EXECUTIVE SUMMARY

Since our inception in 1990, Duos Technologies, Inc. (duostech) has provided a broad variety of sophisticated, technology-based applications to a growing range of clientele. Our primary focus is providing solutions for rail centric critical infrastructure systems.

We specialize in automated systems with an emphasis on intelligent digital video and integrated smart Command and Control centers that combine both new and existing equipment and a broad range of smart sensor systems. We also offer expertise in instrumentation and control technologies, information technology, and engineering services. Via the convergence of these disciplines, duostech provides customized integrated systems for business and government requirements, with a focus on critical Homeland Security applications.

Our combined team expertise includes subject matter experts (with years of practical experience) in the diverse fields of mechanical, electrical, chemical, industrial, electronic, and computer engineering, IT, procurement, project management, and construction management. We start with a customer’s rough concept or requirement, and leverage our unique synergy to define, create, enable, and implement a solution to meet those requirements. Our organizational structure and company culture encourage our team members to respond and interact innovatively and proactively to the needs of our customers.

We typically respond best to the challenge when engaged to design, build, and deliver comprehensive turnkey solutions. Should you invite us to develop a challenging, cutting-edge application, we will reward you with an efficient, seamless, specific state-of-the-art solution, and at a reasonable cost. In most cases, duostech will commit to a fixed price for a complete turnkey system.

When asked to integrate complex systems into existing infrastructure, we take the responsibility of interacting with your engineering and IT departments. We recognize—and are sensitive to—system security issues (after all, that’s our business) and unless specifically asked not to, we always include appropriate system protection of your physical and electronic assets.

Most companies drive you toward their cookie-cutter, “one size fits all” solutions – this is the Duos “point of difference.” duostech has a richness of expertise, experience, partnerships, and resources to provide “one-stop-shop” solutions that specifically meet your needs.

Usually, our customers also engage us to provide 24/7/365 full service maintenance. Our proprietary system-wide monitoring applications include algorithms that detect any anomaly to any equipment deployed within a deployed system. Our help desk will be automatically alerted of component failures or degradation of equipment performance and, in most cases, is able to remedy issues remotely within minutes.
**duostech** - The Leader in Rail Security Systems

Since 2002 our designs and systems have been used as a model for many different aspects of freight rail security. Under a congressional budget earmark, our company deployed the first “virtual security fence” technology which applies our video-analytics based systems to a 7-mile rail track through Washington D.C. In 2009, **duostech** was asked to provide guidance and information to the Department of Homeland Security (DHS), Transportation Security Administration (TSA) and Rail Protection Advisory Group specifically to harden rail assets designated as critical infrastructure assets, such as:

- Rail Bridges
- Rail Tunnels
- Secure Rail Corridors
- Diesel Fuel Storage Farms
- TIH Storage
- Rail Yards
- Border Crossings

**duostech** currently offers a variety of products and engineered solutions tailored for the Rail industry. Some of our primary products and solutions used by our rail clients include:

- rip™ – Rail Inspection Portal
- centraco™ – Command & Control Platform
- praeidium® – Video Analytics Software & Alarm Management

**TECHNOLOGY PORTFOLIO**

**rip™ Rail Inspection Portal Platform**

Duos Technologies’ Rail Inspection Portal (rip™) is the latest technological innovation and deployment for rail security and inspection at border, yards and inspection areas. Under a Union Pacific (UP)-funded pilot program at the Eagle Pass, TX border crossing, **duostech** designed and developed a leading edge portal to provide the US Customs and Border Protection (CBP) agency with a tool that would aid customs officers in the inspection of inbound rail cars. The rip™ system uses multiple technologies and sub-systems to remotely scan all railcars passing through the inspection portal, then displays stitched 360-degree views of the entire rail consist. It uses sensors and analytical algorithms to pre-screen railcars and to automatically detect and report anomalies and standard deviations from established norms. These systems have now been adopted to secure multiple border crossings throughout Southern United States border crossings.
The duostech rip™ provides the following modules for automated analysis, detection and inspection:

- Linear Panorama Generator
- Automated Detection of Open Doors
- Automated Detection of Open/Missing Hatches
- Train Rider Detection System
- Under Vehicle Inspection with Foreign Object Detection
- Gondola Car Inspection System
- Automated Pantograph Inspection System

Utilizing the centraco™ command and control platform as the system interface, the user accesses a variety of features enabling remote inspection, analysis and detection from the safety of remote command centers. Images containing detailed views of areas of concern, determined to be “potentially suspicious”, are automatically presented to a human operator for further inspection. Users conduct a quick review of the pre-screened imagery and decide whether to refer specific areas of interest to field personnel for further (physical) inspection.

The system also resolves the particularly difficult process of inspecting rail car undercarriages by providing high resolution images of the entire undercarriage. The system is not intended to “replace” the human operator; rather it is designed to help streamline the physical inspection process by narrowing the number of inspection targets down to cars with “potential” anomalies. Consequently, the detection sensitivity is intentionally set to err on the safe side so as to avoid false negatives.

**Linear Panorama Generator**

The Linear Panorama Generator (LPG) assembles images gathered from cameras on all four sides of the train and stitches all frames to create a continuous 360 degree view of the entire train. Operators can quickly inspect the entire train consist by selecting the side of interest and scrolling through the continuous panorama view. The main purpose of the linear panorama is to provide inspection personnel with geospatial information of detections. The system marks the approximate location of detection on the linear panorama image.
and displays the target car location specifying the “car sequence number” and the approximate distance from the locomotive and/or the AEI tag data if available. The operator can select areas to enlarge, tag, save, or print any image of interest. Panoramas are stored indefinitely and dependent only on the size of the storage drives.

**Automated Detection of Missing or Open Hatches or Open Boxcar Doors**
As the train passes, laser sensors scan the top and sides of the train to detect open/missing hatches and open doors. In the event of a “potential” detection, the system saves a series of images and enters the corresponding car information into a database. The detections are marked on the Panorama images and presented to the operator who will either acknowledge the suggested detection as valid (green button) or reject the detection as invalid. The operator can expand the event to view car and consist information, additional images, or can enlarge specific areas for a closer view of the detection.

**Train Rider Detection System (trids™)**
The Train Rider Detection System performs automated detection of riders hiding in railcar wells, which have been the typical hiding place on trains traveling at speed. **trids™** is designed to offer inspection personnel an expedient and efficient method of isolating and identifying anomalies of interest, particularly unauthorized train riders. Images of areas of interest are identified automatically by the software algorithms and presented to the operator for validation. The system is intentionally set to a high sensitivity to avoid false negatives. A version upgrade has just been completed which expands the detection area to the entire car areas.

**Vehicle Undercarriage Examiner (vue™)**
The Vehicle Undercarriage Examiner is a specially designed system to provide extremely high resolution images from the undersides of railcars at speeds up to 70 mph. Incorporating **xtld™** (Extreme True Definition) and AISC (Automated Identification of Structural Components) technologies provide unparalleled high definition imagery and intelligence for analysis.
The Vehicle Undercarriage Examiner System (vue™) is embedded between the rails and captures three (3) distinct views in order to maximize the visual information. The images are assembled (stitched) to create a continuous panoramic view of the entire length of the rail car’s undercarriage. By employing the vue™, the undercarriage can be remotely inspected safely and efficiently.

**Gondola Car Inspection System (gcis™)**

The Gondola Car Inspection System has high resolution video cameras strategically installed to monitor and record the railcar loading process. To routinely monitor the physical condition of gondola cars, gcis™ will automate the inspection process by capturing and recording detailed video images of passing gondola cars. The images are stored and made available remotely for visual inspection by any authorized user on the railroad’s network. Not only does this eliminate the need for an on-site inspector, it also improves accountability in the event of an incident and can be counted on to operate reliably in all weather conditions.

**Automated Pantograph Inspection System (apis™)**

Intelligent video analytics capture, inspect and process real-time images from trains passing inspection points. The system automatically detects obvious pantograph defects such as bends, chips and cracks and flags those records for manual inspection. apis™ eliminates the need for routine manual pantograph inspections, greatly enhancing maintenance operations and control, and minimizing the possibility of unplanned down time.
**centraco™ Command & Control Platform**

**centraco™** is a dynamic and flexible command and control platform. It consolidates data and alarm events from multiple sources into a unified, interactive user interface, which is customized to the individual customer’s concept of operations. It provides situational awareness and data visualization for security and operations objectives.

This system is capable of supporting the integration of data from existing camera infrastructure and from other sensor-based systems, on the same graphical user interface.

With **centraco™**, authorized personnel will be able to simultaneously view, monitor, and analyze video and alarms from multiple locations.

**centraco™** includes shared event distribution and distributive alarm management features. It offers a multi-layered, drill-down interface with either 2D or 3D graphical navigation through a scene. Users employ customized investigative and analytics tools, using multiple search and seek criteria, to perform forensic analysis, research a specific event, or search for trends. Both standard and customized reports can be created from the user interface. **centraco™** can represent multiple target events for rapid investigation and response.

In addition to integrating current sensors and data sources, the system includes a built-in flexible design module that would allow the user to modify the user interface and add additional sensor or data sources. It integrates an unlimited number and type of sensor technologies, providing a unified, comprehensive solution. This browser-based system offers availability to an unlimited number of users on both desktop and mobile platforms.
**praesidium® Video Analytics**

**duostech** is the leader in rail based video analytics. **praesidium®** video analytics were originally developed and customized to meet the specific challenges faced by the Class 1 (freight) railroad industry and have been successfully used to secure rail bridges, tunnels, and yards. The software is trained not to generate alarms for trivial movement, such as wind-blown debris or small animal activity.

The **praesidium®** sensor detection software processes and analyzes the video feeds, using intelligent video analytics to detect a perimeter breach, visualize the location of the intrusion, and send a real-time event alert to a graphic user interface (GUI), including both a live video feed as well as video clips of the scene during the incident.

The intrusion detection/virtual fencing system will provide situational awareness that minimizes the need for continuous video monitoring. It will distribute live and archived video images and intrusion alerts over a secure network connection to authorized personnel, and provide the information needed to respond promptly to a security event.

The **duostech** system includes a built-in buffering capability that is an important part of an intrusion detection system. This buffering provides pre- and post-incident alarm recording, scalable from 10 seconds to 60 minutes in either direction. When **praesidium®** generates an intrusion alarm, the user can examine the buffered video to review activity in the intrusion area for a time period just before and after the alarm.

Since there are no defined industry standards for analytics performance, it is hard to separate one product from another. We have taken it upon ourselves to develop a performance standard based upon our historic data from our existing railroad installations. We have a documented false positive detection rate of 0.0017% for our currently deployed systems. And just as important, these are not "new" deployments. These are systems that in many cases have been successfully active for several years.

Our **praesidium®** video analytics software is based on the principle of behavioral analytics and employs distributive layer analysis (DLA) technology for optimal video analytics accuracy. DLA splits a video scene into three separate layers, and then independently analyzes each layer to allow for statistical variations in the scene, which reduces false alarms.

**praesidium®** includes superior video analytics to reduce false alarms using the following:

**Continuously adaptive background modeling**
A statistical model of the background is automatically built and adapted every frame to ensure the best representation of the scene. This allows for detecting and tracking ‘foreground objects’ which may not necessarily be moving at that time. This method allows for statistical variations in the scene that could be nuisance motion to be automatically ignored. This is a strong component for avoiding false positive alarms.
Prediction based saliency estimation
Several cues such as speed and multiple movement patterns are considered and analyzed by our algorithms. Each frame analysis renders a “prediction” of speed and movement “expected in the next frame.” The real-time information is compared to the “prediction” and matched against a set of rules that defines “allowed vs. disallowed” activities. If the predicted motion is statistically close to measured motion, there is an increased probability that the object is a human. This result is one of many powerful indicators that identify an object as a person or non-person. This method yields maximum reliability in the classification of moving objects and minimizes false alarms.

Weather filters to ignore ambient motion
Weather conditions like rain and snow are the bane of video surveillance systems. They provide significant ambient motion that causes most intelligent video systems to either throw incessant false alarms or fail to detect a true intrusion. A statistical model of this motion is developed and incorporated into our algorithms. This model is used to filter weather motion and detect only purposeful motion (coupled with the saliency estimation).

Elimination of shadows
Other important cues used for accurate classification are the “dimension” and the “aspect ratio” of an object. (For example, the dimension and aspect ratio of a human being are quite different from those of an animal or vehicle). A shadow cast by an object on the ground masks these dimensions. In order to be able to detect intruders with acceptable sensitivity, most video surveillance systems either decrease the detection thresholds or decrease the weight of the variables used for detection. This leads to an increased false alarm rate. Using a patent pending ‘Drop Histogram’ method, the width and the height of the unfiltered object (object with the shadow attached to it) are adjusted to the contour of just the object, thereby eliminating shadows as a cause for false alarms.

Accurately modeling the scene surface by using piece-wise planar models
Dimensions of a potential intruder at any point (coordinate) in the field of view (FOV) are predicted based on site calibration. A typical calibration procedure includes fitting a plane (or two) onto the FOV surface. However, real world scenes are not planar, so prediction using these planar models can lead to inaccurate results. We use a piece-wise planar model in which a surface is approximated by a number of small planes (from tens of planes to hundreds of planes, depending on the scene surface). This leads to more accurate dimension prediction, further minimizing false alarms.

What makes our software unique and different from the many failures of competitors is the process through which we analyze and process video. Using Differential Layer Analysis, we deconstruct a scene into three independent layers; the foreground, mid-ground, and background. Our software then independently analyzes all three layers for the unique event taking place in the video scene. This allows us to guarantee with a high level of certainty that when our system generates an alarm event that it is a positive alarm and not a false alarm.

Additionally, the software was developed specifically for outdoor, railroad applications. We incorporate analytic modules with features such as:

- Modular Video Analytics Engine w/False Positives only 0.005%
- Bad Weather Resilience
- Self-casting Shadow Removal
- Piece-wise Planar Site Calibration
- Remote Access, Administration & Monitoring
- Browser Based Interface – Unlimited Users
• API/SDK for 3rd Party Integration

Our systems are currently deployed at multiple locations for CSX Transportation, Union Pacific, Kansas City Southern Railroad, Conrail and other freight and transit railroads.

PAST RAIL PROJECTS

Our primary business focus has historically been with both Class-I and passenger railroads, and we have deployed more successful, active security projects (including virtual fences) than any other company in the U.S. Our systems are currently in use by the following railroads and major corporations:

• Amtrak
• Chicago METRA
• Conrail
• CSXT
• Kansas City Southern de Mexico
• Maryland Transit Authority
• National Grid
• Union Pacific

Duostech has successfully executed projects both domestically and internationally. The following pages outline a few of the projects we have completed for our customers.

National Capital Region Railroad Pilot Program (NCRRPP)

Customer: U.S. Department of Homeland Security

This project established a comprehensive virtual security buffer zone in a wide area that secures approximately six miles of critical rail corridor through metropolitan Washington, D.C. It was also funded under a Department of Homeland Security grant in a cooperative effort between Duos and Epsilon. Epsilon acted as the program manager on behalf of DHS, and Duos provided this as a turnkey design/build project to DHS using natively developed Duos technologies. Duos is currently responsible for the 24/7 Help Desk.

This project establishes a virtual security buffer on both sides of the rail tracks along the six-mile route between the Anacostia Bridge in the north and the Long Bridge near Crystal City in the south. It includes the Virginia Avenue Tunnel, and consists of over two hundred fixed and PTZ cameras combined with Duos’ praesidium® Video Analytics Suite and rvspro™ servers. The entire system is monitored remotely over industry-standard network connections. It monitors constantly for intrusion detection and suspicious objects that breach the perimeter, and automatically alerts railroad security personnel when user-set security parameters are met.

The system includes a “Friend or Foe” RFID system to prevent authorized railroad personnel from generating alarms. Two additional portals were deployed, in Maryland and Virginia, to provide early alerts of inbound train traffic. A chemical detection system component was added on a pilot basis and is currently under review.
Border Security Rail Inspection Portal (rip™)
Customer: Union Pacific Railroad, U.S. Customs and Border Protection and Kansas City Southern de Mexico
The Rail Inspection Portal automatically inspects passing railcars using a group of advanced technologies. The system captures and records video images from passing trains, stitching the images together to present the four sides of each railcar—a full 360 view. The system creates an inspection point for trains and includes the following features: Train Rider Detection System (trids™), Linear Panorama Generator, Video Capture of Top and Sides of a Train (Railcars), Under Vehicle Inspection System (UVIS), and Missing Hatch Detection.

Railroad Tunnel Security
Customers: Amtrak, CSXT, Union Pacific, LA Metrolink, Maryland MTA
These systems were developed by Duos to utilize intelligent video security and remote surveillance technology for critical infrastructure asset protection. It has been deployed at several different tunnels around the United States owned by the above-listed railroads.

An intelligent digital video surveillance system monitors and secures both portals of a tunnel via a group of fixed digital video cameras with infrared illuminators, combined with PTZ cameras. The entire system is monitored remotely at the railroad’s Command Center.

Cameras are deployed with intelligent video software to create a virtual perimeter at the tunnel portals, detecting any moving object within the secure zone (after filtering out windblown movements, weather conditions, and train movements). Railroad police are notified of an intrusion immediately and can remotely operate the PTZ cameras to investigate the situation. Our praesidium® intelligent video software performs continuous, reliable detection at the site.

Railroad Bridge Security
Customers: CSXT, Union Pacific
These projects employed digital video surveillance to create a virtual perimeter at either end of selected railroad drawbridges in the U.S. These systems include motion detection and intrusion detection with alarms. A wireless Ethernet bridge connects equipment at one end of the bridge to a server at the opposite end, eliminating the need to connect wire or cable across the waterway. A group of fixed and PTZ cameras provide real-time video images and intrusion alarm notifications to the railroad’s centralized Command and Control facilities.

Train Rider Detection System (trids™)
Customer: Union Pacific Railroad & U.S. Customs and Border Protection
Duos’ Train Rider Detection System automatically inspects trains moving at speeds up to 70 MPH searching for illegal riders and other predefined anomalies. trids™ utilizes Duos’ artificial intelligence technology to inspect the wells of passing container cars and underneath tractor trailers on flatbed cars. This system also incorporates our patent-pending Linear Panorama technology to provide complete visibility of an entire train in a single high-resolution digital image.
Collision Alert Monitoring & Impact Analysis (camia®)

**Customer: Union Pacific Railroad**

A movable railroad bridge in Texas was subject to recurring collision damage from passing river traffic. The bridge owner needed a way to measure and record collision impact to identify the responsible vessel and measure the damage. Duos developed and deployed the **camia®** system to detect, measure, and document the impact of a passing barge with the bridge fenders. The system alerts security personnel and captures documentary evidence to allow pursuit of a claim for damages.

The **camia®** system:

- Deploys high-resolution, day/night cameras and motion sensors on and around the railroad bridge, partnered with intelligent video surveillance.
- Video software activates the system when a vessel enters the cameras’ field of view.
- A dual-axis accelerometer measures impact, vibration, and inclination on the bridge fenders to sense a collision.
- A collision alarm from the sensors is combined with the video recorded by the cameras to produce a forensic record of any impact.

Sensors mounted on the bridge measure track displacement.

Automated Pantograph Inspection System (apis™)

**Customer: Chicago METRA**

Duos developed and deployed a system that incorporates ultra-high-resolution cameras, structured lighting, speed and proximity sensors, and Radio Frequency identification (RFID) technology to inspect the condition of pantographs on passing railcars. **apis™** includes the following capabilities:

- Captures high-resolution images of each pantograph and carbon strip as trains pass through an inspection station
- Uses software algorithms to process the images and examine them for signs of pantograph and carbon strip wear or defects/anomalies
- Categorizes the defects and anomalies according to predetermined priority and severity guidelines (i.e., Warning List, Scheduled Maintenance, Immediate Repair)
- Alerts customer personnel when a pantograph or carbon strip exceeds predetermined wear or defect parameters.
- Creates a searchable record of the inspection and generates inspection reports regularly and on demand. Performs in all light and weather conditions.
- It has been deployed on three separate tracks at the Randolph Street Station in Chicago.

Tank Farm Surveillance

**Customers: CSXT, Union Pacific, National Grid**

We have designed and deployed intelligent perimeter surveillance systems to secure tank farms for both fuel storage and liquefied petroleum gas (LPG) for the above-listed companies. Digital video cameras and intelligent video analytics combine to create a virtual perimeter around the tank area and vital structures on the site, automatically notifying company personnel of a security breach. The use of day/night cameras and software-based video enhancement delivers a system that works in all light conditions and in bad weather, with the industry’s lowest rate of false alarms.
Rail Yard Security

Customers: CSXT, Conrail, Union Pacific

We have designed and deployed intelligent security perimeter and anomaly detection systems for many U.S. rail yards. These systems employ our patented video analytics technology to provide secure perimeters around the facilities.

Remote Bridge Controls

Customer: CSXT

We designed a system that eliminated the need for local drawbridge operators, allowing centralized and remote control of the drawbridges from a single location. This system has received U.S. Coast Guard accreditation and approval for use. It consists of a combination of PLC technology integrated with multiple sensors to provide operators complete situational awareness of the drawbridge.

Gondola Car Inspection System (gcis™)

Customer: Conrail

The gcis™ system was developed to provide Conrail with an automated method for conducting inspections of gondola cars with steel slab loads. The system provides complete visibility utilizing our praesidium® systems of the interior of a gondola rail car.

Virtual Fence/Secure Rail Corridor

Customer: CSX, Union Pacific

These systems were deployed to isolate and protect trains as they move through specific high-threat areas along their routes. They consist of the same virtual fence technology deployed at other facilities.

For more information on Duos Technologies Rail Security Solutions,
Please contact us at:

info@duostech.com
+1.904.296.2807

Or logon to www.duostech.com