Summaries of Three
Critical Infrastructure Applications

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1 Introduction

Modern society depends on a wide variety of infrastructure services, for example power distribution, telecommunications, transportation, and financial systems. Without these services, normal life would be severely disrupted, and so they are referred to as critical infrastructure applications.

It is often the case that critical infrastructure applications are supported by large computerized information systems. Frequently, these information systems are so extensive and so important that the activities of the associated critical service cannot proceed if the information system is not working correctly. Loss of the information system or its defective operation usually leads to severe reduction - or complete loss - of service.

Complicating an already difficult situation is the interdependence of many infrastructure applications. For example, although limited protection against loss of power is afforded for some information systems, service following a power loss is usually reduced considerably. Thus, for example, management of transportation systems will be affected significantly if there is a widespread loss of power. Similarly, loss of communication service will disrupt many other information systems such as finance, electronic commerce, and transportation.

In order to be able to develop technology that will improve the survivability of the information systems used by infrastructure applications, it is necessary to understand the characteristics of the applications. This report presents the results of an investigation into the information systems used by three critical infrastructure applications: banking and finance, rail transportation, and air traffic control. In each case, key parts of the system are described together with minimal information about the underlying computing systems. For the banking and finance domain, the functionality of the payment systems is described. For rail transport, the emphasis is on the system-wide management of equipment and resources. For air traffic control, the major aspects of aircraft routing are described.

The complexity of these systems precludes their complete description in this report. The descriptions rely heavily on material cited in the bibliographies, and a thorough understanding requires review of several of the references.

The remainder of this report has major sections for each application area, and these sections are followed by a bibliography, list of acronyms, and glossary for each area.

2 Financial Payment Systems

2.1 INTRODUCTION

The nation's payment systems are the core component of the nation's entire financial industry. The payment systems are composed of sets of rules, institutions, and technical mechanisms for the transfer of money. They permit the ownership of products, funds, securities (stocks, bonds, etc.), options and futures contracts, and other financial instruments to be exchanged and paid for between financial institutions, businesses, government entities, and consumers. These payment systems are critical for the efficient functioning of the nation's modern market economy, and in fact, the worldwide economy. The daily business operations of every industry in the United States relies on the payment systems in order to pay salaries and buy supplies, collect funds from customers, and save and invest monetary resources.

The national payment systems infrastructure consists of two primary groups of systems:

Wholesale payments ($3 million average value), clearance and settlement systems

Examples include Fedwire, Clearing House Interbank Payments System (CHIPS), and Society for Worldwide Interbank Financial Telecommunications (S.W.I.F.T.).

Retail payments ($25 average value), clearance and settlement systems

Examples include checks, credit cards, Automated Clearing House (ACH: electronic deposits of paychecks, direct billing of insurance premiums, etc.).

Other components of the payments systems infrastructure that are not covered in this section include:

Equities, Treasuries, Futures and Options

Examples include equities clearance and settlement, treasuries and the Fedwire Book-Entry securities system, futures and exchange-traded options.

New and emerging products and services

Examples include stored-value cards, electronic banking, and financial services over the Internet.

For each wholesale and retail payment system, the following information is identified:

- Description and key features
- Process Description
- Regulatory Information
- Statistical Information
- Risks and Risk Mitigation Strategies

This section begins with a background and an overview of the financial payments system and the banking system in particular. An analysis of the structure and role of the Federal Reserve and its Automation Services group is presented next. This is followed by examinations of the wholesale payments systems and the retail payments systems.

2.2 BACKGROUND AND OVERVIEW

Key elements of the payment systems are provided through services offered by banks and the infrastructure of the banking industry. A modern market economy typically has a two-tier banking structure. The central bank provides services to commercial banks and issues bank notes and coins (currency). Commercial banks provide services to the non-bank public, including other financial firms, and to other commercial banks. The primary services that banks provide are depository accounts (bank liabilities), loans (bank assets), and transfer facilities to move money from account to account (within the same institution or between institutions). Non-cash payments (value transfers) account for almost 100% of the value of all transactions [18].

The following timeline shows the key historical events in the development of the U.S. Financial Payments Systems:

1853	New York Clearing House Association founded to exchange checks
1913	Establishment of Federal Reserve as the Central Bank
1918	Fedwire started for large-value transfers
1933-1934	Securities Act (1933) and Securities Exchange Act (1934): legislation that established most of the modern banking system
1970	Clearing House Interbank Payment System (CHIPS) founded
1972	Automated Clearing House (ACH) founded
1980	Monetary Control Act: Federal Reserve started charging fees for the payments services it provided banks
1996	Debt Reduction Act of 1996: All Federal payments must be made electronically by January 1, 1999

These are a few general principles of payment systems:

1. Payment systems that rely on fiat money as a store value and medium of exchange (i.e. systems in which an entity has the power to create money not backed by a value standard such as gold) must have price stability if an effective payment system is to develop.
2. The nation's monetary regime (the government itself or a central bank), which defines the terms and conditions under which deposit money held at commercial banks and the central bank can be used, must play a major part in determining the design for the payment system.

3. Technical efficiency (cost effectiveness and physical performance) influences the efficiency with which the stock of deposit money balances in banks is used and the degree of credit, liquidity risk, and fraud risk carried by a particular system.
4. Payment processes center around the banks' management of their currency, deposits, and access to sources of credit (very important).
5. The laws and regulations upon which payment relationships are based are as important a building block as the institutions and operational systems themselves.
6. The payment system has 'public good' characteristics that require a certain amount of official oversight that are usually discharged by a central bank.
7. The final interbank settlement is best accomplished by the transfer of balances held in accounts with the central bank (no interest earned on these balances) [18].

A major issue in financial payment systems is the regulation of large-value transfer systems. The essence of the United States legal regime governing large-value transfer systems can be summarized by the following five rules:

1. *Scope rule*: to differentiate the parties and payment instructions that are included in the law from those that are not.
2. *A trigger event*: to indicate the moment when the rights and obligations of a party to a funds transfer are manifest.
3. *Receiver finality rule*: to establish when credit to an account is irrevocable.
4. *Money back guarantee*: to cover situations where a funds transfer is not completed, combined with a discharge rule for cases where the transfer is completed.
5. *Anti-fraud rule*: to allocate liability for fraudulent transactions [18].

In order to understand payments systems, several terms must be defined. Payment system refers to the means by which monetary value and related information is transferred. Value can be transferred when a customer writes a check to a company and the funds are then transferred electronically from the customer's bank account to the bank account of the company. Related information includes the names of the payee and payor, bank account numbers, the American Banking Association (ABA) number of the payor's bank, and the date of the payment. (See the Glossary for additional definition of terms.)

Clearance is the process of transmitting, reconciling, and frequently confirming payment orders of securities transfer instructions before settlement takes place. This may include the netting (adding up debits and credits) of instructions and determining the final positions for settlement. Settlement is the final step in the transfer of value. In a banking transaction, settlement is the process of recording the debit and credit positions of the payor and payee; in a securities transaction, settlement includes the transfer of securities by the seller and the payment by the buyer.

Payment systems must provide for a reliable and accurate exchange, transactions must be reasonably secure, and finality of payment must be ensured (transactions cannot be reversed). In almost all systems there is a delay in time between the exchange of instructions and the final settlement. For the check clearing system, the delay can be several days because of the air and ground transportation necessary to present the actual check to the payor bank for final settlement. However, for electronic funds transfer systems, the delay can be minutes, hours, or a day.

There are several risks associated with each system. The most significant risks and associated mitigation strategies are discussed. An example of a business risk is the counterparty/credit risk that one party in a transaction will fail to fulfill its obligation. Wholesale systems for large-value payments generally have greater security and risk controls than do retail systems [18].

2.3 FEDERAL RESERVE: THE NATION'S CENTRAL BANK

The Federal Reserve System was created in 1913 to manage the nation's money supply and provide stability to the nation's financial markets. Today, the Federal Reserve has three primary responsibilities:

- Influencing the supply of money and credit and establishing monetary policy;
- Regulating and supervising bank holding companies and certain commercial banks;
- Providing payment services to depository financial institutions and the U.S. Treasury Department (fiscal agent to the U.S. Government).

In a complex banking system with thousands of participants, it is inefficient for banks to establish large numbers of bilateral relationships and hold many accounts at correspondent banks for settling purposes. Correspondent accounts can be expensive. Every bank must be prepared to meet customer's needs to send money to or receive money from any economic entity holding an account at any other bank in the system. A central institution that provides account services to virtually the entire banking industry is required for efficient settlement [18].

The Federal Reserve System is composed of 12 regional banks along with the Board of Governors in Washington, D.C., 25 branch offices, and 11 regional check processing centers nationwide. 9,500 of the nation's 26,000 banks are members of the Federal Reserve. The smaller non-member banks have access to the Federal Reserve System through a correspondent relationship with a member bank. Member banks are required to maintain a reserve requirement of 10% of total assets at their respective reserve bank.

The Federal Reserve System is the most critical component of the nation's financial payments system. Most of the nation's Electronic Funds Transfers (EFT) - whether it is a large dollar payment via Fedwire ($3 million average), the transfer of funds to settle a check, or an ACH payment - must go through the Federal Reserve System to settle. All of the Federal Reserve banks serve as settlement banks. This means that instead of presenting a check or transfer of funds directly to the payor bank, it is presented to a settlement bank (clearing house) which will have accounts for the payor's bank and the payee's bank. The Federal Reserve bank will then debit the payor bank's account and credit the payee bank's account. The payee bank will then make the funds available to the payee.

All member banks must use the Federal Reserve's proprietary software, Fedline Station, to access the system. The software requires the minimum specifications of networked Intel 486-based PCs. Member banks can use the Fedline Station software to link directly via a leased line to the nearest Federal Reserve bank and transfer funds, buy or sell annuities and treasury bonds, etc. for their own account or for customers. For example, if a company wanted to pay a $3 million down payment as part of a contract, it would instruct its bank, which would then use the Fedline Station to enter the transaction and routing instructions.

2.3.1 Federal Reserve Automation Services (FRAS)

In 1996, the Federal Reserve completed the consolidation of its data processing facilities from sites at each of the 12 reserve banks to 3 data centers (Richmond, VA, East Rutherford, NJ, and Dallas, TX) and 2 network operations centers (Richmond, VA, and Chicago, IL). The headquarters is in Richmond. The customers are the Federal Reserve banks, not the depository institutions themselves. The responsibilities include system software (MVS, IMS, etc.), operations, resource planning, and change control [9]. The division of functions between the sites is shown below:

Site	Functions & Hardware
East Rutherford, NJ	Primary for central applications (national, i.e. Fedwire) District Electronic Payments Systems (DEPS) for New York Federal Reserve Contingency for Richmond IBM ES9000
Richmond, VA	Primary for 6 Districts, District Unique Network Operations: Focus on Access & SNA Contingency for East Rutherford, Dallas and Chicago Amdahl 1400 (2), IBM ES9000, HDS GX8000 (2)
Dallas, TX	Primary for 6 Districts, District Unique Amdahl 1400 IBM ES9000, HDS GX8000
Chicago, IL	Network Operations: Focus on backbone & non-SNA Contingency for Richmond

Term/Applications:

- District Unique: Payroll, Inventory, 4GL, 12 Hour off-site recovery

- District Electronic Payments Systems (DEPS): One system per district, primary, On-site XRF, and contingency
- Central Applications (One centralized copy for all districts):
  - Fedwire
  - Automated Clearing House (ACH)
  - Integrated Accounting
  - Treasury Direct and Ca$hLink
  - National Book Entry-securities

2.3.2 FEDNET: High Speed Telecommunications Network

The Federal Reserve and depository institutions are connected via a high-speed telecommunications network called FEDNET. The network was completed in 1996. All of the 9,500 depository institutions that are members of the Federal Reserve and have accounts at a Federal Reserve branch use the proprietary Fedline Station software to perform various transactions with the Federal Reserve. These include sending funds using Fedwire, making routine payments via ACH, buying/selling Treasury bills and other annuities, etc. System characteristics include the following:

- Leased Line access - digital service; connects to nearest Federal Reserve branch
- Dial-up access - distributed among three sites (multiple carriers)
- Physical backbone - Time Division Multiplexed
- Logical services - SNA; nodes (3745) at most Federal Reserve System offices
- LAN IPX or TCP/IP [2]

2.4 WHOLESALE PAYMENT SYSTEMS

Wholesale payments are large-value payments made by large financial institutions and other corporations. The two primary large-dollar value electronic payment systems in the United States are Fedwire and Clearing House Interbank Payments System (CHIPS). The Federal Reserve's Fedwire is primarily used for domestic payments and CHIPS is used for U.S. dollar payments related to foreign transactions. Table 1 displays a summary of the two primary large-value systems.

	Fedwire	**CHIPS**
Type of System	Gross settlement system with central bank credit	Privately operated multilateral net settlement system
Year Started	1918	1970
Governing body	Federal Reserve System	New York Clearing House
Operating Day	8:30-18:30	7:00-16:30
Settlement times	Continuous	Before 18:00
Number & type of participants	11,435 banks	20 settling banks and 119 non-settling banks

Daily average transaction volume (1996)	328,000	213,000
When is payment settled finally and irrevocably on books of central bank?	When payment is accepted for processing.	By 18:00.
Bilateral credit limits	None.	Each participant determines maximum amount it is willing to receive from each other participant.
What happens if not enough funds in sender's account at settlement time?	For institutions subject to real-time monitoring, account balance with the Federal Reserve bank is continuously monitored. If overdraft amount reaches a predefined cap, transaction is either rejected or pending until covering funds are received.	Settlement is guaranteed against failure of largest net debtor defaulting on its obligation by participants in arrangement and a loss sharing procedure is in place to back up guarantee [18].

Table 1. Summary Profile of Large-Value Systems

2.4.1 Fedwire Electronic Transfer of Funds

The Fedwire funds transfer service allows depository institutions to transfer funds for their own accounts or customer accounts. Approximately 11,000 institutions have access to Fedwire [18]. The Department of the Treasury and other federal agencies also use Fedwire to make payments and collect funds.

Fedwire is real-time gross settlement (RTGS) system that operates from 8:30 a.m. Eastern Time (ET) to 6:30 p.m. The electronic funds transfers are conducted via the FEDNET that electronically links all Federal Reserve Banks and branches with depository institutions. A critical feature of Fedwire is that it offers immediate finality. This distinguishes it from any other electronic payment system operating in the United States. The Federal Reserve "guarantees" the payment to the depository institution receiving the Fedwire transaction and assumes any credit risk if there are insufficient funds in the Federal Reserve account of the bank sending the payment. Fedwire transactions are typically completed in a matter of seconds.

Fedwire is operated by the Federal Reserve Automation Services (FRAS) facility at the East Rutherford Operations Center (EROC). The primary (XRF) backup facility is also at the EROC site and the secondary backup facility is in Richmond. The secondary back-up facility can begin processing transactions within 30 minutes of a decision to change the processing sites.

Process Description

The following example demonstrates the steps of the Fedwire transaction process:

1. Customer A requests $1 M in its depository account at Bank A to be transferred to Customer B's account at Bank B.
2. Bank A transfers $1 M for Customer A by sending a message over Fedwire authorizing the Federal Reserve to electronically debt Bank A's account at the Reserve Bank for $1 M and to transfer $1 M to Bank B's account.
3. Once the payment of $1 M is credited to Bank B's account, the Fedwire funds transfer is completed. For member depository institutions, the time elapsed is only a few seconds.
4. When the Fedwire transaction is completed, Bank B makes the $1 M available to Customer B on the day the payment occurs [3].

Regulatory Information

Fedwire's funds transfers are regulated under subpart B of the Federal Reserve's Regulation J. This generally incorporates Article 4A of the Uniform Commercial Code (UCC) as the governing law of the Fedwire funds system [3].

Statistical Information

The total dollar volume transferred over the Fedwire funds transfer service was $249 trillion in 1996 [3]. Table 2 displays Fedwire statistics.

	1992	**1993**	**1994**	**1995**	**1996**
Average Number of Daily Messages	267,000	277,000	287,000	302,000	328,000
Average Daily Transfer Value	$787 billion	$824 billion	$841 billion	$888 billion	$989 billion
Average Value per Transfer	$2.9 million	$3.0 million	$2.9 million	$2.9 million	$3.0 million
Fees per Transaction	$0.53	$0.53	$0.53	$0.50	$0.50 [3]

Table 2: Fedwire Statistics

Risk and Risk Mitigation Strategies

Risk	**Risk Mitigation**
Counterparty credit risk	Net debit caps (including zero caps) Account balance monitoring system (ABMS) Daylight overdraft fees [1]
Operational risk	Back-up facilities Automated recovery
Fraud risk	Data security: Encryption Authentication procedures Access controls

Risk 1: Counterparty credit risk
The Federal Reserve Bank (FRB) grants finality (final and irrevocable credit) to the recipients of funds sent over Fedwire; therefore, the FRB assumes any credit risk if there are insufficient funds in the Federal Reserve account of the depository institution sending the funds. If there are insufficient funds in the sender's account, the FRB will allow the sending bank to overdraw its account. The FRB assumes risk for the amount of the overdraft. This is known as a daylight overdraft. The FRB requires depository institutions to eliminate daylight overdrafts by the close of Fedwire each day. They become unsecured overnight overdrafts if not paid by the end of the day. The FRB discourages overnight overdrafts by imposing high monetary penalties and taking administrative action against repeat offenders.

Mitigation 1: Net Debit Caps

In 1985, the FRB adopted a program of maximum limits, or net debit caps, for each depository institution. This is the maximum level of daylight overdrafts that may occur in a bank's account at the Federal Reserve. The stronger institutions may obtain a higher Net Debit Cap. Since its implementation, the FRB has found that the growth of daylight overdrafts has been restrained.

Mitigation 2: Account Balance Monitoring System (ABMS)

Net debit caps are provided by the FRBs. The ABMS allows the FRB to monitor depository institutions' account positions on a real-time basis and therefore hold or reject funds transfers that may cause account holders to overdraft their net debit caps.

Mitigation 3: Daylight Overdraft Fees

In April 1994, the FRB began charging interest for the average daylight overdraft positions. The fee was initially set at 10 basis points (0.1%) of chargeable daily daylight overdrafts. In April 1995, the fee was increased to 15 basis points. An FRB study showed that the aggregate intraday peak overdrafts fell approximately 40% for the six months following the introduction of fees.

Risk 2: Operational Risk
Any disruption to the service of Fedwire due to the enormous value and importance of the funds sent over Fedwire on a daily basis would cause significant economic and financial risks.

Mitigation 1: Back-up facilities

The primary back-up site is also located at the East Rutherford Operations Center (EROC). The back-up site is designed to resume payment processing immediately. If the entire EROC site is down, a remote database is designed to allow Fedwire to resume payment processing at its secondary back-up center (Federal Reserve Bank of Richmond) within 30 minutes. The tertiary back-up site is at the Dallas Federal Reserve Bank.

Mitigation 2: Automated Recovery

Fedwire databases are duplicated for instantaneous availability. If a database recovery is required, each participant has to retransmit only those payments that were previously sent on Fedwire and indicate the loss of payments through the recovery report [3].

Future Changes

The Federal Reserve is enhancing the Fedwire's operating environment to reduce risk related to funds transfers and to increase the usefulness of Fedwire. The two most significant changes are the expansion of the operating hours and a new, expanded message format for funds transfers. Beginning on December 8, 1997, Fedwire's funds transfer online operating hours will be expanded to an 18-hour day, from 12:30 a.m. ET to 6:30 p.m. ET. This change was driven by the potential risk of the growing volume of cross-border payments. This will also facilitate international transfers due to the increased number of overlapping hours of operation. The expanded message format is designed to improve efficiency by reducing the need for manual intervention when processing and posting transfers and by making the format more compatible with the formats used by CHIPS and S.W.I.F.T.

2.4.2 Society for Worldwide Interbank Financial Telecommunications (S.W.I.F.T.)

S.W.I.F.T. is incorporated in Belgium and is a cooperative owned by over 2,800 banks around the world, including over 150 from the United States (owning 13% of the shares). It operates a network that processes and transmits financial messages among members and other users worldwide.

1. Messages are formatted and contain information about the originator, purpose, destination, terms, and recipient.
2. The largest use is for sending instructions for payments but it can also include orders to buy and sell securities, contract specifications, a foreign exchange trade, etc.

3. The network transmits messages, not funds. The messages generally contain instructions for value transfers to be made on CHIPS or Fedwire.

Statistical Information

An average of 2.4 million messages per day of all types is processed by S.W.I.F.T. The value of the payments messages averages $2 trillion per day.

2.4.3 Clearing House Interbank Payments System (CHIPS)

CHIPS is privately owned and operated by the New York Clearing House Association (NYCHA). Eleven New York money center banks comprise the membership of NYCHA. CHIPS began operations in 1970 as an electronic replacement for paper checks. The payments transferred over CHIPS are primarily related to interbank transactions of an international nature, including the dollar payments resulting from foreign currency transactions and Eurodollar placements and returns.

In 1996, there were 103 CHIPS participants representing financial institutions from 29 countries. Participants may be commercial banks, Edge Act corporations (chartered by the Federal Reserve to engage in international banking for financing trade), or investment companies. A CHIPS participant is required to maintain a branch or agency in New York City. Settling participants must maintain funds and book-entry accounts at the Federal Reserve Bank of New York. There are 19 settling banks and 84 non-settling banks. If a non-participant United States bank wants to transfer funds to a foreign bank, it must employ one of the CHIPS participants to act as its agent to transfer funds to the foreign account [20].

CHIPS transfers are irrevocable, but they are final only after the completion of end-of-day settlement (Fedwire offers immediate finality). CHIPS nets its transactions on a multilateral basis. If a bank receiving a CHIPS transfer makes funds available to its customers before settlement is complete at the end of the day, the bank is exposed to the risk of loss if CHIPS does not settle. However, CHIPS has never failed to settle in its 27 years of operation.

The CHIPS communications network is a single-node network with all participants connected directly to a single message-switching center. CHIPS maintains a primary and back-up site. Participants are connected directly to both sites. All connections have additional contingency dial-up lines. All CHIPS participants must maintain data communications circuits and two computer processing facilities in the New York City area (primary and contingency).

Settlement occurs through designated settling participants. Non-settling participants must rely on the settling correspondents to settle for them. Immediately after CHIPS closes at 4:30 p.m. each day, the clearinghouse informs every participant of its net position and each settling participant of the overall net positions of the settling participants for which it settles. CHIPS notifies each settling participant who has a net debit position to transfer funds to the CHIPS settlement account at the Federal Reserve Bank of New York by 5:45 p.m. When all net debit obligations have been paid, the clearinghouse transfers funds via Fedwire to all settling participants in a net credit position and notifies all participants by 6:00 p.m. that settlement is complete [3].

Process Description

The following example shows a typical CHIPS transfer process:

1. Bank A in Paris instructs its New York branch to pay $1 M to Bank B for deposit in the account of a particular company.
2. An employee of Bank A's branch in New York enters the payment information into the branch's CHIPS interface computer.
3. The central CHIPS computer authenticates, stores, and acknowledges the message.
4. Bank A's branch bank, via its computer interface, releases the payment message to CHIPS.
5. CHIPS compares the amount against limit controls. If it is within the controls, CHIPS sends the payment message to Bank B's interface computer (authenticates the message) and records a debit for Bank A and a credit for Bank B.
6. Final Settlement of CHIPS:
   a) At 4:30 p.m. ET, CHIPS closes and notifies each participant and settling participant of its respective net debit or credit position.
   b) By 5:00 p.m. the settling participants in a net debit position must send a Fedwire funds transfer to the CHIPS settlement account at the FRB at NY.
   c) When all settling participants have paid their respective amounts to this account, NYCHA sends Fedwire funds transfers from the CHIPS account at FRBNY to settling participants in a net credit position.
   d) Prior to this, the non-settling participants will have settled with their settling participants and settlement is normally completed by 5:10 p.m. [3].

Regulatory Information

All CHIPS participants are supervised by the New York State Banking Department or a federal bank supervisor. CHIPS transfers are governed by UCC Article 4A. This subsection details the rights and obligations of the various participants in a wire transfer.

Statistical Information

Table 3 displays CHIPS statistics.

	1992	**1993**	**1994**	**1995**	**1996**
Average Number of Daily Messages	154,439	167,311	181,667	203,318	212,544
Average Daily Transfer Value	$942 billion	$1 trillion	$1 trillion	$1 trillion	$1 trillion
Average Value per Transfer	$6 million	$6 million	$7 million	$6 million	$6 million
Fees per Transaction	$0.15	$0.15	$0.15	$0.15	$0.15
Number of CHIPS participants	122	121	115	111	103 [3]

Table 3: CHIPS Statistics

Risks and Risk Mitigation Strategies

Risk	**Risk Mitigation**
Systemic risk/counterparty credit	Same-day settlement Bilateral credit limits Net debit caps Loss sharing-backed up by collateral Membership requirements
Operational Risks	Back-up facilities Automated recovery

Risk 1: Systemic risk/counterparty credit

This risk occurs when one participant fails to meet its obligation and causes other participants not to meet their obligations.

Mitigation 1: Same-day settlement

In 1981, NYCHA instituted same-day settlement and dramatic improvement resulted. This has eliminated overnight exposure to failures, reduced float in the banking system, and accelerated the availability of funds to customers.

Mitigation 2: Bilateral credit limits

In 1984, NYCHA began to require that each CHIPS (typically 105-115 members) participant establish a bilateral credit limit with each of the other CHIPS participants. Each CHIPS participant must indicate whether or not it is willing to receive payment messages from other participants. If so, then each participant must set a limit on the maximum net-dollar amount that it is willing to receive from the other participant. The CHIPS operating system automatically monitors payment messages and checks them against bilateral limits. If a payment message would result in a transfer exceeding the bilateral limit, CHIPS would not allow the payment message to be released.

Risk 2: Operational Risk
Due to the enormous value of dollars sent over CHIPS ($trillions), even a temporary outage in the CHIPS electronic system would present significant economic and financial risks.

Mitigation 1: Back-up facilities

The remote database, established by CHIPS, is designed to allow CHIPS to resume processing at the backup center within 5 minutes of a decision to relocate operations. Because of the trillions of dollars sent over CHIPS, even any temporary outage would present serious economic and financial risks.

Mitigation 2: Automated recovery

CHIPS has a computerized method for rebuilding its database. According to the NYCHA, CHIPS quarterly tests its contingency plans in mandatory exercises involving all participants [3].

2.5 RETAIL PAYMENT SYSTEMS

A discussion of small-dollar retail payment systems includes checks, credit cards, and the Automated Clearing House (ACH). Retail payments are primarily small-dollar payments used by individuals and businesses in payment for goods and services.

2.5.1 Checks

The paper check is the oldest and most frequently used payment instrument in the United States that is used for payment for goods and services. Paper checks account for the largest number of transactions of non-cash payments made in the Unites States.

Check clearing is the movement of a check from the depository institution at which it was deposited back to the institution on which it was drawn (or written). The funds move in the opposite direction, with an appropriate credit and debit to the respective accounts. Paying bank is the bank at which a check is payable and to which it is sent for payment or collection.

A paper check includes the following information:

- Names of payor and payee
- Amount of check
- Name of paying bank
- Magnetic ink character recognition (MICR) line at the bottom for high speed processing. This sequence of numbers includes a two digit code that identifies the bank's Federal Reserve district, the bank's 4 digit ABA# (American Banking Association), the check number, and the account number of the check writer.

There are several different methods of depositing checks:

- On-us checks: Checks are deposited at the same bank on which they were drawn. Banks can settle these in-house.
- Interbank checks: Checks are not drawn on the depository institutions at which they were deposited. There are four subcategories of interbank checks:
    - Direct presentment: Checks are presented directly to the paying bank.
    - Correspondent banks: Correspondent banks can settle the checks that they collect for other institutions by using accounts on their books or by sending Fedwire funds transfers.
    - Clearing house association: Banks have formed many voluntary associations that establish a meeting place for the exchanging of checks drawn on those banks. Typically, however, banks participating in check clearing houses use the Federal Reserve's net settlement service to effect settlement for the checks exchanged each day. Examples include the largest banks, e.g. Citicorp, Chase, etc.
    - Federal Reserve Banks: The Federal Reserve operates a comprehensive, nationwide system for clearing and settling checks [18].

Clearing houses are voluntary associations of depository institutions that facilitate the exchange of payment transactions (checks) at a centralized location. In 1853, the first clearing house in the United States was established as the New York Clearing House Association. Presently, there are about 150 private clearing houses. The share of checks processed by the Federal Reserve System has fallen dramatically since the Federal Reserve began charging banks for its check processing services in the Monetary Control Act of 1980. Only about 40% of all check processing is now done through the Federal Reserve System. Checks are also processed at regional banking clearing houses, regional/national clearinghouses, and correspondent banks.

Process Description

An example showing the steps involved in processing a check is the following:

1. Company B receives Customer A's check for $100 and deposits the check into its account with Bank B.
2. Bank B codes the value of the checks it received from Company B (using MICR) on the bottom of the check, bundles it with other checks it received on Day 0, and deposits the bundle of checks with the L.A. Branch of the Federal Reserve Bank of San Francisco. Bank B credits Company B for the value of its deposits as "unavailable" funds.
3. The L.A. branch sorts the checks using high-speed sorters that read the MICR characters on the checks to verify the amount of Bank B's deposit and to sort checks by their various destinations. Consumer A's check will be sent with other checks drawn on banks located in the same territory served by the Federal Reserve Bank of New York.

4. The L.A. Branch ships the bundle of checks to the Federal Reserve Bank of New York by air.
5. The Federal Reserve Bank of New York receives the bundle of checks shipped to it by the L.A. branch. Again, using high-speed sorters, it verifies the dollar amount and number of the checks received from the L.A. branch, sorts them by the banks that they are drawn, and bundles them accordingly.
6. The New York Federal Reserve delivers the checks to the paying banks, including Bank A, by ground carriers.
7. After Bank A receives its checks, the New York Reserve Bank debits its Federal Reserve account and credits the L.A. Branch through the Federal Reserve's accounting system. Almost simultaneously the L.A. Branch credits the Federal Reserve account of Bank B.
8. Bank A processes the checks using its sorting equipment, capturing data on the value of each check written by each of its customers. Bank A then debits Customer A's account.
9. On day 2-5, Bank B makes the $100 available to Company B [3].

Statistical Information

Table 4 shows the volume of checks cleared at each major institution.

	1992	**1995**	**% Change**
Federal Reserve	19.1 billion	15.5 billion	-19%
CBCH	1.3 billion	1.6 billion	+20%
CCH	385 million	563 million	+46%
NYCHA	493 million	336 million	-32%

Table 4: Check Clearing Volume

Risks and Risk Mitigation Strategies

<u>Risk</u>	**<u>Risk Mitigation Strategy</u>**
Return item risk	Credit monitoring Large-dollar return notifications Electronic check presentment
Check fraud risk	Positive pay Electronic check presentment

Risk 1: Return item risk
A check may be returned to the depository bank unpaid if there are insufficient funds in

the account, the account is closed, a stop payment order has been issued, a signature is found to be fraudulent, or the paying bank failed. It takes on average 5.5 calendar days for local and non-local checks to complete a full cycle.

The risk faced by the banks depends on when they make the funds available to their customers. Banks are obligated by the Expedited Funds Availability Act of 1987 (EFAA) to make funds available based on mandatory funds availability schedules. This may result in the bank making funds available before a check is returned unpaid. When the depository bank receives a return item it will charge back its depositing customer's account for the item even if it has already made the funds available to the depositing customer. The depository bank is exposed to risk that the customer does not have sufficient funds in his account.

Mitigation 1: Credit monitoring

Federal Reserve recommends that depository institutions assess the credit of customers for which they collect large-dollar volumes of checks and monitor the payment activity of their customers.

Mitigation 2: Large-dollar return item notification

Federal Reserve Regulation CC requires that when a paying bank decides to return a check of $2,500 or more, it must provide a notice of nonpayment to the depository bank. The notice must be received by 4:00 p.m. local time of the depository bank on the 2nd business day following the banking day on which the check was presented.

Mitigation 3: Electronic check presentment (ECP)

ECP reduces the risk by permitting banks to deliver check data sooner than with paper checks. The shorter time enables the paying banks to identify checks that cannot be paid and notify the depository bank about those returned checks up to 1 day earlier by using an electronic notice. This would enable the depository bank to know that it should not make the funds available to the depositing customer. The use of ECP is increasing but is not yet of general use.

Risk 2: Check fraud

Check fraud accounts for losses that reduce bank profits by almost 1 percent. The total for 1995 was $615 million for depository institutions. Types of check fraud include check kiting, forgery, altered checks, counterfeit checks, and paperhanging. Check kiting often involves writing checks on two or more banks to fraudulently obtain interest-free unauthorized loans. Forgery involves forging a signature on a check. Altered checks have had information, such as the amount, altered on the check. Counterfeit checks are imitation or copies of genuine checks. Paperhanging involves checks written on closed accounts.

Mitigation 1: Positive pay

A corporation sends an electronic file of information on all checks to its bank. The bank reconciles this list with those checks presented for payment. If a check presented for payment is not included in the positive-pay list, the corporation is notified and requested to make a pay/no pay decision.

Mitigation 2: Electronic check presentment (ECP)

Electronic check presentment permits the paying bank to identify earlier the checks that cannot be paid and notify the bank of first deposit of an impending returned check [18].

Future Changes

Clearing houses, the banking industry, and the Federal Reserve are developing new technologies to shorten the time it takes to clear and settle checks. Electronic check presentment (ECP) is a process by which MICR-line information is sent electronically to the paying bank. Many large commercial banks participate in the Electronic Check Clearing House Organization (ECCHO), formed in 1990. ECCHO drafts rules and designs formats for electronic check processing for its members. This process enables ECCHO participants to exchange electronic check data before the paper checks are presented for payment.

ECP can also include check truncation and check imaging technology. The process of check truncation involves retaining the paper check at some point in the collection process, and only the information is sent to the paying bank. ECCHO is developing a set of national rules for check truncation. Check imaging involves taking a digital picture of the front and back of a check, and the images are stored on electronic media for processing.

The Federal Reserve currently offers ECP products to member banks. In 1996, the Federal Reserve electronically presented to paying banks 1.4 billion checks, or 9% of checks collected by the Federal Reserve. By January 1996, 2,200 depository institutions used the Federal Reserve's ECP service (a 37% increase over 1995). In 1992, NYCHA created the Clearing House Electronic Check Clearing System (CHECCS), in which the Federal Reserve's ECP is a key component.

The primary constraint to the growth of check truncation and imaging is the consumer preference for their returned checks. Current banking law requires banks to physically present checks to paying banks to obtain settlement for checks [18].

2.5.2 Credit Cards

A credit card is a payment card issued to a person for purchasing goods and services against an established line of credit. Two types of credit cards are issued: those issued by vendors or merchants such as oil companies or department stores and general purpose credit cards issued by financial institutions (VISA, Mastercard, etc.). Credit cards enable cardholders to make minimum monthly payments and carry over balances, on which interest is charged. Cardholders may also obtain cash advances. Table 5 displays the growth in cardholders from 1990 to 1995.

Credit Card Company	Number of Cards 1990	Number of Cards 1995	% Change
VISA	120.1	221.1	84%
MasterCard	88.2	144.1	63%
American Express	25.9	26.7	3%
Discover	37.8	45.1	19%

Table 5: Growth in Cardholders from 1990 to 1995

The total charge volume of VISA, MasterCard, American Express and Discover increased 318% from 1985 to 1995.

Process Description

The following steps are involved in a credit card transaction:

1. Authorization: A cardholder uses a major credit card to make a purchase from a merchant.
2. Clearance Begins: The merchant electronically submits the cardholder's CCC draft, along with all the other credit card drafts, to its bank at the end of the day.
3. The merchant's bank credits the merchant's account. The merchant's bank submits the cardholder's draft, as well as other credit card drafts, to the major credit card company.
4. The major credit card company receives the drafts and sends them to each card-issuing bank.
5. Settlement Begins: The major credit card company adds up the amount of money that each card-issuing bank owes (including the cardholder's bank).
6. The card-issuing bank pays the major credit card company via Fedwire.
7. The major credit card company pays the merchant bank.
8. The card-issuing bank then bills the cardholder.
9. Card-issuing bank receives payment from the cardholder [3].

Step 1 is the only Authorization procedure. Steps 2-4 correspond to the Clearance procedure. Steps 5-9 determine Settlement.

The credit card companies are international in nature (cardmembers all over the world are making charges every day). Therefore, the credit card companies operate on a daily processing cycle on Greenwich Mean Time, which starts at 7:00 p.m. EST and ends at 7:00 EST the next day. Member banks of a major credit card company may be required to maintain collateral with the credit card company in the event of a failure.

Regulatory Information

The primary federal laws governing credit card issuance and operation are the Equal Credit Opportunity Act of 1974 and the Truth in Lending Act of 1974. These laws are implemented in Federal Reserve Regulations B and Z. Regulation B prohibits lenders from discriminating against applicants and establishes guidelines for gathering and reviewing credit information. Regulation Z requires uniform methods for computing cost of credit and disclosing credit terms, prohibits the unsolicited issuance of credit cards and limits cardholder liability for unauthorized use.

The Fair Credit and Charge Card Disclosure Act of 1988, the Fair Credit Billing Act of 1974 and the Fair Credit Reporting Act of 1970 also govern solicitation and reporting requirements for credit card issuers.

Risks and Risk Mitigation Strategies

Risk	Risk Mitigation Strategy
Fraud risk	Neural networks Address verification service Issuer's clearing house service
Credit risk	Credit monitoring

Risk 1: Fraud risk
Fraud risks result from unauthorized use of lost or stolen credit cards, fraudulent applications, counterfeit or altered cards, and fraudulent use of a cardholder's credit number. Fifty percent of all credit card fraud results from lost or stolen credit cards. Cardholders are responsible for at most $50 if they report. A merchant is responsible for paying any costs related to credit card fraud if the merchant does not do at least one of the following: obtain an authorization, cardholder's signature, or the electronic imprint of the card. Issuing banks are responsible for paying approximately 70% of the credit card fraud costs while merchants are responsible for the other 30%.

Mitigation 1: Neural Network

Neural networks allow a card-issuing bank to track the cardholder's spending patterns, to detect any spending discrepancies, and to alert the issuing bank and the cardholder of potential fraud.

Mitigation 2: Address Verification Service (AVS)

The mail-order catalog industry developed a program called AVS that allows mail and telephone order companies to verify a cardholder's billing address on-line. The address the customer provided on the phone can be verified with the one on file with the card issuer. If different, then fraud is suspected.

Mitigation 3: Issuer's Clearing House Service (ICS)

VISA and MasterCard developed the ICS database to detect fraudulent credit applications. ICS allows credit card applications to be compared against a database of invalid addresses and Social Security numbers.

Risk 2: Credit
Consumer delinquency and default are the primary credit risks to the issuer. If the cardholder defaults, then the issuing bank is liable to the merchant's bank.

Mitigation: Credit Monitoring

Issuing banks can mitigate these credit risks through the normal authorization process of charges and credit reviews of customers. If a customer has been delinquent on a bill, the card-issuer can deny authorization for a transaction. Financial standards can also be applied in the application process [3].

2.5.3 Automated Clearing House

An automated clearing house (ACH) network is an electronic batch processing system by which payment orders are exchanged among financial institutions. In 1972, the Federal Reserve started the ACH and it was designed for high-volume, predominantly small-dollar recurring payments, such payroll, mortgage, insurance, loans, Social Security, Federal employee retirement, disability and corporate tax payments. A significant difference for ACH transactions is that they can be debits or credits.

The fees for ACH are only $0.01 compared to $0.50 for the Fedwire and $0.13 to $0.40 for a CHIPS transfer. This has resulted in many organizations using ACH for large-value transfers. This involves greater risks because the ACH networks are not as secure as the Fedwire. The Debt Reduction Act of 1996 requires that almost all federal payments be made electronically by January 1, 1999. This will continue to strongly increase the growth in the use of ACH, particularly by the government.

Process Description

There are two major processes associated with Automated Clearing Houses: credit transactions and debit transactions.

The steps involved in an ACH credit transaction are the following:

1. Company A (originator) originates an ACH credit transaction for each of its employees.
2. Company A electronically transmits its ACH transactions to its bank, Bank A (originating institution).
3. Bank A edits the ACH transactions, then it balances the total value of the individual transactions against the total value Company A says it sent to Bank A.

4. Bank A combines Company A's ACH transactions from its other customers; then it electronically transmits these to the Federal Reserve, which receives them at its centralized ACH processing center (EROC).
5. After EROC receives Bank A's ACH transactions, Fed ACH (operating system) sends a copy of them to a back-up processor.
6. Federal ACH sorts all transactions, then it electronically transmits them to the banks (receiving Institutions) of Company A's employees (receivers) in Chicago, Los Angeles, Washington, D.C., and to NYACH. NYACH will transmit the transactions to the New York Federal Reserve.
7. At 8:30 a.m. (ET), the Federal Reserve posts the debit to bank A's reserve account (or Bank A's correspondent account) and posts the credits to the receiving institutions of Co. A's employees in Chicago, Los Angeles, Washington, D.C., and New York. This payment is now provisionally settled.
8. Each of the employees' banks posts the value of their pay to their accounts, making it available at the opening of business.
9. After the Federal Reserve completes its accounting and settlement of the ACH transaction is final [3].

The steps involved in an ACH debit transaction are the following:

1. The mortgage company (originator) prepares the withdrawal information and submits the information to its deposit institution, Bank A, in San Francisco.
2. Bank A presents the ACH debit entry for $2,000 to VISA, Bank A's ACH operator.
3. VISA processes the information and transmits the ACH debit entry or $2,000 to NYACH via PAX. The homeowner's depository institution Bank B (receiving institutions) uses NYACH as its ACH operator.
4. NYACH presents the debit information to Bank B.
5. Bank B debits the homeowner's account for $2,000 and sends that transaction in a file to VISA.
6. VISA receives the file from Bank B including the $2,000 transaction and sends the file to Bank A including the $2,000 transaction using the Federal Reserve net settlement service.
7. VISA settlement is final when Bank A is credited. Bank A makes the funds available to the mortgage company no later than close-of-business that day [3].

Regulatory Information

The ACH is primarily governed by private sector bodies. The National Automated Clearing House Association (NACHA) has set forth the NACHA Operating Rules and Guidelines as the operating rules for electronic payments through the ACH. These are supplemented by local ACH associations. NACHA represents 38 regional ACH associations and their more than 14,000 depository institution members. The Federal Reserve recognizes the NACHA as the informal rulemaker, but states that it has no authority over enforcement.

Depository institutions using the Federal Reserve's ACH services must comply with the Reserve Banks' uniform ACH Operating Circular, which incorporates the operating rules of the NACHA by reference with a few modifications. In addition, depository institutions must comply with the Federal Reserve's Regulation E, which implements the Electronic Funds Transfer Act. Corporate ACH credit transactions are governed by UCC 4(A). If the Federal Government is the originator, the transactions are governed by Treasury Department's regulations 31 CR Part 210.

Statistical Information

Table 6 shows the transaction volumes of the largest Automated Clearing House providers.

ACH Provider	1992 Items (Millions)	1996 Items (Millions)	% Change	1992 $ Volume (Billions)	1996 $ Volume (Billions)	% Change
Fed. Res. Commercial	1,275	2,372	86%	$6,500	$8,700	34%
Fed. Res. Government	531	625	18%	$860	$1,300	51%
NYACH	185	317	71%	$2,000	$2,600	30%
VISA	151	311	106%	N/A	$656	N/A
American	49	93	90%	$77	$175	128% [3]

Table 6: Largest ACH Providers

Risks and Risk Mitigation Strategies

Risk	**Risk Mitigation Strategy**
Temporal credit risk	Credit monitoring
Return item risk	Credit monitoring

Risk 1: Temporal credit risk

The originator of an ACH credit transaction is obligated to pay for any ACH that it initiates. Due to the 2-day time lag between the origination of an ACH credit and the funding of the obligation late on the second day, the originating depository institution is exposed to this credit risk for as much as 3 business days.

Mitigation: Credit Monitoring

The Federal Reserve's payment system risk policy directs depository institutions to do the following:
- Perform a credit assessment of all customer's originating large-dollar volumes of ACH credit transactions.
- Establish intra-day credit limits for originating customers.
- Monitor compliance with the credit limit across all processing cycles for a given settlement date.
- Require the customer to prefund its account, provide collateral, or deposit the ACH file on the night cycle preceding settlement day.

Risk 2: Return Item

Return item risk is faced by institutions originating ACH debit transactions. This occurs when institutions receiving these messages are unable to fund the payment request. The ACH debit transactions may be returned by the receiving organization for insufficient funds, a stop order, or an unauthorized transaction.

Mitigation: Credit monitoring

The Federal Reserve payment system risk policy recommends that depository institutions originating ACH debit transaction perform a debit assessment and monitor the performance of their customers. Depository institutions should take steps to protect themselves from losses, such as delaying availability for some or all funds collected or requiring collateral or requiring balances to cover the balance of potential return items [3].

3 Rail Transportation

3.1 INTRODUCTION

Rail transportation is one of the pillars of the American economy. Much of today's economy relies on rail transportation to supply the necessary components for its production. The railroad industry is the primary mode of transportation for such vital commodities as coal, lumber, grain, minerals, and industrial chemicals. Electric power plants, food processors, refineries, automotive manufacturers, and many other industries rely on the railroads to deliver essential supplies and distribute their finished products across the country and to the rest of the world.

Consolidation in the rail transportation industry through mergers and acquisitions has reduced the number of Class 1 railroads from thirty-eight in 1980 to five in 1997. These five companies carry almost ninety percent of all rail freight [31].

The railroads are able to control their operations by integrating a number of information systems at a centralized control center. The railroad companies use a combination of proprietary and shared information networks to provide the information needed for the dispatchers and managers to make the decisions that run the system. Railroads have invested heavily in Information Systems and Information Technology to improve the safety and efficiency of their operations. Advances in Information Technology promise further improvements in the future.

Despite advantages over many other transportation sectors, rail transportation is underutilized. Consolidation in the industry has made rail transportation much more efficient, but fear of a return to the restrictive regulatory environment of the past influences many of the strategic decisions made by the railroads. Safety considerations are given an elevated importance. The management practices of the different railroads, their use of MIS, and the degree of human involvement in the control processes have evolved to a point where they are more similar than different. The transition to fully automated rail management is being driven by attempts to increase the safety of the overall system. The new technologies being adopted today are designed, in part, to produce an increase in safety. The system of the future will be implemented in phases as the economic and safety issues are addressed.

This section examines the American rail transportation system in a historical context so that the contemporary infrastructure can be better understood. The management structure that is used to make both routine and critical operating decisions is examined. An overview of the networks and systems that provide the information necessary to run the railroad industry is provided next. Finally, technologies being tested today that will be utilized in the near future are explored.

3.2 BACKGROUND AND OVERVIEW

The role of rail transportation in the growth of the American economy in the twentieth century should not be underestimated. Expansion across the North American continent could not have been accomplished without railroads. Cities such as Chicago and Kansas City owe much of their greatness today to their location as hubs for the railroad industry.

Rail transportation historically has been one of the most regulated industries in America. Beginning in 1905, a series of laws and regulations had created so many rules and inefficiencies that the railroad industry was being strangled to the point of bankruptcy.

This led to such deterioration in the condition of track and equipment that lives and freight were jeopardized. The federal government was forced to assume much of the train business. Inter-city passenger service had become so unprofitable that, in order to save the service, the federal government created Amtrak in 1971. The collapse into bankruptcy of the six major freight haulers of the Northeast (Penn Central Railroad being the largest and most celebrated of the six) forced the creation of Conrail in 1976 to maintain freight service in that region.

The construction of the interstate highway system was almost the final blow. It gave motor carriers (trucks) the ability to compete successfully with the railroads for much of the inter-city freight market. By offering competitive rates, with a much higher level of service than rail transportation could possibly deliver, the trucking industry became the preferred mode for the inter-city transportation of goods. Between the end of World War II and 1980, the railroad share of the inter-city freight transportation market dropped from 67 percent to 36 percent [40]. This had been a market traditionally dominated by railroads.

Recognizing the danger to the country by the probable loss of a viable rail transportation system in America, Congress passed the Staggers Rail Act in 1980. It moved the supervision of the railroad industry to the Interstate Commerce Commission (eventually eliminated by Congress in 1995). By removing most of the regulations and restrictions that had hindered the industry, the Staggers Act allowed the railroads the flexibility necessary to meet the competition of the motor carriers. The railroads were finally free to set their own schedules and rates to reflect the constraints of competition.

Safety-related regulation has remained an area of governmental responsibility. The Federal Railroad Administration (FRA) was created to act as watchdog and administrator of the safety of the rail transportation system. The fear of possible re-regulation will play a part in some of the technology decisions that face the railroad industry [6].

The recent development of intermodal shipping seems to offer a great opportunity for the railroad industry. By allowing goods to be shipped by the most efficient mode of transportation, whether by water, rail, or road, the railroads seem poised to gain market share. For example, the long hauls from the Pacific coast to the Midwest seem ideal for the railroads. However, the railroad industry has been slow to capitalize on this advantage because they have been unable to make timely deliveries.

This inability to exploit a natural advantage has forced the railroads to reconsider how they handle customer service [3]. Bulk shippers, heretofore indifferent to timeliness of delivery, have always been their mainstay clients. But process engineering and the move to Just in Time (JIT) inventory deliveries are gradually changing this environment. The shift to automated systems by the railroads is designed, in part, to increase the rate of on-time deliveries. Despite these problems, the rail transportation share of the freight transportation market has increased from thirty-six percent to more than forty percent since 1990 [40].

Since the Staggers Act, a consolidation of the railroad industry has taken place. In 1980, thirty-eight Class 1 (the largest railroad category, measured by revenues) railroads were in existence. The elimination or absorption of the weaker service operations and the merging of railroads that had previously been competitors has reduced the number of freight carriers. With the absorption of Conrail by CSX and Norfolk Southern, there are only five Class 1 railroads left in the United States (and two in Canada). Despite the problems that Union Pacific is experiencing in its merger with Southern Pacific, it is postulated by many in the industry that we will eventually see only two major railroads in the United States, each system connecting the Atlantic and Pacific coasts [16].

The rail transportation operating system of the future will be totally automated, with the only human interaction limited to monitoring the system. Redundancies and fail-safe systems will make automated train control a reality, providing seamless delivery service regardless of the number of railroads in existence.

While such a system seems unlikely any time soon, phased implementation is already being explored. The transition to a totally integrated, automated train control system will have at least four stages:

1. Computer-assisted train control, the system in use today.
2. Positive Train Separation, a system being tested today.
3. Precision Train Control, an automated closed loop system.
4. Totally integrated, automated train operating system.

Table 1 shows a high-level functional comparison of the phases [17].

COMPUTER-ASSISTED TRAIN CONTROL (1)	**POSITIVE TRAIN SEPARATION (2)**	**PRECISION TRAIN CONTROL (3)**	**INTEGRATED NETWORK (4)**
Reactive Safety System	Safety Overlay System	Precise Train Planning and Control	System-Wide, Closely-Bound Planning
Fixed Block	Authority and Speed Enforced	Closed-Loop System	Simultaneous Solutions
Human Dependent	Interoperable[1]		Real-Time Replans

Table 1: Phases of Automated Train Control

3.3 OPERATING SYSTEM OF TODAY: COMPUTER ASSISTED TRAIN CONTROL

The rail transportation infrastructure of today is widely distributed, using a combination of public and proprietary technologies, networks, and systems. Operations system functionality is similar for all of the major freight railroads. Each system provides real-time, computerized information for managers and dispatchers at a central control center that assimilates and analyzes the information to direct the trains accordingly. System-wide information is distributed on a need-to-know basis and to a large screen displaying the entire rail network.

There are three levels of managerial responsibility:

- Dispatchers who monitor and manage train traffic in a section of the overall system.
- Dispatch managers with system-wide responsibilities, including traffic management, equipment utilization and movement control.
- Additional management that makes annulment, detour, and reroute decisions.

Dispatchers micromanage clearly defined sections of the overall system. Information flows to the control centers allowing crews of dispatchers to handle the movements of thousands of trains each day. Computerized workstations allow dispatchers to monitor and manage rail traffic. Systems provided for this purpose include the following:

- Car Location Message systems deliver precise locations of cars, shipments and locomotives.
- Automated systems receive and transmit instructions to switches.
- Automated systems receive and transmit instructions to speed authorities.
- Crew Management systems allow railroad personnel to be utilized more effectively.
- On-board locomotive monitoring systems recognize maintenance problems in advance to avoid breakdowns.
- Track side “hot boxes” monitor freight car chassis’ to recognize maintenance problems in advance to avoid breakdowns and accidents.

[1] The ability to run a locomotive anywhere and to communicate with the host’s dispatch operation.

Dispatchers are responsible for the safety and efficient operation of the trains under their control. They can view the large screen to see how their sector is performing in relation to the rest of the system.

Dispatch managers are responsible for movement decisions throughout the system. Locomotive disbursement, unscheduled maintenance, and train assemblies are decisions made at this level. These managers have access to system-wide information at computerized workstations and monitor the entire system on the large screen that displays the location and movement of all the locomotives and cars in the system.

The decisions that impact the entire system are reserved for high-level management. These decisions include the cancellation of trains, cancellation of routes, rerouting trains and authorizing detours. Any intersystem problems are handled at this level, such as the use of system tracks by Amtrak. The entire Management Information System is required for these decisions. It is made available through desktop workstations and the system-wide map.

The operations centers of the major railroads are distributed throughout North America. Their commands are relayed electronically to switches and wayside control points on the train routes so that train crews do not need any movement authority other than the signs beside the track. Each railroad has its own dispatch and control system, but shares its tracking information through outside network systems. It is presently a reactive system. Human personnel make the decisions [35].

The following are operations center locations for the major U.S. freight railroads:

- Burlington Northern Santa Fe — Fort Worth, TX (BN); Schaumburg, IL (SF)
- Conrail — Philadelphia, PA
- CSX — Jacksonville, FL
- Norfolk Southern — Atlanta, GA
- Union Pacific — Omaha, NE

3.4 ASSOCIATION OF AMERICAN RAILROADS (AAR) SYSTEMS

The rail transportation infrastructure of today uses a combination of public and proprietary technologies, networks, and systems. The Association of American Railroads (AAR), an organization of the major freight carriers, was created to perform a variety of public, industry-wide functions. This report documents three functions that are critical to the rail transportation infrastructure:

- Administering system-wide information communications networks.
- Setting standards for the railroad industry.
- Conducting research.

It is important to note that use of these networks is not limited to the major freight carriers, but is made available to any railroad that interfaces with their systems. More than 225 railroads make use of or contribute to the AAR networks [37].

Each railroad runs its own operations system. Each system incorporates all or part of the AAR information network into their train control systems. While there are many similarities among them, each system evolved independently. The systems integration problems encountered by the recent mergers indicate that there are great differences between the individual systems [6]. This will slow any efforts to integrate the entire railroad system in the future.

3.5 RAILINC

The information transfers necessary to integrate the AAR systems are distributed to the railroads via RAILINC. RAILINC is a communications network designed to be easily distributed. It is not hardware or software specific. There are a number of options to access the system:

- RAILINC Dial-in Asynchronous (1200-9600 BPS)
- RAILINC Dial-in Bisynchronous-3780 (2400-9600 BPS)
- RAILINC Dedicated Network Bisynchronous (2400-19200 BPS)
- RAILINC Dedicated Network SNA-LU6.2 or LU1 (2400-19200 BPS)
- On-Line using PC or terminal equipped with 3270 emulation
- On-Line SNA/SDLC
- Via Tape 1600/6250 BPU and 3480/3490 Cassette

The communication backbone may be copper wire, fiber, and/or microwave. The protocol is predominantly IP but older x.25 still exists in some places. AAR has six 900 MHz channels to use throughout North America. AAR has its own communications protocol for wireless communication (it is a variation of a Motorola protocol).

This communication system provides the connectivity that ties all the railroad operating systems together [12].

3.6 TELERAIL AUTOMATED INFORMATION NETWORK (TRAIN II)

One of the most important systems that AAR administers is TRAIN II. The TeleRail Automated Information Network (TRAIN II) is a railroad equipment information system that collects data on freight cars, trailers, and containers in use throughout North America. More than 225 railroads input approximately 3.0 million events to the system each day [42]. These inputs include interchanges, releases, pulls, boundary crossings, departures, arrivals, placements, bad orders, early warnings, lost or stolen notices, and waybills. One of the functions of TRAIN II is to transfer car hire liability after railroad interface switches. TRAIN II processes the data and creates outputs that are used for shipment monitoring, equipment tracing, auditing car hire payments, early warning identification, car grading, and car distribution. TRAIN II is a collection of automated systems with AAR acting as a central information collection agency [42]. The following subsections will describe the major automated systems that comprise TRAIN II.

3.6.1 Interline Trace

One subsystem of TRAIN II is Interline Trace. It provides railroads with two methods of monitoring off-line shipments. A Phase I parameter trace is conducted as a query on individual pieces of equipment. The Phase II parameter trace is conducted via automatic generation of location messages based upon waybill information or car ownership [32].

3.6.2 Car Location Messages (CLMs)

CLMs are collected from the systems of most of the major rail carriers in North America and distributed to subscribers over the RAILINC network. Scanners read bar-coded tags attached to each car as the trains pass by and transmit the information to host computers [24].

3.6.3 Electronic Data Exchange (EDE)

EDE, operated by AAR, is one of the largest networks in the world utilizing Electronic Data Interchange (EDI) technology. The computer-to-computer system exchanges more than one million messages a day between trading partners. Typical messages cover the range of daily commerce, including bills of lading, freight bills, purchase orders, invoices, and waybills [29].

3.6.4 Interline Settlement System (ISS)

ISS provides an electronic method for the railroads to settle their accounts amongst themselves (similar to a check-clearing house). Types of accounts settled include car hire, car repair billing, interline freight revenue settlement, freight loss and damage, and interline switching settlement. The system distributes revenue waybills and provides a mechanism for concurrence prior to settlement to eliminate most post-settlement disputes. This service is also available at no charge to smaller railroads not otherwise part of AAR's RAILINC [31].

3.7 POSITIVE TRAIN SEPARATION (PTS)

Positive Train Separation (PTS) is a new name for the Advanced Train Control System (ATCS). The name was changed to better reflect the safety function of the system [12]. The technology for ATCS has been available for almost a decade. Burlington Northern successfully operated a pilot project (called ARES) as early as 1987. But the anticipated cost of developing the system independently (at the same time that AAR was exploring a similar system) and a lack of business justification led to the abandonment of the ARES project in 1989.

The specifications of the PTS system define the physical, logical, and electrical interfaces. It is a non-vital, safety overlay, open architecture system that is designed to operate with existing hardware and software systems. Without human intervention, it enforces corrective train movements to prevent collisions.

PTS is a predictive, but still reactive, system that ensures safety by enforcing speed limits and limits of operating authority. It is a collision-avoidance system that maintains the separation between trains by issuing and autonomously enforcing movement authorities. The on-board location determination equipment and track database enable the system to compute safe braking distances in real time. Position reports are routinely transmitted back to the control center. This information is displayed on the large screen and individual workstations and is used to generate new movement authority and safety checks.

Technologies presently available will be the basis of this system. PTS will use multiple location sensors to precisely determine train position and speed.

Transponders are the primary train location devices in use today. Using the existing Automated Equipment Identification (AEI) system as its foundation, transponders are scanners that read and relay the train identification information as a train passes its location. The ground-based wireless relays are installed between the rails on a track bed at strategic points in the rail system such as junctions, yards, crossing gates, fuel lanes and maintenance facilities. The scanner has the capability of measuring speeds up to 300 MPH. It then radios the location information to a host computer. The transponder operates in both 915 and 2450 MHz bands.

Three PTS projects are being tested today and two others are under consideration. All of the large freight railroads and Amtrak are involved with one of the present or proposed projects. FRA has said that it expects "to the maximum extent possible, specifications developed in the ATCS program {by AAR} will be followed [17]."

4 Air Traffic Control System

4.1 INTRODUCTION

The Air Traffic Control (ATC) system manages air traffic from various sources throughout the United States National Airspace System (NAS) [4]. The mission of air traffic control is “to promote the safe, orderly, and expeditious movement of aircraft [7].” The Federal Aviation Administration is responsible for providing the NAS infrastructure to enable air operations in the United States, 24 hours a day, 365 days a year [3]. Air traffic control, the primary component of the NAS architecture, is a complex system comprising many types of facilities, a plethora of hardware and software systems, and complicated interactions between humans and machines.

There are two goals that must be met by the Air Traffic Control system: safety and efficiency [4]. To ensure safety, minimum separation must be maintained between aircraft as they pass through the national airspace. Efficient air traffic control, however, requires that separation not be so great as to adversely affect the flow of traffic through the airspace [4].

This section explores the history of air traffic control and evolution of the systems that comprise the Air Traffic Control system. An overview of the major facilities involved in air traffic control is provided. Then, more detailed subsections explore functions performed at each facility and the hardware and software systems utilized at each facility.

4.2 BACKGROUND AND OVERVIEW

Much of the air traffic control system in place today was designed in the 1960s and 1970s. In order to meet the demand for increased capacity and provide more reliable hardware and software, the Federal Aviation Administration (FAA) initiated a system modernization effort in 1981 [14]. This effort has been riddled with failure. The initial competition to redesign the system began in 1984. In 1988, IBM Federal Systems won the $2.5 billion contract to build this next generation air traffic control system, called the Advanced Automation System (AAS). Schedule slips occurred almost immediately into the project. In 1992, Loral Space and Communications purchased IBM Federal Systems. By 1994, the FAA had cancelled the program with expected costs to complete of $7.6 billion [5].

AAS was an overly ambitious plan to modernize all computing systems at all major air traffic control facilities. It was to be comprised of five major component systems [7]:

- Peripheral Adapter Module Replacement Item (PAMRI)
- Initial Sector Suite System (ISSS)
- Terminal Advanced Automation System (TAAS)
- Tower Control Computer Complex (TCCC)

- Area Control Computer Complex (ACCC)

Each of the above systems was to replace existing hardware and software computing systems in the various air traffic control facilities.

A great deal of work has been done studying the failure of the AAS effort and the causes contributing to that failure. In particular, the United States General Account Office (GAO) has conducted numerous studies and produced many reports detailing the current and proposed Air Traffic Control system, including annual reports on the modernization effort [6], [8]. GAO designated air traffic control as one of the high-risk infrastructure systems for the United States [12]. The FAA has spent billions of dollars on modernization since 1981 and expects to spend $34 billion through the year 2003 [13]. GAO has identified some of the problems that have plagued the air traffic control modernization effort, including a lack of a complete systems architecture [11] and poor cost control mechanisms [10].

The Air Traffic Control system is composed of multiple types of facilities that share responsibility for control of an aircraft, depending on the aircraft's location. The following types of facilities primarily comprise the Air Traffic Control system [11]:

- Airport Tower
  The tower at each airport is responsible for control of the aircraft on the ground before and after take-off and close to the airport.
- Terminal Radar Approach Control (TRACON) Facilities
  TRACON facilities control aircraft approaching and leaving the busiest airports.
- Air Route Traffic Control Centers (ARTCCs)
  ARTCCs, also called En Route Centers, control aircraft over the continental United States, each center handling a region of airspace.
- Air Traffic Control System Command Center (ATCSCC)
  The Air Traffic Control System Command Center coordinates operations between en route centers and provides scheduling and monitoring support.

Reference [4] contains a figure showing the interaction between the different facilities. Each of the facilities will be explored in more detail in subsequent sections.

The Air Traffic Control system is a complex system of systems [11]. Each of the above facilities described in the System Overview contains numerous hardware and software systems. For example, the En Route Centers alone contain approximately 50 separate hardware and/or software systems [11]. Some of the systems within a facility exist in multiple types of facilities and others communicate across facilities. In addition, the modernization effort has left the Air Traffic Control system in various stages of upgrade. The following sections explore the various hardware and software systems in each facility, including current and upgraded systems.

4.3 AIRPORT TOWER

The airport tower controls aircraft on the ground and flying within close proximity of the airport. The airport tower is responsible for traffic management of all aircraft on the runways. In addition, aircraft within 5 nautical miles of the airport and up to 3000 feet above the airport after take-off and before landing are under the control of the Airport Tower. The systems utilized by air traffic controllers at the Airport Tower to perform air traffic management are described in the following subsections.

4.3.1 Processing Systems

Flight Data Input/Output (FDIO) Computer

Flight strips are pieces of paper used to maintain local aircraft information, including the flight number, aircraft type, and clearances. Information on flight strips is communicated between the Airport Tower and TRACON using the FDIO Computer [4].

4.3.2 Display Systems

Digital Bright Radar Indicator Tower Equipment (DBRITE)

DBRITE is a radar display to augment visual control of airborne traffic around the airport. Aircraft information from TRACON computer systems is displayed on the DBRITE radar screen, including information on aircraft not yet under Airport Tower control [4].

4.3.3 Radar Systems

Airport Surveillance Radar (ASR)

ASR is radar used to monitor the airspace around an airport. ASR-9 is the version of system installed in the early 1990s; it is IC-based radar that can track a target within 300 feet at a 20-mile range [5]. Raytheon is the contractor for the next generation ASR, digital radar to be phased in between 1999 and 2007.

Airport Surface Detection Equipment (ASDE)

ASDE is ground surveillance radar to monitor the runways at an airport [5]. ASDE detects both aircraft and ground vehicles [4]. The current version, ASDE-3, has been installed in 29 of 40 scheduled airports. It is high-resolution radar designed to overcome adverse weather conditions. The contractor is Northrop Grumman’s Norden Systems Division [5].

4.4 TERMINAL RADAR APPROACH CONTROL (TRACON) FACILITIES

There are approximately 180 TRACONs across the United States, providing aircraft control approaching and leaving the busiest airports. In particular, the TRACONs are responsible for aircraft between 5 and 50 nautical miles of the airport and up to 10,000 feet above ground. The hardware and software systems present at the TRACON facilities are described in this section.

4.4.1 Processing Systems

Automated Radar Terminal System (ARTS)

The primary computer system at TRACONs is ARTS. ARTS coordinates information on aircraft from the FDIO computer and primary and secondary radar to maintain a data block on each aircraft. Information includes aircraft call sign, aircraft type, destination, and location. There are different versions of the ARTS computer system at the various TRACON locations; later versions provide automated monitoring and warning systems [4]. ARTS is comprised of linked Sperry-Univac 1140 computers. A serious problem with ARTS computers is that they are acutely limited in memory [5].

Standard Terminal Automation Replacement System (STARS)

A replacement system salvaged from the failed Advanced Automation System effort is the STARS. STARS is intended to replace both the displays and the radar processors at the TRACON with a distributed computing system [5]. Raytheon is the primary contractor for STARS, which resolves information from multiple radars to track aircraft. The system is being developed in C to run on Sun UltraSparc UNIX workstations [5]. A detailed analysis of the STARS development effort is being conducted by the GAO [16].

4.4.2 Display Systems

Data Entry and Display Subsystem (DEDS)

Information from the ARTS computer system is displayed on DEDSs. The DEDS was designed in the 1960s and has reliability problems relating to the age of the equipment [5].

Full Digital ARTS Display (FDAD)

A more recent display facility for the ARTS computer system is the FDADs. In contrast to the DEDS, the FDAD is was designed in the 1980s and is a microprocessor-based system [5].

4.5 AIR ROUTE TRAFFIC CONTROL CENTERS (ARTCC)

There are 20 ARTCCs, also called En Route Centers, throughout the country, controlling aircraft in flight across the continental United States. Each En Route Center handles a region of airspace, responsible for commercial aircraft above 18,000 feet. There will be different altitudes determining control of the aircraft due to interaction with Airport Towers and TRACONs within a particular En Route Center's region.

The 20 ARTCCs across the United States are found in the following locations [9]:

- Boston, MA
- Washington, D.C.
- Miami, FL
- Indianapolis, IN
- Chicago, IL
- Minneapolis, MN
- Dallas-Fort Worth, TX
- Denver, CO
- Salt Lake City, UT
- Oakland, CA
- New York, NY
- Jacksonville, FL
- Cleveland, OH
- Atlanta, GA
- Memphis, TN
- Kansas City, KS
- Houston, TX
- Albuquerque, NM
- Seattle, WA
- Los Angeles, CA

Reference [9] contains figures showing the interaction between the many hardware and software systems located in the ARTCCs. A description of the major hardware and software systems assisting controllers in the ARTCCs follows in this section.

4.5.1 Processing Systems

HOST Computer System

The HOST computer system was initially developed in 1960s; during the 1980s it was "hosted" on new hardware. The HOST computer primarily processes flight data and radar data for display in the ARTCCs [4]. In addition, it provides alerts of possible aircraft separation violations and processes weather data [9]. The HOST computer system runs on IBM 3083 computers [5].

4.5.2 Display Systems

Plan View Display (PVD)

The PVD is the digitized display at En Route Centers showing estimates of the current location of radar targets using information from the HOST computer [4].

Display Channel Complex (DCC)

The DCC accepts radar and flight data from the HOST computer system and processes it for display on the controller screens, the PVDs. The DCC was designed in the 1960s and runs on IBM 9020E mainframes. Software running on the DCC is written in assembly language and JOVIAL [9].

Display Channel Complex Rehost (DCCR)

The increasingly frequent failures of the PVDs at the busiest En Route Centers necessitated a temporary fix for the DCC, called the DCCR. The DCCR replaces the 1960s IBM computers with an IBM ES/9121 mainframe to translate data from the HOST computer system for the PVD [5]. The two primary components of the

DCCR are the Display Channel Rehost Processor (DCRP) and Display Controller and Switch (DC&S) [9].

Computer Display Channel (CDC)

The CDC is an alternative to DCC and its replacement system, DCCR, used in fifteen of the twenty ARTCCs. It is not plagued with the same reliability problems as the DCC [9].

Display System Replacement (DSR)

DSR is a display-only system to replace the PVDs in ARTCCs with workstations that have no radar processing capability. DSR is a surviving component of the cancelled Advanced Automation System (it was to be the ISSS [9]), contracted to Lockheed Martin Corporation. The software is implemented in C and Ada running on IBM 6000 RISC workstations with the AIX operating system. DSR is currently in testing and is expected to be operational in the first ARTCC site in October, 1998 [5].

4.5.3 Radar Systems

Air Route Surveillance Radar (ARSR)

ARSR is three-dimensional, long-range radar for tracking aircraft through the ARTCC regions. Information is transmitted to the HOST computer system [5].

4.6 AIR TRAFFIC CONTROL SYSTEM COMMAND CENTER (ATCSCC)

The ATCSCC is located in Herndon, VA. One of its primary functions is coordinating operations between en route centers by combining traffic flow. In addition, the ATCSCC establishes data flows for 28 major airports. The ATCSCC provides central flow control: primarily monitoring, not active participation. ATCSCC uses the HOST computer system to monitor traffic and has a data link to computers in Cambridge, MA for display purposes [4].

5 Conclusion

This report presents details of an investigation into the information systems used by three important infrastructure applications. From this investigation we can conclude that these information systems are extremely complex, very large, and exposed to a number of different threats.

Although these three applications differ considerably, they illustrate a number of important characteristics that are shared by many infrastructure applications: very high dependability requirements; very serious consequences of failure; well-defined survivability requirements; and limited opportunities for change to improve survivability.

The dependability requirements that arise with many critical information systems are quite extraordinary. For example, many current systems and others that are being planned are required to operate on networks that are distributed nationally (sometimes globally) and require twenty-four-hour-per-day, seven-day-per-week operation. In addition, these systems have to support combinations of dependability requirements. For example, they have to maintain very high levels of availability while also ensuring network-wide security.

The consequences of failure of these systems can be very serious. Some of these consequences are fairly obvious--the failure of part of the air traffic control system has manifest implications. Other consequences of failure are less obvious. The failure of certain parts of the banking system, Fedwire for example, would have widespread negative impact because it would devastate the entire payment system and do so very quickly.

Rather surprisingly the consequences of failure of some elements of infrastructure applications are not as serious as they might seem at first. The loss of communications, data, or computing by a retail bank, for example, would be traumatic for the bank and its customers. But this would only be a small fraction of the population even for a large bank and so there would be very little overall societal impact.

Dealing with the effects of faults in information systems leads to the notion of survivability. Informally, by survivability we mean the ability of the system to continue to provide service (possibly degraded) when various changes occur in the operating environment. For example, when events such as hardware failure, software failure, operator error, or malicious attack occur, a critical subset of normal functionality or some alternative functionality might be needed to mitigate the consequences of the event.

There is a need to improve the survivability of critical information systems given the increasing dependence on them, the serious consequences of their failure, and their demonstrated fragility and vulnerability. However, the approaches that can be followed to achieve this goal are limited. For example, there is little point in considering completely rewriting the software for the systems because they are just too large. Similarly, it is not possible to make drastic changes to the present system architectures. Computers and network links are performing various application functions, and this fabric is determined largely by the application itself. It is not subject to change, at least not in anything but the very long term.

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7 Abbreviations

7.1 FINANCIAL PAYMENT SYSTEMS

ABMS	Account Balance Monitoring System
ACH	Automated Clearing House
CBCH	California Bankers Clearing House
CCH	Chicago Clearing House Association
CHECCS	Clearing House Electronic Check Clearing System
CHIPS	Clearing House Interbank Payment System
ECP	Electronic check presentment
EDC	Electronic Data Capture
EFAA	Expedited Funds Availability Act of 1987
EFTA	Electronic Funds Transfer Act
EMS	Electronic Money System
EROC	East Rutherford Operations Center
FDIC	Federal Deposit Insurance Corporation
FRBNY	Federal Reserve Bank of New York
FTC	Federal Trade Commission
MCA	Monetary Control Act of 1980
MICR	Magnetic Ink Character Recognition
NACHA	National Automated Clearing House Association
NOCH	National Organization of Clearing Houses
NSCC	National Securities Clearing Corporation
NYACH	New York Automated Clearing House
NYCHA	New York Clearing House Association
PAX	Private ACH Exchange
RTGS	Real-Time Gross Settlement System
S.W.I.F.T.	Society for Worldwide Interbank Financial Telecommunications
SEC	Securities and Exchange Commision
TAP	Transaction adjusted payment
TLA	Truth in Lending Act of 1968
UCC	Uniform Commercial Code

7.2 RAIL TRANSPORTATION

AAR	Association of American Railroads
AEI	Automated Equipment Identification
ATCS	Automated Train Control System
CLM	Car Location Message(s)
EDE	Electronic Data Exchange
EDI	Electronic Data Interface
FRA	Federal Railroad Administration
IP	Interface Protocol

ISS	Interline Settlement System
PC	Personal Computer (IBM-compatable)
PTC	Precision Train Control
PTS	Positive Train Separation
TRAIN II	TeleRail Automated Information Network

7.3 AIR TRAFFIC CONTROL SYSTEM

AAS	Advanced Automation System
ACCC	Area Control Computer Complex
ADS	Automatic Dependent Surveillance
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Centers
ARTS	Automated Radar Terminal System
ASDE	Airport Surface Detection Equipment
ASOS	Automated Surface Observing System
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
CDC	Computer Display Channel
CTAS	Center-TRACON Automation System
DBRITE	Digital Bright Radar Indicator Tower Equipment
DCC	Display Channel Complex
DCCR	Display Channel Complex Rehost
DEDS	Data Entry and Display Subsystem
DSR	Display System Replacement
FAA	Federal Aviation Administration
FDAD	Full Digital ARTS Display
FDIO	Flight Data Input/Output
GPS	Global Positioning System
HCS	HOST Computer System
ISSS	Initial Sector Suite System
NAS	National Airspace System
PAMRI	Peripheral Adapter Module Replacement Item
PVD	Plan View Display
STARS	Standard Terminal Automation Replacement System
TAAS	Terminal Advanced Automation System
TCAS	Traffic Alert and Collision Avoidance
TCCC	Tower Control Computer Complex
TRACON	Terminal Radar Approach Control
VSCS	Voice Switching and Communications Systems
WAAS	Wide-Area Augmentation System

8 Glossary

8.1 FINANCIAL PAYMENT SYSTEMS

ACH Operator/Processor:

A central clearing facility that receives batches of ACH credit and debit transactions from originating depository institutions; edits, sorts and distributes the transactions to receiving depository institutions; and facilitates the settlement among participants.

Check truncation:

Check truncation is the practice of holding a paper check at the bank at which it was deposited (or at an intermediary bank) and electronically forwarding the essential information on the check to the bank on which it was written. A truncated check is not returned to the writer.

Clearance:

Clearance is the process of transmitting, reconciling, and in some cases, confirming payment orders or security transfer instructions prior to settlement, possibly including the netting of instructions and the establishment of final positions for settlement. In the context of securities markets, this process is often referred to as clearance.

Clearing Agent Banks:

Clearing agent banks are Fedwire participants that are regularly engaged in the business of providing clearing services in eligible securities for members and GSCC.

Clearing House:

A clearing house is a voluntary association of depository institutions that facilitates the exchange of payment transactions such as checks, automated clearing house transactions, large-value funds transfers and the settlement of participants' net debit or credit positions.

Daylight overdraft:

A daylight overdraft is a negative position in an institution's Federal Reserve account at any time during the business day.

Depository Bank:

The bank at which a check is first deposited.

Electronic Data Capture (EDC):

EDC is a point-of-sale terminal that reads the information encoded in the magnetic stripe of bank cards. These terminals electronically authorize and capture transaction data, eliminating the need for a paper deposit.

Federal Reserve account:

A Federal Reserve account is the noninterest earning account that depository financial institutions maintain with a Federal Reserve Bank. The balance in a Federal Reserve account is maintained for purposes of (1) satisfying the Federal Reserve's reserve requirements and/or (2) settling payments cleared through the Federal Reserve. The balances in these accounts play a central role in the exchange of funds between depository institutions.

MICR-Line Information:

MICR-Line information refers to the data characters at the bottom of a check. The magnetic ink character recognition (MICR) line at the bottom of a check includes the routing number of the payor bank, the amount of the check, the number of the check, and the account number of the customer.

Multilateral netting:

An arrangement among three or more parties to net their obligations. The obligations covered by the arrangement may arise from financial contracts, transfers of funds, or both. The multilateral netting of payment obligations normally takes place in the context of a multilateral net settlement system.

Originator:

An originator is the person or organization that initiates an ACH entry.

Originating Depository Institution:

Originating depository institution is a depository institution that initiates and warrants electronics payments processed through the ACH network on behalf of its customers.

Paying bank:

A paying bank is the bank at which a check is payable and to which it is sent for payment or collection.

Payments System:

Payments system is a collective term for mechanisms (both paper-backed and electronic) for moving funds, payments, and money among financial institutions throughout the nation. The Federal Reserve plays a major role in the nation's payments system through distribution of currency and coin, processing of checks, electronic transfer of funds, and the operation of automated clearing houses that transfer funds electronically among depository institution; various private organizations also perform payments system functions.

Real-Time Gross Settlement:

Real-time gross settlement is a system that processes each transaction as it is initiated rather than processing it in a batch. Gross settlement means that the system settles each transaction individually.

S.W.I.F.T.:
: Society for Worldwide Interbank Financial Telecommunications is an international financial payment cooperative organization that operaties a network that facilitates the exchange of payment and other financial messages between financial institutions throughout the world.

8.2 RAIL TRANSPORTATION

Class 1 Railroad:
: The federal government classifies railroads by their level of operating revenue. For 1996, the Class 1 railroads had revenue of $255 million or more.

Electronic Data Interchange:
: Translation software to perform computer-to-computer exchange of business information using standard electronic formats.

Fixed Block:
: A clearly defined sector of railroad. Dispatchers are responsible for fixed blocks, e.g. a 30-mile stretch of track.

Intermodal:
: A freight transportation system. It allows a standardized container to go from origin to destination by rail, water or motor carrier or any combination of modes without disturbing the contents.

Interoperable:
: The ability to maintain control of a train on different rail systems.

Just in Time (JIT):
: An inventory system that requires a continuous delivery stream supply necessary components of a manufacturing process. It relies on the arrival of goods at the time they are needed (just in time) to reduce on site inventory levels.

8.3 AIR TRAFFIC CONTROL SYSTEM

National Airspace System:
: "The common network of United States airspace; air navigation facilities, equipment, and services; airports and landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information; and manpower and material [3]."

Primary Radar System:
: A series of energy bursts that hit an airplane and that are reflected back to a radar

antenna, used to present a single-dot primary target on a radar scope [1].

Secondary Radar System:

A radio signal received from an aircraft transponder by a secondary antenna on the radar antenna [2].