung traction motors and conventional adhesion. (We are not proposing a cog railway). While this arrangement will mean the route will need to divert from the I-70 alignment at some places, the same will true of every other technology other than "bus rapid transit" because none can share the existing E-J Memorial Tunnel bores. Regenerative braking will be used to minimize the net power requirement, likely producing the most energy efficient form of transportation that will be offered.

Owen Transit Group *(Not attending the Technology Forum)*

OTG offers both high-capacity transit and high speed rail systems, using individual passenger vehicles running quietly in two directions on opposite sides of a single elevated concrete monorail beam, high curving I-70 corridor. They have very high horsepower VFD electric motors for ascending mountain grades while using multiple brake systems above the snows and traffic. The systems require no changes to existing roadways, and use tilting cabin design for operating within the for descending mountain grades, returning power to the electrical grid. Rails are steel, heated to remove ice and snow. Construction costs per mile are low, as are the operating costs for the automated systems, allowing them to be self-sustaining with competitive fares. Although they have not yet been built as systems, the technology is proven because it uses proven-in-service off-the-shelf components.

Transrapid *(Not attending the Technology Forum)*

Flying on the ground....Quiet, comfortable, fast, safe, clean, reliable - one of the most modern high-speed Transportation Systems in the world. Developed over the last 30 years in Germany, the Transrapid high-speed Maglev system consists of the electromagnetic levitation, the guidance and the propulsion system. Support magnets lift the vehicle up to the guideway, while guidance magnets

located on both sides of the vehicle keep the vehicle lateral to the track. The synchronous long-stator motor acts as both, the drive and the braking system. The drive, consisting of stator packs with a three-phase traveling field coil is built into the guideway rather than into the vehicle. Here electricity produces an electromagnetic travelling field which either pulls the magnetic levitation train forward or slows it gently down. The train speed is continuously variable and controlled via the frequency of the alternating current. Since the electromagnetic traveling field determines the direction of movement, it is impossible for two vehicles to move towards each other. Derailments are not possible since the vehicles 'wrap around' the guideway and are therefore firmly fixed to the guideway. Transrapid today is well proven and in day-in-day-out revenue operation in Shanghai China. Since the Pudong International Airport Connector went into operation in 2004 it has travelled more than 6.5 million miles and 32 plus million people have taken the 19 mile ride between the Airport and Shanghai, operating seven days per week at a punctuality of 99.9 %. Further developed today with emphasis on system capital cost reduction and even lower electric energy consumption per seat and mile traveled, makes Transrapid a premier choice for the Colorado AGS Project. Transrapid is capable to overcome the stringent grade differentials, is able to maneuver the tight curves in the I-70 corridor ROW and can meet the challenges of the Colorado weather. Transrapid is proven and ready to be deployed. Safety certifications have been granted in Germany and in China. In a 'Memorandum of Understanding' the German Government and the FRA have addressed a cooperation to jointly develop the 'Rules of particular Applicability' in order to arrive at the safety certification for a U.S. Transrapid Maglev System. It is the intent of Transrapid to engage in a 'Technology Transfer' with qualified American companies to manufacture the system components in the U.S. rather than to import. This approach could foster the formation of a U.S. high-speed passenger transportation industry, started and based in Colorado.