TP 13756E

OCRail

A Container ID Recognition Engine

Project Overview

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TRANSPORTATION DEVELOPMENT CENTRE
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INO

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BY

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16. Abstract

The objective of the AEI/OCR project (automatic equipment identification/optical character recognition) was to provide the Port of Montreal with an automated system for generating train consists in electronic data interchange (EDI) format. The project was structured around an AEI system equipped with video cameras and able to perform OCR image processing.

What made this system unique was its video processing capabilities. To perform OCR in an outdoor environment, several technical hurdles had to be overcome. Image quality had to be impeccable, as variations in container surfaces would produce shadows and reflections, thus affecting character segmentation. Also, other surface defects (rust, scratches, graffiti) and winter weather conditions made this step an even greater challenge. Finally, as container codes adhere only loosely to the ISO 6346 standard, the OCR system software had to be very flexible with respect to the format of character groupings making up the codes and the representation of individual characters.

The *Institut national d'optique* and the Closed Circuit Television Corporation met this challenge and built an operational AEI/OCR system with a recognition rate of 81 percent and a processing time of less than 40 minutes. In conclusion, the Port of Montreal now has a one-of-a-kind prototype of an AEI/OCR system for producing lists of the contents of container trains in electronic format.

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16. Résumé

L'objectif du projet IAE/ROC (identification automatique d'équipements/reconnaissance optique de caractères) consistait à fournir au Port de Montréal un système générant automatiquement une liste d'échange de données informatisées (EDI) donnant le bulletin de composition de trains (*train consist*). Le projet s'articulait autour d'un système IAE équipé de caméras vidéo, doté de la capacité de réaliser l'analyse ROC des images.

L'originalité du système résidait dans la fonction d'analyse vidéo. Pour réaliser la ROC en milieu extérieur, plusieurs défis techniques ont été surmontés. Ainsi, la qualité des images devait être irréprochable, car la segmentation des caractères devait s'accommoder des variations de surface des conteneurs, produisant ombrages et réflexions. D'autres altérations de surface (rouille, égratignures ou graffitis) ainsi que les conditions environnementales hivernales, réduisaient davantage la probabilité de succès de cette étape. Enfin, les codes de conteneurs ne suivant que sommairement la norme ISO 6346, le logiciel du système ROC devait présenter une souplesse quant à la disposition des groupes de caractères formant un code et quant à la représentation des caractères.

L'Insitut national d'optique et la *Closed Circuit Television Corporation* ont relevé le défi et ont bâti un système IAE/ROC opérationnel, affichant un taux de reconnaissance de 81 p. cent pour un temps de traitement inférieur à 40 minutes. En conclusion, le Port de Montréal possède donc un prototype unique d'un système IAE/ROC produisant une liste électronique du contenu des trains de conteneurs.

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Executive Summary

This project is part of a larger program for deploying information processing systems at the Port of Montreal to facilitate the management of container movements by eliminating paper records. In this way, the Port of Montreal will enhance the value added to its services to intermodal carriers operating in the region. This will also solidify the Port's position as the dominant player in intermodal traffic in North America by reducing delays and costs related to billing as well as container handling and transit.

The success of this program lies in the uniform integration of data collected from various sources. Thus, the availability of unified information combining railcar and container identifiers with data about container status and position within the Port will help improve the efficiency of operation.

As for the railcars, automatic equipment identification (AEI) tag readers were already in place before this project began. This proven technology allowed the Port of Montreal to attain part of its objective, but there was still much work to be done in adapting this technology to integrated information processing systems.

Other needed technologies would have to be developed. Since it was unlikely that all containers would be equipped with AEI tags any time in the near future, an alternative automated identification method would have to be found. Making use of the ISO 6346 standard for containers offered interesting possibilities. Automated recognition of container ID codes, an activity identified by the Port of Montreal as an important cost control tool, was an option for which the development of new technologies would be necessary.

The specific objective of the AEI/OCR (optical character recognition) project was to produce, test, and install a system capable of generating train consists for trains entering or leaving the Port of Montreal, work that was still being done manually. Producing a digital consist would have the advantage of allowing direct conversion to electronic data interchange (EDI) format, which would allow the Port of Montreal to distribute information collected this way through the usual information processing channels, such as the Internet.

Essentially, the AEI/OCR project was built around a hybrid AEI system – a standard AEI tag reader equipped with video cameras. Numerous hybrid AEI systems are already in operation throughout North America. These systems allow visual inspections of train consists to be conducted after the fact, based on images acquired and stored as the trains pass. For the Port of Montreal, the goal was to add to this type of system the capacity to perform OCR analysis of the images, thus completely automating the process. The AEI/OCR system would be able to generate complete train consists by combining railcar AEI tag information with container codes collected through OCR.

The element that gave this system its unique advantage, but also its greatest potential stumbling block, was the ability to analyse video images, a complex visual task. In order to carry out an accurate OCR analysis of container surfaces in an outdoor environment, a considerable number of technical challenges had to be overcome.

The quality of images acquired had to be impeccable, as digital image processing demands much higher standards of lighting uniformity and contrast maximization than ordinary human inspection. This requirement meant that particular care would have to be taken with the alignment of the lighting system and the type of cameras used.

Container surfaces may by flat, corrugated or, in the case of tank containers, cylindrical. This can lead to shadows and reflections that produce dramatic variations in surface contrast for the same container. As a result, the initial task of determining image zones where characters may be located (segmentation) becomes an extremely complex one. To make matters worse, normal wear and tear on container surfaces, such as rust, scratches, dents and graffiti, make it even more difficult to obtain usable images.

Quebec's winter weather conditions add snow and ice to the images in the system, thus further complicating character segmentation. Similarly, rainy weather during the warmer seasons leaves container surfaces wet, changing their reflectivity. Even on clear, cloudless days there is a certain risk that rays from the rising or setting sun may shine directly into one of the cameras.

Moreover, ID codes on containers only conform to the ISO 6346 standard in a relatively broad manner with respect to character format, and the ISO standard does not specify a particular font. The resulting situation requires that OCR software have a built-in capacity to generalize in order to be able to recognize not only the ways in which characters are grouped, but also the shapes of the characters themselves. This kind of flexibility is not usually found in OCR products currently on the market.

The *Institut national d'optique* (INO) and its partner, the Closed Circuit Television Corporation (CCTC), met the challenge of this complex project for the Port of Montreal and made it a reality. They succeeded in overcoming the project's inherent difficulties and making the AEI/OCR system operational. Working together over a period of three years, they managed to develop new and unique expertise in the field of container ID recognition. Thanks to this expertise, INO and CCTC have been able to position themselves as the team of choice for future development of the AEI/OCR system.

With the project completed, the Port of Montreal now has a unique piece of technology: a prototype hybrid AEI reader with OCR capacity that can automatically produce a consist for any train that passes by its antennas and cameras.

This overview is an introduction to the complete set of documents produced by INO and CCTC for this project. It gives a general outline of the project as a whole, plus a general description of the prototype AEI/OCR element. The physical layout of the hardware components and the logical relationships between the various functions of the prototype are described and illustrated with diagrams. There is also a list of the prototype's critical components, plus a brief description of potential malfunctions in each of these components and their effects on the system. This report is designed to give the reader an understanding of the relationships governing the individual parts of the system.

Sommaire

Ce projet s'inscrit dans le cadre d'un plus vaste programme de déploiement de systèmes de traitement de l'information au sein du Port de Montréal. Cet effort vise à faciliter la gestion des mouvements de conteneurs en éliminant le besoin d'enregistrements papier. De cette manière, le Port de Montréal rehaussera la valeur ajoutée de ses services auprès des opérateurs intermodaux actifs sur son territoire. De plus, il fortifiera sa position dominante de plaque tournante intermodale en Amérique du Nord, en réduisant les délais et les coûts associés à la manutention et au transit des conteneurs, ainsi qu'à la facturation.

Le succès d'un tel programme passe par l'intégration cohérente des données recueillies à différentes sources. Ainsi, la disponibilité d'une information unifiée, fusionnant les identificateurs de plates-formes et ceux de conteneurs, ainsi que leur état et leur position respectifs au sein des limites du Port de Montréal, contribuerait à l'amélioration de l'efficacité des opérations.

En ce qui à trait aux plates-formes, il existait déjà avant le début du projet des lecteurs d'étiquettes d'identification automatique d'équipements (IAE). Cette technologie éprouvée permettait d'atteindre partiellement le but visé par le Port de Montréal. Toutefois, il restait un important travail à accomplir en ce qui a trait à l'adaptation de cette technologie aux processus intégrés de traitement de l'information.

Par ailleurs, d'autres technologies nécessaires restaient à développer. Puisqu'il était invraisemblable de voir dans un proche avenir chaque conteneur équipé d'une étiquette IAE, il était nécessaire d'envisager une méthode alternative d'identification automatisée. Heureusement, la norme internationale ISO 6346, relative aux conteneurs, offrait un cadre de travail intéressant. La reconnaissance automatique des codes identificateurs de conteneurs, une opération identifiée par le Port de Montréal comme étant un outil important de contrôle des coûts, est un exemple d'application pour laquelle le développement de nouvelles technologies est nécessaire.

L'objectif spécifique du projet de développement IAE/ROC (reconnaissance optique de caractères) était de produire, tester et installer un système capable de générer automatiquement une liste donnant le bulletin de composition de trains (*train consist*), entrant ou sortant de l'enceinte du Port de Montréal, un travail jusque-là réalisé manuellement. Le fait de produire une liste de composition numérique offre l'avantage de permettre une adaptation directe au format d'échange de données informatisées (EDI). De cette manière, le Port de Montréal peut disséminer l'information ainsi recueillie par les canaux usuels aux processus de traitement de l'information, tel l'Internet.

À la base, le projet de développement IAE/ROC s'articule autour d'un système IAE hybride, c'est-à-dire un lecteur d'étiquettes IAE standard équipé de caméras

vidéo. Il existe de nombreux systèmes IAE hybrides en opération en Amérique du Nord. Ceux-ci permettent une inspection visuelle *a posteriori* de la composition d'un train à partir des images acquises au passage du convoi et conservées. Au Port de Montréal, on a visé à doter ce type de système de la capacité additionnelle de réaliser l'analyse ROC des images, afin d'automatiser l'opération. De cette manière le système IAE/ROC générera un bulletin de composition de trains complet, en fusionnant l'information relative aux étiquettes IAE des plates-formes à celle des codes de conteneurs produites par la ROC.

L'essentiel de l'originalité du système et, de ce fait l'essentiel du risque, résidait donc dans l'analyse vidéo des images, une tâche de vision complexe. En effet, afin de réaliser une ROC valable sur des surfaces de conteneurs en milieu extérieur, il était nécessaire de surmonter un nombre considérable de défis techniques.

La qualité des images acquises devait d'être irréprochable; les contraintes d'uniformité d'éclairement et d'optimisation du contraste sont de loin supérieures en traitement numérique des images qu'en simple inspection humaine. Cela contraint à porter une attention particulière à l'alignement de l'éclairement d'appoint et au type de caméras utilisées.

La surface des conteneurs varie de plate à ondulée, en passant par cylindrique dans le cas de conteneurs-citernes. Cela produit des effets d'ombrages et de réflexions qui font dramatiquement varier les contrastes à la surface d'un même conteneur. La tâche préliminaire qui consiste à déterminer les zones de l'image où se situent les caractères potentiels, la segmentation, s'en trouve énormément complexifiée. De plus, il va de soi que des circonstances courantes altérant la surface des conteneurs, telles que la rouille, les égratignures et les marques de heurts, ou encore les graffitis, réduisent davantage les probabilités de succès de cette première étape.

Les conditions environnementales que connaît le Québec en hiver ajoutent neige et glace aux images tirées du système, compliquant un peu plus la segmentation des caractères. De même, les pluies des saisons tempérées mouillent la surface des conteneurs, ce qui en change les conditions de réflexivité. Même les jours clairs et sans nuages d'été présentent un élément de risque, lorsque les rayons éclatants du soleil matinal (ou crépusculaire) viennent éblouir directement l'une des caméras.

Ensuite, les codes apparaissant sur les conteneurs ne suivent que sommairement les prescriptions de la norme ISO 6346 quant à la disposition des groupes de caractères. Par ailleurs, cette norme ne spécifie aucune police de caractères particulière. Cette situation demande que le logiciel d'analyse de ROC ait non seulement une capacité intrinsèque de généralisation quant à la disposition variable des groupes de caractères formant un code, mais aussi quant à la représentation des caractères eux-mêmes. Ce genre de flexibilité ne se retrouve généralement pas dans les produits ROC disponibles sur le marché.

L'Institut national d'optique (INO) et son partenaire, la *Closed Circuit Television Corporation* (CCTC), ont relevé le défi complexe du projet IAE/ROC du Port de Montréal et, afin de réaliser ce système, ont continuellement investi dans le projet. Ils ont réussi à faire en sorte que le système IAE/ROC surmonte les difficultés rencontrées et soit opérationnel. Ensemble, ils ont développé, sur une période de trois ans, une expertise nouvelle et unique dans le domaine de la reconnaissance des codes de conteneurs. Cette expertise positionne maintenant l'INO et la CCTC comme l'équipe de choix pour les développements à venir sur le système IAE/ROC.

Au terme du projet, le Port de Montréal possède maintenant un exemplaire technologique unique : un prototype de lecteur IAE hybride capable de ROC et produisant automatiquement le bulletin de composition des trains de conteneurs passant devant ses antennes et ses caméras.

Ce survol est le point d'entrée de l'ensemble de la documentation produite par l'INO et la CCTC dans le cadre du projet. Il donne en premier lieu une vue d'ensemble générale du projet, puis on y trouve une description générale de l'aspect du prototype IAE/ROC. L'implantation physique des composantes matérielles et les interactions logiques entre les différentes fonctions du prototype sont traitées et illustrées à l'aide de diagrammes. On y trouvera aussi une liste des composantes critiques du prototype, accompagnée d'une brève description des impacts sur le système d'un mauvais fonctionnement de chacune d'entre elles. L'objectif est de fournir au lecteur une perception des interrelations régissant les parties individuelles du système.

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1 INTRODUCTION

The scope of the AEI/OCR development project was to provide existing automatic equipment identification (AEI) readers and video monitoring systems with optical character recognition (OCR) capability. The objective was to fully automate the process of building a container train consist, work that was still being done manually. In addition, the train consist had to be directly provided in electronic data interchange (EDI) format, such that once that piece of information is available to the Port of Montreal (POM), the latter can integrate it into a broader information processing scheme and provide value-added service to its clients and partners.

Hence, the system delivered to POM is a first of its kind: unique prototype performing automated train consist generation for passing container trains. The prototype was designed and developed over a three-year period of time, then integrated from April to November 2000. Acceptance tests were finally performed over a 15-day period at the beginning of December 2000.

The *Institut national d'optique* (INO) and its subcontractor, the Closed Circuit Television Corporation (CCTC), took on the challenge of continuously investing into the project. Together, they developed a new and unique expertise in the field of container ID recognition, a complex vision task. That expertise now positions INO and CCTC as the best team to continue with further developments on the AEI/OCR system.

This document is intended as a system overview of the hybrid AEI/OCR prototype installed at POM, and as a short guide to the various documents that constitute the project documentation package.

In Section 2, a general description of the system aspects of the prototype is presented. Both the physical implantation and logical implantation are discussed, followed by the dynamics in the prototype. The intent is to give a general overview of the system integration by describing the interrelations among the individual parts in the system.

Following system integration issues, Section 3 consists of a list of the critical components in the prototype. A brief explanation of the role of each component and the system-level consequences of a malfunction are also given.

Section 4 provides a brief description of the individual documents forming the documentation package of the project. It is intended as a structured checklist, helping the reader to position each document in relation to the others.

Finally, the list of project deliverables is provided in Appendix A. The name of every individual document in the documentation package can be found in Table A.2.3, the only exception being the present document, which was added by INO for clarity.

2 AEI/OCR SYSTEM OVERVIEW

The aim of the prototype is to perform on-the-fly reading of both the AEI tags present on the railcars, which is a standard operation, and the ID code painted on the containers, which is the original R&D contribution of the project. In order to do so new elements enabling OCR processing had to be developed. Also, INO and its subcontractor CCTC, had to modify and adapt existing hardware and software.

This section describes the system architecture of the resulting AEI/OCR prototype. General system integration issues between the AEI and OCR parts are addressed to give an overall picture of the system functions.

2.1 Physical Implementation

Figure 2-1 gives a schematic view of side 1 of the physical implementation of the AEI/OCR system, and Figure 2-2 shows a photograph of the actual on-site installation at the POM facility, near elevator 5.

2.1.1 Outside Setting

The prototype features a number of sensors distributed outside along the track side. Three wheel sensors (axle detectors) are positioned on the track. The two extreme ones detect the presence of a train, while the middle one is for speed assessment.

The post farthest from the track holds the camera and its housing. The camera is a line scan type, with a field of view covering 6.1 m (or 20 ft.), such that a double-stack of containers falls entirely within its vertical field of view.

The post nearest to the track bears a standard AEI antenna (SmartPass) and different types of lighting. The latter include two main lighting stages (top and bottom) that are responsible for the uniform illumination of the surface of the containers. The other lights are used as a calibration target to control the gain of the camera on the opposite side. A reference light helps segment the container groups during OCR processing.

Apart from the reference light, all of the components described above are standard to video-equipped AEI sites.

Side 2 duplicates the two posts and all of the individual components attached to them.

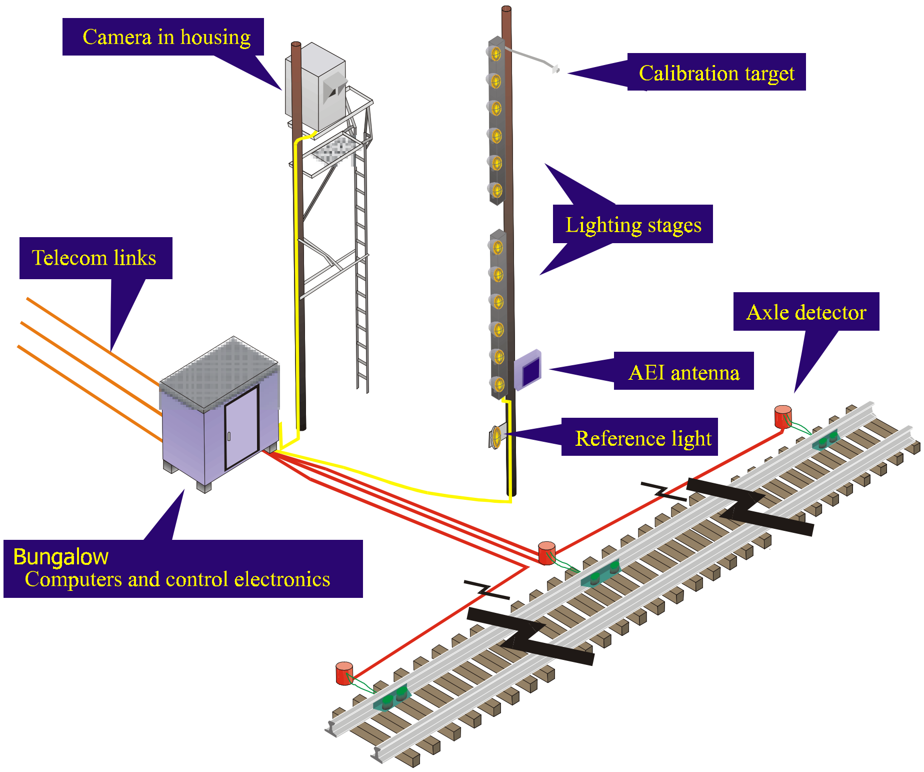

Figure 2-1: Site schematics for side 1 of the prototype, and its relation to the track

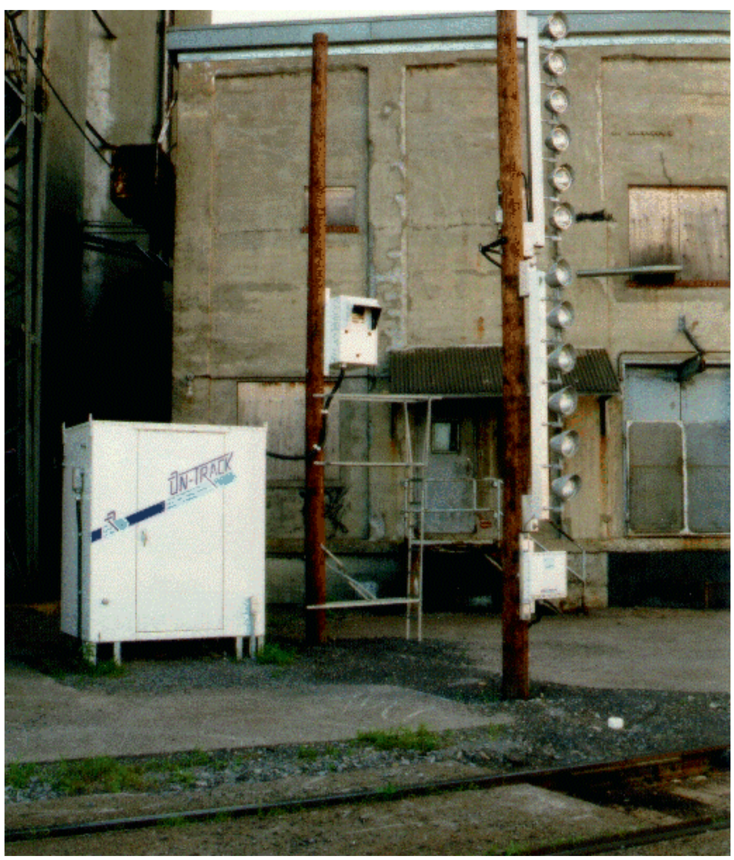

Figure 2-2: Actual view of side 1 of the prototype

2.1.2 The Bungalow

The bungalow shelters the control electronics and the processing node of the prototype. All sensors and lighting are connected to it.

As the architecture is file-oriented, the bungalow contains a local area network (LAN) of six computers, under control of a 100-Mbps switch. A POM-owned PC is located within the bungalow as well. However, it is logically external to the system, its role being to receive the resulting AEI/OCR train consist.

2.2 Logical Implementation

The AEI/OCR logical system architecture is presented in Figure 2-3 as a functional block diagram with data flow. All of the sensors mentioned in Section 2.1.1 appear, as well as every PC present within the LAN in the bungalow. In the figure, references to “near” and “far” are equivalent to side 1 and 2 respectively. A-B/C-D wheel sensors are the presence detectors, and the L-R wheel sensor is the middle one, performing speed assessment.

The system consists of four independent sub-systems (or sections) referred to as the linear camera (LICO), OCR, AEI and file server sections.

The LICO section handles train detection, image acquisition and file generation (IMG format). Since linear cameras are used, images are formed in linescan fashion. A two-dimensional reconstruction of the train is thus achieved by juxtaposing several line frames. Consequently, the whole length of the train can be considered to be a single image although its physical representation is divided into smaller, more manageable blocks for convenience.

IMG files form the main stream of data in the LAN and they are sent directly over the switch to the OCR section. As represented in Figure 2-4, there is a one-to-one logical association between the LICO and CoRAIL computers.

The OCR section features two computers: CoRAIL2 and CoRAIL3. Together, they handle the recognition of the printed container IDs using the IMG image files provided by the LICOs. This operation is equivalent to reducing the information contained in a large set of images into a single code ID file.

The AEI section is responsible, among other things, for reading the AEI tags attached to railcars. In addition, it provides timing signals for the LICO section. Once the OCR processing is complete, the AEI section is also responsible for integrating the AEI information with the OCR information. The result of this integration is an EDI-based file that is transmitted to POM.

The server section consists of the switch and a computer with mass storage.

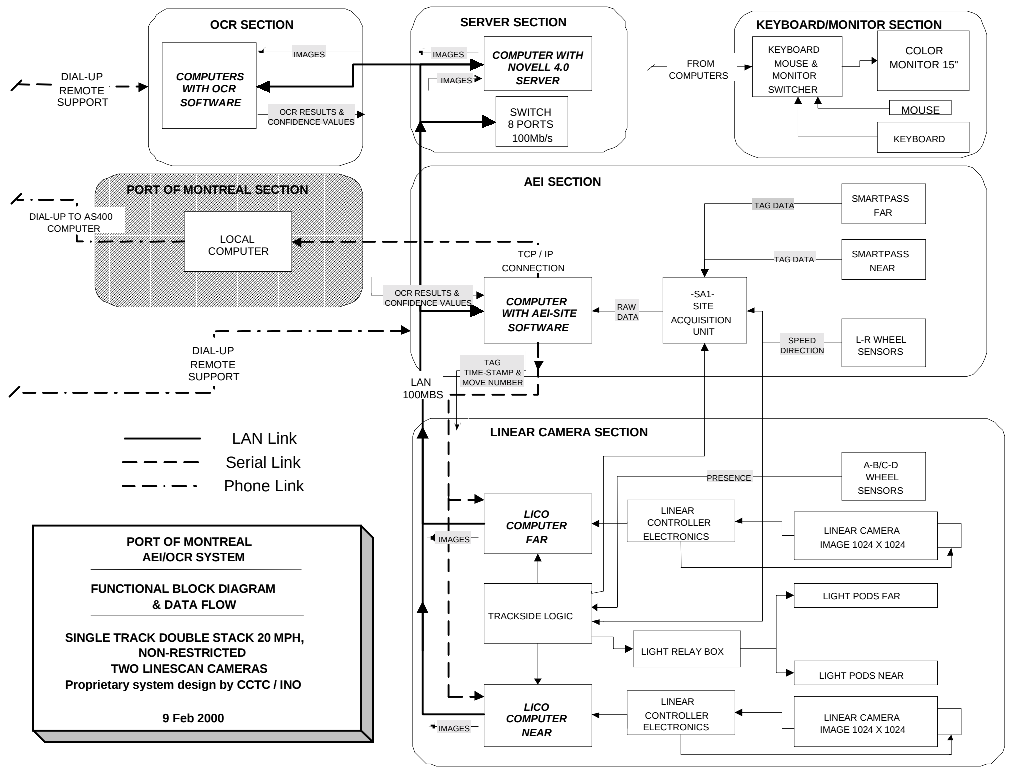

Figure 2-3: **AEI/OCR system architecture: functional block diagram and data flow**

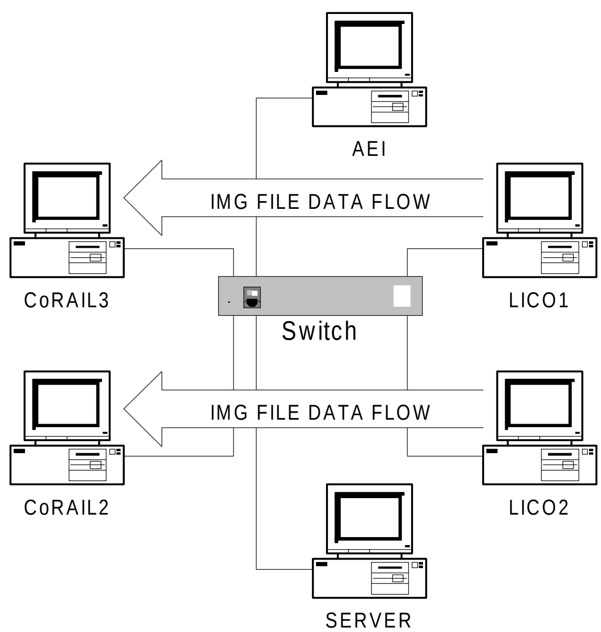

Figure 2-4: **LAN topology. At the heart of the LAN is a 100 Mbs switch. Also illustrated is the main data flow (IMG files) between LICOs and CoRAIL computers.**

2.3 System Dynamics

In essence, the dynamic aspects of the system can be modelled by three concurrent state diagrams, such as depicted in Figure 2-5. These diagrams are related to the LICO, OCR and AEI sections, respectively. Every time a train enters the system (i.e., each time a new move happens), the prototype makes a cycle through the states of the three diagrams.

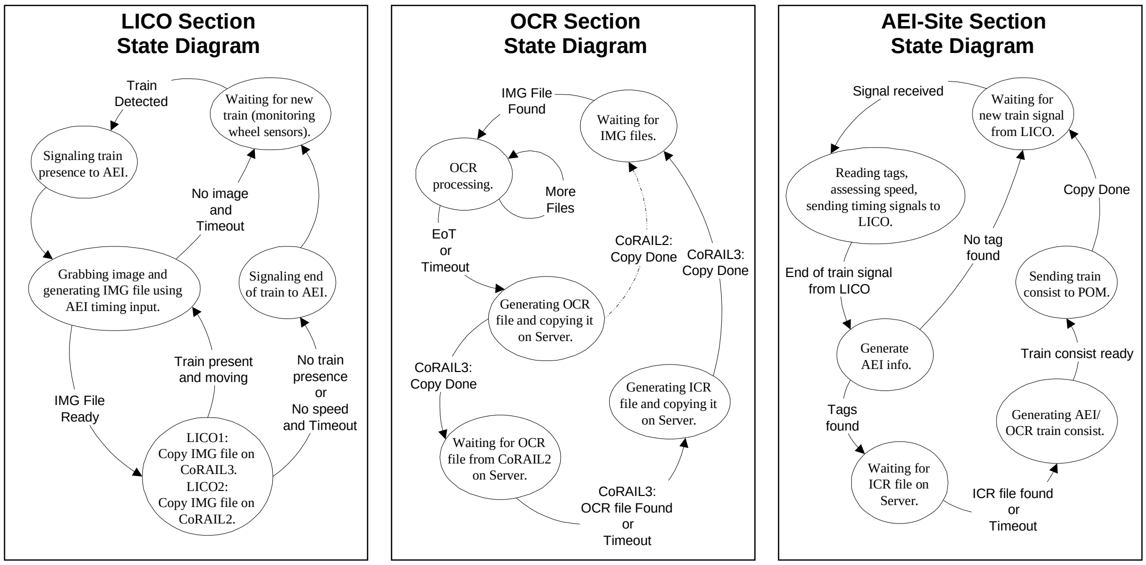

Figure 2-5: Dynamic aspect of the prototype: state diagrams for the LICO, OCR and AEI sections

Initially, all three state machines are in waiting mode. In fact, both the AEI section and OCR section are waiting for the LICO section to perform an action to trigger them. Meanwhile, the LICO section itself is waiting for a new move. Once a new train is detected by the LICO section (through its wheel detectors), the move is processed by cycling through the three state machines until each returns to its initial waiting state.

Take note that the LICO section state diagram describes the behaviour of both LICO1 and LICO2 computers simultaneously, whereas the OCR section state diagram is for CoRAIL2 and CoRAIL3 separately. Differences are noted in the figure where applicable.

In short, once the train is detected, the LICO section signals the AEI section and starts generating IMG files. It will keep doing this until there is no train presence detected (i.e., end of train, or EoT) or there is no speed and a timeout condition is met. Then the AEI section is signalled that the train has ended and the LICO section returns to its waiting state.

When the OCR computers detect the arrival of IMG files on their respective hard disks, they start processing them to extract any container code that might be present in the images. Each computer keeps processing until the EoT condition is met or until there are no new files and a timeout condition is met. The OCR then generates the OCR files, one for CoRAIL2 and one for CoRAIL3. CoRAIL2 is now finished and falls back into IMG file waiting mode. CoRAIL3, however, goes into a special waiting state until CoRAIL2's OCR file is available on the Server, or until a timeout condition is met. Then it processes the OCR files to generate the intelligent character recognition (ICR) file that combines container codes, taking into account redundancy. CoRAIL3 copies the ICR file on the Server before it falls back into the initial IMG file waiting mode.

Once the AEI section receives a train detection signal, it starts a series of concurrent actions. The railcar tags (Smartpass) are read, the train speed is assessed using measurements from the middle L-R wheel sensor, and timing signals are generated and transmitted to the LICO section as time stamps for the image files. The AEI section keeps performing these actions until the LICO section emits an EoT signal (no more presence at the A-B/C-D wheel sensor). Then, depending on whether some Smartpass tags were found in the move, the AEI will adopt a different behaviour. If no tag or wheel is found, the move is over, there were no containers and the AEI falls back into its initial waiting state. On the contrary, if some tags or wheels are detected, the AEI will place itself into a special waiting state until the ICR file from the OCR section is available on the Server. Once that file is ready, or a timeout condition is met, the AEI proceeds to merge the AEI and OCR information to build a full train consist. That consist is transmitted to POM and the AEI falls back into its initial waiting state.

3 CRITICAL HARDWARE COMPONENTS

This section lists the various critical parts of hardware present in the AEI/OCR system installed at POM. Following each component is a short description of the impact of a malfunction.

3.1 Linear Cameras

The system comprises two 1024-pixel EG&G LC3000 linear cameras that are the image-forming devices of the system. Upon malfunction of one of the two cameras, the accuracy of the system would suffer greatly because redundancy would be lost. Should both fail, the system would be blind and non-operating.

3.2 Spot Ramps

The illumination sources for the cameras are another critical part of the OCR system. Two posts with two ramps of six spots each illuminate both sides of the train. Each ramp on/off state is controlled by two electrical relays. Each relay controls three spots interlaced vertically with the three spots controlled by the other relay on the ramp.

The system should feature graceful degradation in performance with each additional burned spot. However, the processing was designed on the assumption that illumination would be uniform over the whole container height, so burned spots must be replaced as soon as they are detected. Since the replacement of a spot could adversely affect the balance of illumination on the surface of the container, a new uniformity calibration may be necessary.

The worst occurrence would be the malfunction of an electrical relay, causing the extinction of a whole set of spots.

3.3 Reference Lights

These four individual lights are used to help segment the containers. The OCRail software relies on them and should any of them burn out, the accuracy of the system would suffer greatly.

3.4 Posts

The system features four wooden posts upon which the cameras, the illumination spots, the target lights and the reference lights are fixed. As the performance of the OCR analysis prototype is highly sensitive to the proper, simultaneous alignment of all these components, the stability of the posts is viewed as a critical component.

Should the posts endure physical or thermal stress, the illumination of the camera's field of view could become less uniform. Worse, the target or reference lights could become out of alignment with the camera, causing loss of camera gain control or impairing the container segmentation process. Those lights would then have to be manually realigned.

3.5 Wheel Detectors

Wheel detectors serve two functions in the system: speed assessment and wheel detection.

To produce uniformly sampled images, the cameras need to adjust their sampling rate to the varying speed of the train. This task is performed by wheel sensor L-R. If that wheel sensor were to fail, the cameras would produce potentially distorted images that would not yield much result.

Each time a wheel is detected by either wheel sensor A-B or C-D, depending on the direction of the train, the system sets a flag into the corresponding image. This information is used by the container segmentation engine, so any malfunction of this wheel sensor would impair the container segmentation as well as the system's accuracy.

3.6 AEI Antennas

Because the purpose of the system is to generate a complete train consist, AEI tags need to be read as the train moves past the system. If one AEI antenna fails, then the redundancy of the implementation should still enable the system to perform, but some platforms are likely to be lost.

The OCR reader performance is independent of the AEI reading.

3.7 Computers

There are six computers working together on the LAN in the bungalow: the Server, the AEI-Site, LICO1 and LICO2, and CoRAIL2 and CoRAIL3. The failure of any one of these computers would have a different impact on the overall performance of the prototype.

3.7.1 The Server

If this computer fails, the OCR information would not be transferred properly to the AEI-Site computer and the system would operate as an AEI reader.

3.7.2 The AEI-Site

This is the computer responsible, among other things, for building up the final output of the system. Should it malfunction, the prototype would be paralysed.

3.7.3 LICO1 and LICO2

LICO1 builds and sends images of the trains to CoRAIL3; LICO2 is similarly linked to CoRAIL2. Failure of one of these computers is equivalent on a system level to the failure of the corresponding CoRAIL computer.

3.7.4 CoRAIL2

This computer is specialized for the OCR analysis of side 2 of the trains. If it fails, the redundancy in the system would be lost, but the system would still carry on its work, albeit with potentially less accurate performance.

3.7.5 CoRAIL3

This is the master computer of the OCR section. Besides performing the OCR analysis of side 1 of the trains, it also retrieves the output of CoRAIL2 to merge OCR results from both sides. CoRAIL3 also outputs the ICR file, used for the AEI/OCR information merger. Thus, the failure of this computer means that the system would operate solely as an AEI reader.

4 PROJECT DOCUMENTATION

The breakdown of the documentation package is presented below. Each of these separate documents constitutes a deliverable under the terms of the AEI/OCR project (see Tables A.2.1 through A.2.4 of Appendix A for reference).

4.1 Hardware

AEI General Section	General description of the AEI hardware and software present at the site.
AEI Hardware Section	Specific, detailed description of the functionality of the AEI equipment, testing procedures and maintenance.
AEI Software Section	User manual and maintenance manual of the AEI software running in the AEI Section of the prototype.
VIDEO Field Service Guide	Describes both the hardware and software parts of the image-forming (LICO) section of the prototype. This includes a user manual and a maintenance (adjustments and alignment) section, as well as the project drawings. (Erratum: in this document, CoRAIL3 should be read instead of CoRAIL1).

4.2 OCR

Software Design:	Detailed description of the purpose and design of the OCRail software, from general concepts to individual functions.
User Manual:	Brief user manual of the OCRail.exe application.

4.3 Testing and Training Issues

Test Plan:	This document comprises the Factory Test Procedure, the Compatibility Test Procedure and the Acceptance Test Procedure.
Acceptance Tests Report:	This report consists of the acceptance test results. In appendix are the Factory and Compatibility test reports.
Training Manual:	This is the plan of the training period.

Appendix A PROJECT DELIVERABLE LIST

A.1 Deliverable List

A.1.1 Hardware

1. Bungalow
2. Single track double stack AEI tag reader
3. Two (2) linescan cameras & lighting system
4. 1024x1024 pixel image grabbing and storage system (max. train speed 32 km/h or 20 mph)
5. 3 PCs, 1 desktop and 2 rack-mount
6. 3 CD-ROM readers
7. 3 Monitors (43 cm or 17 in.)
8. 3 Keyboards
9. 3 mouses
10. 3 modem 56K
11. 2 100 Mbit cards
12. 1 EtherExpress Pro/100 Server Adapter
13. 1 Laptop PC

Remarks:

The first four items of the hardware section correspond to CCTC's installations. Items 5 to 12 represent the required hardware found within the bungalow to perform the container ID recognition.

A.1.2 Software

1. 3 WindowsNT 4.0 licences
2. 3 PC-Anywhere licences
3. 1 Copy of the executable file OCRail.exe on 2 computers
4. 1 Copy of the DLL OCRail.dll on 2 computers
5. 1 BIC codes file on 2 computers
6. Files created by training the neural network from the database of symbols
7. 2 Program configuration files on 2 computers
8. The list of software tools used in the course of the project:

Visual C++ 5.0 Enterprise
SourceSafe 5.0
NeuroSolution (NeuroDimension)
VisSDK (Microsoft - class CVisImage)
Rational Rose 2000, Prof. Ed. for C++
DocExpress, Reporter Lite
MS Word 97
MS Excel 97
MS PowerPoint 97
MS Project 95
Paint Shop Pro 4.0
CorelDraw 8.0
BugTrapper
CapView

9. The tools bought or developed for the project:

   OcrFileDeamon, NsDbManager, TrainView, ContainerAutoSegmentation, ImageScrubber, img2bmp, ManualContainerSegmentation, Normalize, OcrFeatures, OcrPrint, OcrRailDemo, Profile, Utils, BatchProcessor, BatchProcessorDLL, Benchmark1, bmp2img, BmpRe_center, BSC_Dump_Fct, BSC_Tree, bubble_sort, CamCorrespMaker, ChangeTrainDir, comparison, ContainerExtractor4, ContainerExtractor5, Controls, DetectContainer, DetectContainers2, DumpTimeStamps, ExArrayOfPanes, ExtractConnexRegions, fileaccesstry, fileaccesstry2, FindContainerEdges, HistEq, Histo_Crossing, HoughTransform, IcrWriterTest, ImageDBtoPS, Image_Interpolation, img2bmp, img2tif, ListViewControl001, ManualContainerSegmentation, MorphOp, MoveDatabaseElem, Normalisation, NS_ConvertX2m1p1s, OcrFeaturesTestNN, OcrPrint, ocr_interf, OldFeaturesLib, OldFeaturesLibTest, preprocess, RowList, rw_Nblob, SDI_imgs, StatusBarWithProgress, TestBlobs, TestNewControls, TestNOcrEngine, testOcrFileReader, testProject, TrainSignal.

   Remarks:

   Items 1 and 2 of the software section form the operating software of the PCs provided to POM by INO. Items 3 to 7 are the executable files needed to perform container ID recognition. Item 8 is the list of tools used during software development. Those tools will not be delivered since they were not bought with project money. Item 9 provides the names of all software tools developed within the scope of the project. Since these are now useless (except for TrainView and OcrFileDaemon), INO suggests that they not be delivered.

A.1.3 Documentation

1. The OCRail control state diagram with processing state diagram (UML)
2. A general data flow diagram (UML)
3. Class static diagrams (UML)
4. The source code of the programs developed for the contract:
   C, CPP, H, RH, RC files
5. Project files required to build the application
6. The definition of the file formats:
   IMG, IM$, LOG, OCR, ICR, “EDI” AEI/OCR files
7. Test support documents
8. Test reports
9. System operator manual
10. Maintenance documents
11. Installation and set-to-work manual
12. Training documentation

   Remarks:

   Items 1 to 3 document the software graphically. The source code (item 4) will be delivered with a brief description of each module. Item 5 includes the instructions to compile the source code. Items 6 to 12 will be provided in concise form with the essential information.

A.1.4 Training

1. One week training at the Port of Montreal.

A.2 Detailed Deliverable List

Starting from the list in Section A.1, a more practical detailed version was assembled in the following set of tables. The items found therein sometimes bear a new name that best reflects their actual materialization. However, an explicit relationship with the original list is provided in all cases.

A.2.1 Hardware

Name	Ref#‡	Description	Completion Status	Date Delivered (mm/yy)	Location
Bungalow	1	Bungalow (see contents below)	Complete	08/98	Elevator 5 Site
Image-forming hardware	3	Two (2) linescan cameras and lighting system	Complete	08/98	Elevator 5 Site
AEI hardware	2	Single track, double stack AEI tag reader	Complete	08/98	Bungalow
Video capture hardware	4	1024 x 1024 pixel image grabbing and storage system	Complete	08/98	Bungalow
OCR hardware	5-12	3 PCs with 100 Mbit cards:			
		CORAIL1 (desktop)	Complete	02/01	POM
		CORAIL2 (rack-mount)	Complete	04/00	Bungalow
		CORAIL3 (rack-mount)	Complete	04/00	Bungalow
		3 sets of 1 CD-ROM reader, 1 keyboard and 1 mouse.			
		Set #1 and #2	Complete	04/00	Bungalow
		Set #3	Complete	04/00	POM
		3 sets of 1 Monitor (43 cm or 17 in.) and 1 56K modem			
		Set #1	Complete	04/00	Bungalow
		Set #2	Complete	04/00	POM
		Set #3	Complete	02/01	POM
Laptop	13		Delivered	01/01	TDC

‡ In this column, the number is a reference to the item number in Section A.1.1.

Bungalow List

Item	Description	Qty
AEI System		
AEI-SA1	AEI Site Acquisition unit	1
VRPS-12/T	Vertex power supply	1
AEI-Site PC	Pentium 120 MHz	1
Modem	External modem 33.6K	1
VTX-LIGARR	Primary protection	1
VTX-SMP1	Protection 1 smp	1
VTX-SMP2	Protection 2 smp	1
DTK-6TA1	Power bar 6 pos. + ditek tel protection	2
PRDTK-4LVLPX	Terminal screw protector	1
LICO system		
RMO-CFR-A1	Card frame	1
TC64-assy	TC64 assembly	1
TIF	Trackside interface board	1
TSM	Trackside master board	1
VCA-100	Video Correction Amplifier	1
LIGHT-100	Light contactor	2
LININT	Linear camera interface board	2
LICO PC	Pentium 200 MHz	2
DT 3152LS	Frame grabber	2
ATIB	ATIB	2
Server System		
Server PC - Novell	Pentium II 300 Mhz	1
AT-2500TX-001	10/100 Mhz Fast Ethernet card	4
AT-FS708-15	Auto sensing switch	1
SR930A-R2	Monitor/Keyboard/Mouse switch	1
Bungalow and Accessories		
RMO-RM	53 cm or 21 in. rack	2
RMO-SHF-M	PC/Monitor shelf	8
RMO-Wiring	Wiring for rack	1
RMO-PS	Power supply	1
BUN-CSXST	Bungalow complete - single track	1
	VGA Monitor (38 cm or 15 in.)	1

A.2.2 Software

Name	Ref#[‡]	Description	Completion Status	Date Delivered (mm/yy)	Location
WindowsNT	1	3 CD-ROMs WinNT 4.0 Licences Licence #1 Licence #2 Licence #3	 Complete Complete Complete	 02/01 04/00 04/00	 CORAIL1 CORAIL2 CORAIL3
PC-Anywhere	3	3 licences Licence #1 Licence #2 Licence #3	 Complete Complete Complete	 02/01 04/00 04/00	 CORAIL1 CORAIL2 CORAIL3
OCRail.exe	2	2 copies	Complete	04/00	CORAIL2 & 3
OCRail.dll	4	2 copies	Complete	04/00	CORAIL2 & 3
BIC codes	5	2 copies	Complete	04/00	CORAIL2 & 3
Neural nNets	6	2 copies of the files created by training the neural network from the database of symbols	Complete	04/00	CORAIL2 & 3
Config. files	7	2 copies	Complete	04/00	CORAIL2 & 3
List of tools	8	Used during development	Complete	03/00	See A.1.2
Project tools	9	Developed within project	Complete	-	See A.1.2

‡ In this column, the number is a reference to the item number in Section A.1.2.

A.2.3 Documentation

Name	Ref#[‡]	Description	Completion Status	Date Delivered (mm/yy)	Location
Software design	1,2,3,6	Control state diagram General data flow diagrams Class static diagrams Definition of the file formats: IMG, IM$, LOG, OCR, ICR, “EDI” AEI/OCR files	Complete	02/01	TDC
Test plan	7	Test support document	Complete	02/01	TDC
Acceptance tests report	8	Report on: Factory Tests Compatibility Tests Acceptance Tests	Complete	02/01	TDC
System operator manuals	9	AEI OCR	Complete	02/01	TDC
Maintenance	10	AEI/OCR system	Complete	02/01	TDC
Installation and set-to-work	11	AEI/OCR system	Complete	02/01	TDC
Training manuals	12	AEI OCR	Complete	02/01	TDC
Source code	4,5	CR-ROM containing file types: DSW, DSP, C, CPP, H, RH, RC	Complete	09/00	TDC

‡ In this column, the number is a reference to the item number in Section A.1.3.

A.2.4 Training

Name	Ref#[‡]	Description	Completion Status	Date Delivered (mm/yy)	Location
Training	1	Training at POM	To be done	-	N/A

‡ In this column, the number is a reference to the item number in Section A.1.4.