BANK FOR INTERNATIONAL SETTLEMENTS

REAL-TIME GROSS SETTLEMENT SYSTEMS

Report prepared by the Committee on Payment and Settlement Systems
of the central banks of the Group of Ten countries

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Foreword

The work of the Committee on Payment and Settlement Systems of the central banks of the Group of Ten countries (CPSS) has consistently emphasised the importance of large-value funds transfer systems which banks use to settle interbank transfers for their own account as well as for their customers. Estimates compiled by the CPSS indicate that these systems transfer several trillion dollars per day in the G-10 countries, a large portion of which is related to the settlement of financial market transactions.

During the past decade a number of countries, inside as well as outside the Group of Ten, have introduced real-time gross settlement (RTGS) systems for large-value funds transfers. Nearly all G-10 countries plan to have RTGS systems in operation in the course of 1997 and many other countries are also considering introducing such systems.

RTGS systems effect final settlement of interbank funds transfers on a continuous, transaction-by-transaction basis throughout the processing day. Because of the growing importance of RTGS, the CPSS set up a Study Group to identify and analyse the major issues related to the operation of such systems. The Group, which was chaired by Mr. Yvon Lucas of the Bank of France, has produced the present analytical report. The report is intended to provide information on the important features of RTGS systems to a broad audience, including operators of and participants in clearing and settlement systems for securities, derivatives and foreign exchange that make or intend to make use of RTGS systems, and the various supervisory authorities and industry groups interested in the enhancement of risk controls in payment and settlement systems. The report might also be particularly helpful to the many countries currently in the process of introducing or developing RTGS systems.

Mr. Lucas and the members of the Study Group are to be commended for the in-depth analysis which they have carried out. The active contribution which the CPSS Secretariat at the BIS has made to drafting the report is acknowledged, as well as the able assistance provided by the BIS in editing and publishing the report.

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INTRODUCTION

During the past ten years a number of countries have decided to introduce *real-time gross settlement (RTGS) systems* for large-value interbank funds transfers. In the Group of Ten, nine countries are now using RTGS systems and such systems will be in operation in all G-10 countries except Canada by mid-1997 according to current plans.[1] Moreover, the central banks of the European Union have collectively decided that every EU member state should have an RTGS system for large-value transfers and that these domestic RTGS systems should be linked together to form a pan-EU RTGS system (the TARGET system) in order to support stage three of economic and monetary union. The use of RTGS is also growing outside the Group of Ten and the European Union. For example, RTGS systems are already in operation in the Czech Republic, Hong Kong, Korea and Thailand, and it is reported that, among others, Australia, China, New Zealand and Saudi Arabia will introduce RTGS systems in the near future.

The development of RTGS systems is one response to the growing awareness of the need for sound risk management in large-value funds transfer systems. RTGS systems can offer a powerful mechanism for limiting settlement and systemic risks in the interbank settlement process, because they can effect final settlement of individual funds transfers on a continuous basis during the processing day. In addition, RTGS can contribute to the reduction of settlement risk in securities and foreign exchange transactions by providing a basis for delivery-versus-payment (DVP) or payment-versus-payment (PVP) mechanisms. An understanding of RTGS is thus essential when considering risk management in payment and settlement systems.

The Ad Hoc Study Group on RTGS was established by the Committee on Payment and Settlement Systems (CPSS) at its meeting in December 1994 and was asked to study various important issues relating to RTGS with a view to achieving a clearer understanding of the design and operation of RTGS systems. The Study Group examined a range of issues including (a) liquidity issues, (b) queuing arrangements, (c) message flow and information structures, (d) issues arising from the interrelationship between RTGS systems and other settlement systems, (e) monetary policy implications, and (f) the distinctions between RTGS systems and net settlement systems. The Group's study was conducted on the basis of its members' contributions on these issues as well as a detailed survey of G-10 RTGS systems currently in operation or under development. The Study Group also took stock of the existing literature on RTGS. This report summarises the Group's main findings.

Throughout its study and discussions, the Study Group recognised that the design and operation of G-10 RTGS systems differ noticeably. These differences partly reflect the fact that each country's system is designed to meet the needs and structure of the local banking system and that new systems often represent modifications or enhancements to previous systems or procedures. This report is intended to provide a common understanding of concepts and terminology and to describe the spectrum of views on major issues in connection with RTGS systems. It is not intended to be prescriptive.

The report is structured in three parts. Part I gives a brief overview of various key payment system concepts and the types and sources of payment system risk on the basis of analyses in earlier CPSS reports.[2] This is intended to provide a general framework for defining and describing RTGS systems as well as for discussing RTGS system issues in the later sections. Part II then describes the

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[1] In Canada, a new large-value net settlement system (LVTS) will be introduced in late 1997 (see Section III.3).

[2] These reports include the *Report on Netting Schemes* (February 1989), the *Report of the Committee on Interbank Netting Schemes*, (the Lamfalussy Report, November 1990), *Delivery Versus Payment in Securities Settlement Systems* (the DVP Report, September 1992), *Central Bank Payment and Settlement Services with respect to Cross-Border and Multi-Currency Transactions* (the Noël Report, September 1993), *Payment Systems in the Group of Ten Countries* (December 1993), *Cross-Border Securities Settlements* (March 1995) and *Settlement Risk in Foreign Exchange Transactions* (the Allsopp Report, March 1996).

generic features of RTGS systems and looks at the issues associated with their design and operation, including intraday liquidity, message flow structures and queuing arrangements. An overview of the RTGS systems in use or under development in the G-10 countries is also provided in Section II.1. Some of the important factors that influence the design of RTGS systems are summarised in Section II.5. Part III looks at the use of RTGS from a broader perspective. Specifically, it considers the interrelationship between RTGS systems and other settlement systems, some possible monetary policy implications, and distinctions between RTGS systems and net settlement systems. Annex 1 provides a comparative table of G-10 RTGS systems. Annex 2 presents a comparative table of selected net settlement systems.

PART I INTERBANK PAYMENT AND SETTLEMENT MECHANISMS: KEY CONCEPTS AND RISKS

1. Key design concepts in interbank funds transfer systems

Interbank funds transfer systems are arrangements through which funds transfers are made between banks for their own account or on behalf of their customers.[3] Of such systems, *large-value funds transfer systems* are usually distinguished from retail funds transfer systems that handle a large volume of payments of relatively low value in such forms as cheques, giro credit transfers, automated clearing house transactions and electronic funds transfers at the point of sale.[4] The average size of transfers through large-value funds transfer systems is substantial and the transfers are typically more time-critical, not least because many of the payments are in settlement of financial market transactions. The report focuses on these large-value systems.

The processing of funds transfers involves two key elements. The first of these is the transfer of *information* between the payer and payee banks. A funds transfer is initiated by the *transmission* of a *payment order or message* requesting the transfer of funds to the payee. In principle, the payment messages may be credit transfers or debit transfers, although in practice virtually all modern large-value funds transfer systems are credit transfer systems in which both payment messages and funds move from the bank of the payer (the sending bank) to the bank of the payee (the receiving bank). The payment messages are processed according to predefined rules and operating procedures. *Processing* may include procedures such as identification, reconciliation and confirmation of payment messages.[5] The transmission and processing of payment messages in large-value funds transfer systems is typically automated (i.e. electronic).

The second key element is *settlement* - that is, the actual transfer of funds between the payer's bank and the payee's bank. Settlement discharges the obligation of the payer bank to the payee bank in respect of the transfer. Settlement that is *irrevocable* and *unconditional* is described as *final settlement*. In general, the settlement of interbank funds transfers can be based on the transfer of balances on the books of a central bank (i.e. central bank money) or commercial banks (i.e. commercial bank money).[6] In practice, settlement in the vast majority of large-value funds transfer systems takes place in central bank funds. Although the rules and operating procedures of a system and the legal environment generally may allow for differing concepts of finality, it is typically understood that, where settlement is made by the transfer of central bank money, final settlement occurs when the final (i.e. irrevocable and unconditional) transfer of value has been recorded on the books of the central bank. The report focuses on the settlement finality of the central bank transfers in this sense.

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[3] For the rest of the report, the term "bank" is used as a shorthand expression for a participant in interbank funds transfer systems.

[4] Large-value funds transfer systems are sometimes referred to as *wholesale funds transfer systems*. However, in most cases there is no limit on the minimum value of individual transfers carried. In fact, some large-value funds transfer systems also handle "retail" transactions (see the comparative table in Annex 1 in the case of RTGS systems).

[5] The term *"clearing"* is also often used, in particular in the context of net settlement systems, to refer to the process of transmitting, reconciling and in some cases confirming payment orders *before* settlement, possibly including netting of payment orders and the calculation of the positions to be settled.

[6] An entity across whose books transfers between participants are settled is referred to as a *settlement agent*. One of the major roles of the central bank as a settlement agent is to provide a monetary asset free of default risk that can be used for settling interbank obligations.

Table 1

Salient features of selected large-value funds transfer systems

(figures relate to 1995)

Country	System (planned)	Type	Launch date	Average value of transaction (USD million)	Ratio of transactions value to GDP[1]
Belgium	ELLIPS	RTGS	1996	11.0[2]	35.4[2]
Canada	IIPS (LVTS)	Net Net	1976 (1997)	5.0 n.a.	20.4 n.a.
France	SAGITTAIRE (TBF)	Net RTGS	1984 (1997)	4.7 n.a.	13.6 n.a.
Germany	EIL-ZV EAF2[3]	RTGS Net	1987 1996	3.4 5.8	7.8 42.9
Italy	BISS (BI-REL) ME SIPS	RTGS RTGS Net Net	1989 (1997) 1989 1989	1.9 n.a. 6.2 3.8	0.1 n.a. 10.4 15.4
Japan	BOJ-NET FEYCS	Net + RTGS Net	1988 1989	112.9 9.2	85.0 16.0
Netherlands	FA (TOP)	RTGS + Net (RTGS)	1985 (1997)	14.8 n.a.	13.3 n.a.
Sweden	RIX	RTGS	1986	67.7	32.6
Switzerland	SIC	RTGS	1987	0.3[4]	88.9
United Kingdom	CHAPS[3]	RTGS	1984	3.4	38.1
United States	CHIPS Fedwire	Net RTGS	1970 1918	6.1 2.9	42.7 30.7
European Union	ECU clearing[5]	Net	1986	9.7	2.0

[1] At an annual rate. For the ECU clearing and settlement system, GDP is that of the European Union. [2] October to December 1996. [3] For EAF2 and CHAPS, figures relate to those of the previous version of the systems. EAF was substantially modified to form EAF2 in March 1996. CHAPS switched from net settlement to RTGS in April 1996. [4] SIC is routinely used to process large-value as well as retail payments. [5] Private ECU clearing and settlement system.

Settlement characteristics and the types of interbank funds transfer system. Interbank funds transfer systems can be classified in several ways. Among other things, differences in the way settlement takes place provide a useful framework for the discussions in the later sections of this report. A common distinction in this respect is to divide systems into *net settlement systems* and *gross settlement systems.* In a net settlement system, the settlement of funds transfers occurs on a net basis according to the rules and procedures of the system. A participating bank's net position is calculated, on either a bilateral or a multilateral basis, as the sum of the value of all the transfers it has received up to a particular point in time minus the sum of the value of all the transfers it has sent. The net position at the settlement time, which can be a net credit or debit position, is called the net settlement position. Net settlement systems for large-value funds transfers in the G-10 countries are now primarily multilateral (rather than bilateral) net settlement systems in which each (settling) participant settles its multilateral net settlement position.[7] In a gross settlement system, on the other hand, the settlement of funds occurs on a transaction-by-transaction basis, that is, without netting debits against credits.

Interbank funds transfer systems can also be classified according to the timing (and frequency) of settlement. Systems can in principle be grouped into two types, designated-time (or deferred) settlement systems and real-time (or continuous) settlement systems, depending on whether they settle at pre-specified points in time or on a continuous basis.[8] In this report, these two types are more narrowly defined in terms of the timing of *final* settlement. One type of system is thus a *designated-time (or deferred) settlement system*, in which final settlement occurs at one or more discrete, pre-specified settlement times during the processing day. Designated-time settlement systems in which final settlement takes place only once, at the end of the processing day, are called end-of-day settlement systems. Currently, net settlement systems for large-value transfers are typically end-of-day net settlement systems that settle the net settlement positions by means of transfers of central bank money from net debtors to net creditors. In some countries, there are systems in which the final settlement of transfers occurs at the end of the processing day without netting the credit and debit positions - on a transaction-by-transaction basis or on the basis of the aggregate credit and aggregate debit position of each bank. Such systems are often called end-of-day gross settlement systems.[9] On the other hand, a *real-time (or continuous) settlement system* is defined as a system that can effect final settlement on a continuous basis during the processing day. RTGS systems, as defined below, fall into this category. Table 2 summarises the main possibilities.

Table 2

Types of large-value funds transfer system

Settlement characteristics	Gross	Net
Designated-time (deferred)	Designated-time gross settlement	Designated-time net settlement (DNS)
Continuous (real-time)	Real-time gross settlement (RTGS)	(not applicable)*

* By definition, netting involves the accumulation of a number of transactions so that credits can be netted against debits and this is incompatible with genuinely continuous settlement.

It is worth stressing here that the distinction between different systems such as RTGS and designated-time net settlement (DNS) systems concerns the form of settlement, not the form of transmission and processing. Like RTGS systems, many net settlement systems transmit and process payment messages in real time on a transaction-by-transaction basis, but they settle, by definition, on a net basis at discrete intervals.

An important concept that is often used in connection with the timing of finality is *intraday finality* or an *intraday final transfer capability.* The Noël Report defined this concept as the

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7 EAF2, which started operation as a new net settlement system in Germany in 1996, is partly based on bilateral offsetting.

8 Another standard distinction in this respect is to divide systems into same-day settlement systems and next-day settlement systems. Once current reforms are completed, all large-value funds transfer systems in the G-10 countries will be same-day settlement systems (all RTGS systems are, by definition, same-day settlement systems).

9 Such systems include the daily interbank settlement system (DIS) in Ireland and the money market telephone service (STMD) in Spain. These two systems will be converted into RTGS systems. *Payment Systems in the European Union* (the "Blue Book", April 1996) defines an end-of-day gross settlement system in such a way as to also include systems in which transfers are provisionally settled in real time but remain revocable until the end of the day.

ability to initiate - and to receive timely confirmation of - transfers between accounts at the central bank that become final within a brief period of time. The Study Group believes that this definition is useful and in practice is sufficient when discussing the "intraday" nature of finality relative to end-of-day finality. However, the Group also recognised that the phrase "within a brief period of time" is not a precise one. Therefore, care needs to be taken when considering the extent to which systems in which final settlements occur at discrete but very frequent intervals of time during the day can provide some form of intraday finality similar to systems involving continuous settlement (i.e. *real-time intraday finality*).[10]

In describing the settlement characteristics of net settlement systems, the concept of *certainty of settlement* is sometimes used. This concept is not related to the timing of final settlement per se but, as described in the Noël Report, refers to the certainty that the system will be able to effect final settlement when the netting cycle and the associated settlement procedures have been completed. Certainty of settlement relates to a multilateral netting system's ability to meet Lamfalussy Standard IV, namely that such systems should, at a minimum, be capable of ensuring the timely completion of daily settlements in the event of an inability to settle by the participant with the largest single net debit position.[11] Multilateral net settlement systems that are secured in compliance with all the Lamfalussy standards, including Standard IV, and that can therefore assure settlement in the event of any single participant failure are often called *Lamfalussy-compliant* systems. Stronger forms of certainty of settlement arise when a net settlement system is capable of ensuring settlement in the event of more than one participant failing. These systems are often called *Lamfalussy-plus* systems. A particular category of Lamfalussy-plus systems concerns those that can assure settlement in all circumstances, that is, regardless of how many participants fail.[12]

Central bank systems and private sector systems. Interbank funds transfer systems are sometimes classified according to whether they are central bank systems or private sector systems. The distinction typically depends on who owns and operates the systems (rather than on the identity of the settlement agent). At present, it is possible to identify two "typical" types of large-value funds transfer system: (a) central bank systems owned and operated by the central bank (or its affiliated entities) in which the central bank also provides settlement, and (b) private sector systems owned and operated by a private sector group (e.g. a banking association or clearing house), where the main operational role of the central bank is to act as the settlement agent. In the G-10 countries, for example, RTGS systems often belong to the former category and many DNS systems belong to the latter. Nonetheless, a number of DNS systems are owned and operated by the central bank, while in some cases RTGS systems are owned and operated by a private sector group (see Section II.1). Moreover, there are several DNS and RTGS systems in which ownership and operation are shared between the private sector and the central bank.

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10 Continuous intraday finality may also be referred to as "real-time finality" or "immediate finality". To date, no such "multiple" designated-time settlement systems exist. As described in Section III.3, however, EAF2 may be close to such a system, because transfers are *offset* in 20-minute netting cycles and the results of offsetting are considered to be immediately final (i.e. irrevocable and unconditional).

11 The Lamfalussy standards are six standards that were established by G-10 central banks in 1990 as minimum requirements for cross-border and multicurrency multilateral netting systems (see the Lamfalussy Report) and have since also been applied to a number of domestic systems. See also Section III.3.

12 The report uses "secured net settlement systems" as the generic term for Lamfalussy-compliant and Lamfalussy-plus net settlement systems. In using these terms, however, the report does not intend to judge the extent to which particular DNS systems meet or exceed the Lamfalussy standards. As discussed in Section III.3, DNS systems can also be categorised as "survivors pay", "defaulters pay" or "third party pays" systems (or a combination of these) according to who bears the cost of achieving certainty of settlement.

2. Types and sources of payment system risk

Earlier CPSS reports identified the major types of payment system risk. Credit risk and liquidity risk are two basic risks to which participants in payment and settlement systems may be exposed.[13] *Credit risk*, which is often associated with the default of a counterparty, is the risk that a counterparty will not meet an obligation for full value, either when due or at any time thereafter. It generally includes both the risk of loss of unrealised gains on unsettled contracts with the defaulting counterparty (*replacement cost risk*) and, more importantly, the risk of loss of the whole value of the transaction (*principal risk*). *Liquidity risk* refers to the risk that a counterparty will not settle an obligation for full value when due but at some unspecified time thereafter. This could adversely affect the expected liquidity position of the payee. The delay may force the payee to cover its cash-flow shortage by funding at short notice from other sources, which may result in a financial loss due to higher financing costs or to damage to its reputation. In more extreme cases it may be unable to cover its cash-flow shortage at any price, in which case it may be unable to meet its obligations to others. *Settlement risk* may be used to refer to the risk that the completion or settlement of individual transactions or, more typically, settlement of the interbank funds transfer system as a whole, will not take place as expected. Settlement risk comprises both credit and liquidity risks.

Two major sources of these risks are (a) a time-lag between the execution of the transaction and its final completion and (b) a time-lag between the completion of the two legs of the transaction (i.e. any lag between payment leg and delivery leg). Within large-value funds transfer systems the first type of lag, which takes the form of a *settlement lag* between the initiation of payment messages and their final settlement, can be a major source of settlement risk. Settlement lags create the possibility that sending banks could fail in the meantime or at least not be able to settle their obligations when due.

Settlement lags can result in *credit risk* if the two functions of an interbank funds transfer system discussed in the previous subsection (namely the transmission of information about the payment and the settlement of the payment) do not occur simultaneously, so that settlement takes place after the information has been provided. As long as final settlement has not occurred, any payment activity undertaken on the basis of "unsettled" payment messages remains conditional and results in risk. For example, because of competitive pressures or system rules resulting from customers' demand for a fast intraday payment service, receiving banks may credit funds to their customers on the basis of the receipt of incoming payment messages and before final settlement; receiving banks are then exposed to principal risk because, if settlement does not occur (e.g. because of the default of a bank) and they do not receive the anticipated funds at the settlement time, they may not be able to retrieve these transfers.[14] Settlement lags may also result in *liquidity risk*. Until settlement is completed, a bank may not be certain what funds it will receive through the payment system and thus it may not be sure whether or not its liquidity is adequate. If, in planning its liquidity needs, a bank overestimates the funds it will receive when settlement takes place, then it may face a shortfall. Indeed, if the shortfall occurred close to the end of the day, a bank could have significant difficulty in raising the liquidity it needed from an alternative source. See Box 1 for a description of settlement lags as possible sources of interbank risk.

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[13] There are other types of risk, including operational and legal risks. They can contribute to the major types of risk described here.

[14] In some systems, such credited funds are irrevocable under the system's rules (nevertheless, under the general law, the receiving bank may still have a claim on the sending bank or the payer).

BOX 1

SETTLEMENT LAGS AS SOURCES OF INTERBANK RISK

The time axis below describes the stages a payment instruction may go through during the lag between being entered into an interbank funds transfer system (at time t_1) and being settled (at time t_4). This lag is often referred to as a settlement lag.

→ time

t_1	t_2	t_3	t_4
Payment message entered into system	**Partial information available to receiving bank or full information available only on request**	**Full information sent automatically to receiving bank**	**Interbank settlement takes place**

In some systems the payment message is sent automatically to the receiving bank *before* interbank settlement takes place. This intermediate point is designated here as time t_3. As described in the main text, between t_3 and t_4 there is a possibility that the receiving bank will act on this information in a way that exposes it to credit and liquidity risk. For example, even though the receiving bank cannot yet be certain that it will receive the funds from the sending bank (it will not know this until settlement has taken place at t_4), it may nevertheless credit the funds to the account of its customer (the beneficiary of the payment) or it may commit itself to lending the funds in the interbank market. In other words, it anticipates the interbank settlement.

In some cases there may also be an earlier point, between t_1 and t_3, at which the receiving bank receives partial information about the payment being processed, or at which it can receive the full information but only on request. This point is designated t_2.

In the first stage, between t_1 and t_2, no information on the incoming payment is provided by the system. However, the receiving bank may be aware of the incoming funds from other sources (for example, the sending bank may have passed the information directly to the receiving bank).

The extent to which each of these portions of settlement lag may contribute to settlement risk depends on the characteristics of the individual payment system as well as the practices of banks in debiting and crediting payment transfers on their own books. The topic is discussed further in subsection II.4.2.

The risk implications of the timing of delivery of information about funds transfers preceding the timing of settlement have become increasingly important as various types of large-value funds transfer system have come to operate on the basis of real-time processing (i.e. information is transmitted to receiving banks in real time), while settlement may be delayed (either because the system is a DNS system or because, in an RTGS system, liquidity constraints may delay settlement at least temporarily).

The second type of lag, sometimes referred to as *asynchronous settlement*, is the largest source of principal risk in the settlement of foreign exchange and securities transactions, or, more generally, in exchange-for-value systems.[15] This is the risk that the seller of an asset could deliver but not receive payment or that the buyer of an asset could make payment but not receive delivery, which could entail a loss equal to the full principal value of the assets involved. The DVP Report concluded that a delivery-versus-payment system, which ensures that the delivery occurs if and only if payment occurs, would provide a mechanism for eliminating such principal risk.[16] Since the payment leg in an

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15 As defined in the Red Book, an exchange-for-value system is a system which involves the exchange of assets, such as money, foreign exchange, securities or other financial instruments, in order to discharge settlement obligations.

16 The term "delivery versus payment" is usually used in the context of securities settlement. A DVP mechanism for foreign exchange transactions is often called a payment-versus-payment (PVP) mechanism.

exchange-for-value system is supported by interbank funds transfer systems, the settlement characteristics of interbank funds transfer systems as described above have an important influence on how a DVP mechanism could be constructed for an exchange-for-value system.

Systemic risk. As overseers of payment systems, central banks are particularly concerned with *systemic risk*. This is the risk that the failure of one participant to meet its required obligations when due may cause other participants to fail to meet their obligations when due. Such a failure could trigger broader financial difficulties that might, in extreme cases, threaten the stability of payment systems and even the real economy. By their very nature networks, interbank payment and settlement systems are potentially a key institutional channel for the propagation of systemic crises. Central banks have a particular interest in limiting systemic risk in large-value funds transfer systems because aggregate exposures tend to increase with the aggregate value of transactions and potential risks in large-value transfer systems are therefore often significantly higher than those in retail funds transfer systems.

The vulnerability of a system to systemic risk depends on a number of factors. As analysed in the Lamfalussy Report, the size and duration of participants' credit and liquidity exposures in the interbank settlement process are basic factors affecting the potential for systemic risk. As these exposures last for longer and become larger, the likelihood that some participants may be unable to meet their obligations increases, and any participant's failure to settle its obligations is more likely to affect the financial condition of others in a more serious manner. Interbank funds transfer systems in which large intraday exposures tend to accumulate between participants therefore have a higher potential for systemic risk.

The potential for systemic risk may also be related to the propensity of systems to give rise to unexpected or sudden settlement obligations for participants. Such propensity may depend on the extent to which payment and settlement are conditional. A specific case concerns the *unwinding* of funds transfer obligations in the event of settlement problems. In some systems, if one participant is unable to settle its multilateral net (debit) settlement position and the position cannot be covered in another way, the system will recalculate a new set of net settlement positions for each of the remaining participants by deleting some or all of the (provisional) transfers made to and from the defaulting participant. However, in systems where positions are not controlled, this recalculation could lead to an unexpected and sizable change in the remaining participants' settlement obligations. For instance, if bilateral "net credits" due from the defaulting participant are no longer available, the remaining participants are likely to find that their net settlement obligations have increased. This could in turn seriously affect the financial position of these participants, which might result in further knock-on effects.

PART II REAL-TIME GROSS SETTLEMENT SYSTEMS: PRINCIPLES AND DESIGN

1. Overview of RTGS systems

1.1 Main features of RTGS systems

Definition. An RTGS system is defined in this report as a gross settlement system in which both processing and final settlement of funds transfer instructions can take place continuously (i.e. in real time).[17] As it is a gross settlement system, transfers are settled individually, that is, without netting debits against credits. As it is a real-time settlement system, the system effects final settlement continuously rather than periodically at pre-specified times provided that a sending bank has sufficient covering balances or credit. Moreover, this settlement process is based on the real-time transfer of central bank money.[18] An RTGS system can thus be characterised as a funds transfer system that is able to provide continuous intraday finality for individual transfers.

Payment processing. Within this broad definition, the operational design of RTGS systems can differ widely. In particular, important differences may arise in the approaches to payment processing when the sending bank does *not* have sufficient covering funds in its central bank account. One possible way of treating transfer orders in such circumstances is for the system to *reject* the orders and return them to the sending bank. The rejected transfer orders will be input into the system again at a later time when the sending bank has covering funds. Until that time, sending banks may keep and control the pending transfers within their internal systems (*internal queues*). Alternatively, the RTGS system may temporarily keep the transfer orders in its central processor (*system or centrally located queues*) instead of rejecting them. In this case, the pending transfers will be released for settlement when covering funds become available on the basis of predefined rules, agreed between the system and the participating banks.

In many cases the transfer orders are processed and settled with the extension of *central bank credit*, normally provided for a period of less than one business day (*intraday credit*); in other words, the central bank provides banks with the necessary covering funds at the time of processing by extending such credit. The central bank could take a range of approaches to the provision of intraday credit in terms of (a) the amount of credit (including a zero amount), (b) the method by which credit is extended (e.g. overdraft or repo), (c) the terms on the credit (e.g. free or priced) and (d) the collateral requirements (if any).

These possibilities of payment processing (i.e. *rejected*, *centrally queued, settled with central bank credit*) are not necessarily mutually exclusive. For example, when the provision of central bank credit is constrained in some way, the transfer orders for which the sending bank could/would not obtain central bank credit will be rejected or centrally queued. In recent years, new or planned RTGS systems have tended to apply a combination of these possibilities rather than being based on only one form of payment processing.

Ability to limit payment system risks. RTGS systems can contribute substantially to limiting payment system risks. With their continuous intraday final transfer capability, RTGS systems are able to minimise or even eliminate the basic interbank risks in the settlement process.

More specifically, RTGS can substantially reduce the duration of credit and liquidity exposures. To the extent that sufficient covering funds are available at the time of processing,

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[17] RTGS systems are typically electronic systems, using telecommunications networks, which transmit and process information in real time.

[18] In principle it would be possible to construct an RTGS system that settled across the books of a commercial bank. Such a system, however, would involve credit risk associated with the settlement medium.

settlement lags will approach zero and so the primary source of risks in interbank funds transfers can be eliminated. Once settlement is effected, the receiving bank can credit the funds to its customers, use them for its own settlement purposes in other settlement systems or use them in exchange for assets immediately without facing the risk of the funds being revoked. This capability also implies that, if an RTGS system were linked to other settlement systems, the real-time transfer of irrevocable and unconditional funds from the RTGS system to the other systems would be possible. The use of RTGS could therefore contribute to linking the settlement processes in different funds transfer systems without the risk of payments being revoked.[19]

As a corollary of the benefits of RTGS in interbank funds transfers, applying RTGS to funds transfers in an exchange-for-value settlement system can contribute to the reduction of the credit risk (principal risk) that may arise in such a system. Since RTGS permits the final transfer of funds at any time during the day (subject to the availability of covering funds), the final transfer of funds (the payment leg) can be coordinated with the final transfer of assets (the delivery leg) so that the one takes place if and only if the other also takes place. It is in this context that RTGS can provide an important basis for a DVP or PVP mechanism, thereby contributing to the reduction of settlement risk in securities and foreign exchange transactions.

Importantly, RTGS systems can offer a powerful mechanism for reducing systemic risk. As central banks have a common interest in limiting systemic risk, this capability has often been the key motive for many central banks to adopt RTGS in large-value transfer systems. The appeal of RTGS in terms of systemic risk containment may be better understood by breaking it down into separate elements. First, the substantial reduction of intraday interbank exposures could significantly lower the likelihood that banks may become unable to absorb losses or liquidity shortfalls caused by the failure of a participant in the system to settle its obligations. Second, RTGS precludes the possibility of unwinding payments, which can be a significant source of systemic risk in net settlement systems. Third, since banks can, in principle at least, make final funds transfers at the time of their choice during the day, settlement pressures are not concentrated at particular points in time. This makes it likely that banks will have more time to cope with problems (for example, a liquidity or solvency problem of a participant in the system), possibly by raising alternative funds or through the receipt of incoming transfers from other participants.

Intraday liquidity requirements. Provided that there are no legal problems with regard to settlement finality, the only structural impediment to continuous intraday finality is any liquidity constraint a sending bank may face during the day.[20] A liquidity constraint in an RTGS environment has two basic characteristics, namely that it is a *continuous* constraint for settling funds transfers and that intraday liquidity requirements must be funded by *central bank money*; banks must therefore have sufficient balances in their central bank accounts throughout the processing day.

Intraday liquidity requirements raise important issues for both the central bank and the private sector. Central banks, for their part, face a choice as to whether or not to provide banks with intraday liquidity and, if so, what form that provision will take (e.g. by what mechanisms and on what terms the credit will be provided, and how any resulting exposures will be managed).

From the perspective of individual banks, intraday liquidity requirements may lead to concern about the associated costs. Such "liquidity costs" may include direct funding costs (interest paid or any other explicit monetary costs such as charges/fees on central bank credit), opportunity costs of maintaining funds in central bank accounts (e.g. interest forgone), or opportunity costs of tying up collateral or securities in obtaining central bank credit. Furthermore, banks may have to be actively involved in the management of their payment flows in order to use intraday liquidity

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[19] The TARGET system being developed in the European Union in readiness for economic and monetary union is an example of such a linkage between RTGS systems (see Section III.1).

[20] An often-cited legal problem in the context of RTGS systems relates to a so-called zero-hour clause. This is a provision in bankruptcy legislation that may retroactively render transactions of a closed institution ineffective after 00:00 on the date on which closure is ordered.

effectively. This could require investment in the internal systems that they use to control payment flows, as well as entailing running costs.[21]

The intraday liquidity requirements under a particular RTGS system depend critically on (a) the structure of financial markets and systems (e.g. the adequacy of private sector sources of liquidity, the amount of collateral/securities available, reserve requirement regimes) and (b) the central bank's policy regarding the provision of intraday credit. The means by which intraday liquidity is provided can significantly affect the extent to which immediate, or at least very timely, final settlement occurs, and, ultimately, it can influence the balance between the potential benefits and costs of RTGS systems.

1.2 Overview of G-10 RTGS systems

In the G-10 countries, the first automated RTGS system was Fedwire in the United States. The modern version of Fedwire, based on a computerised, high-speed electronic telecommunications and processing network, was launched in 1970. By the end of the 1980s, six G-10 countries had introduced RTGS systems or large-value transfer systems with an RTGS facility. These systems were FA in the Netherlands (1985), RIX in Sweden (1986), SIC in Switzerland (1987), EIL-ZV in Germany (1987), BOJ-NET in Japan (1988) and BISS in Italy (1989).[22] In the 1990s, further new RTGS systems have been introduced, while some of the existing systems have recently upgraded their risk management capabilities and system architecture. For example, the Federal Reserve started charging a fee for intraday (daylight) overdrafts in Fedwire as from April 1994, while SIC was updated to introduce prioritisation facilities into the centrally located queuing in July 1994. New RTGS systems include CHAPS in the United Kingdom, which previously operated as a net settlement system but became an RTGS system in April 1996, and ELLIPS in Belgium, which came into operation in September 1996. In France TBF is under development. In Italy and the Netherlands the existing systems (BISS and FA) will be replaced by completely redesigned systems known as BI-REL and TOP respectively. According to current plans, RTGS systems will eventually be in operation in all G-10 countries except Canada by late 1997.

As summarised in the *comparative table* in Annex 1, the design of G-10 RTGS systems differs considerably. For example, the systems can be divided broadly into two groups - systems without a central bank intraday credit facility and systems with a central bank intraday credit facility.[23] The systems belonging to the former group are SIC (Switzerland) and BOJ-NET (Japan). In SIC, transfer orders are temporarily held in the centrally located queue if covering funds are not sufficient and are processed on the basis of the FIFO ("first in, first out") rule subject to assigned priorities upon the availability of funds, while in BOJ-NET uncovered transfer orders are rejected and returned to the sending bank.

In the remaining G-10 RTGS systems, central banks (will) provide intraday credit. In ELLIPS (Belgium), EIL-ZV (Germany), BI-REL (Italy), TOP (Netherlands), RIX (Sweden) and Fedwire (United States), intraday credit is or will be extended through intraday overdraft facilities.

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21 Similar issues are relevant in secured DNS systems in which limits/caps are used to control interbank exposures and banks need to manage intraday payment flows. See Section III.3.

22 BOJ-NET supports both DNS and RTGS. In BOJ-NET, the share of transactions settled by RTGS is very small. FA also operates both on a gross basis as an RTGS system (i.e. irrevocable transfers) and on a net basis; at present almost 95% of all transactions in terms of both volume and value are processed by RTGS. In RIX, some changes in the architecture are planned for 1997, including the introduction of centrally located queuing.

23 Irrespective of whether specific *intraday* credit facilities are available, all central banks provide some form of overnight financing facility. Where such overnight facilities can be drawn down during the day (rather than just at, say, the close of business), they provide another form of central bank credit that is potentially available to participants in an RTGS system to cover intraday liquidity needs (see also subsection II.2.2).

Intraday overdrafts must be fully collateralised in all of these systems except Fedwire.[24] In Fedwire an institution that incurs an overdraft is charged a fee based on its average daily overdraft and the size of the overdraft is limited according to a predetermined cap; collateral is required in certain rare cases and when an institution frequently exceeds its cap by material amounts solely on account of book-entry securities transactions. In CHAPS (United Kingdom), the central bank does not allow overdrafts but instead provides intraday liquidity through intraday repos; a similar approach will be adopted in TBF (France). In both these cases repos have been chosen largely for reasons associated with the legal status of the central bank's claim on the securities provided.[25]

Besides SIC, centrally located queues are or will be provided in ELLIPS, EIL-ZV, TBF, BI-REL, TOP and RIX, although their architecture shows considerable diversity. CHAPS is based primarily on internal queues; it is for each bank to decide the nature of the payment flow control process (and any associated algorithm) to be applied to transfer orders in an internal queue.[26] Anecdotal information suggests that internal queuing arrangements are also used by some larger participants in Fedwire. Furthermore, it is also reported that many large banks use internal queuing processes even in RTGS systems with centrally located queuing (e.g. SIC and BI-REL). This suggests that participants in RTGS systems often actively manage their own payment flows.

Table 3

G-10 RTGS systems: financial and queuing arrangements

Systems with:	**Centrally located queue**	**No centrally located queue**
Central bank intraday credit	ELLIPS (Belgium) TBF (France)[1] EIL-ZV (Germany) BI-REL (Italy)[1] TOP (Netherlands)[1] RIX (Sweden)[2]	CHAPS (UK)[3] Fedwire (USA)
No central bank intraday credit	SIC (Switzerland)	BOJ-NET (Japan)

[1] Under development. [2] Centrally located queuing is being designed. [3] See footnote 26.

The comparative table in Annex 1 also highlights some key differences other than intraday liquidity facilities and queuing arrangements, which could have important implications for the working of the RTGS system.

(a) *Ownership and access policies.* Most systems are owned by central banks. ELLIPS and CHAPS are owned by an association or a company whose members are the direct participants and the central bank; the systems are connected to the central bank's internal real-time accounting system. Access policies also differ. In principle, direct access to RTGS systems requires participants to hold their accounts at the central bank, which may

[24] In the European Union, full collateralisation of central bank credit is a requirement stemming from the Statute of the European System of Central Banks (ESCB).

[25] In Belgium, banks participating in ELLIPS are also allowed to make use of intraday repos to obtain intraday credit from the central bank.

[26] In CHAPS, the operating rules require that the sending bank should only release settlement requests if sufficient funds are held in its account at the central bank; however, if a bank mistakenly releases a request when insufficient funds are available, the request will be queued at the centre. The Bank of England also has the ability to provide an optimisation mechanism (circle processing) for the resolution of gridlocks, in which case the banks concerned would be asked to release their blocked payments into the system to allow them to be processed by the centre.

raise issues regarding the conditions under which participants can hold central bank accounts. In the majority of systems direct access is open to all banks (or credit institutions or depository institutions as applicable). Additional criteria such as financial strength and technical requirements are applied in several systems. In the European Union the central banks have agreed that, with limited exceptions, direct access should be confined to credit institutions. Partly reflecting the differing access policies, the number of direct participants varies across systems; some systems have large numbers of direct participants, whereas other systems are two-tiered systems with a more limited number of direct settlement members, although indirect participation in the system can be wide.

(b) *Message flow structures.* The majority of systems are based on so-called V-shaped structures, whereas others use Y-shaped or L-shaped structures. Section II.3 discusses message flow structures in more detail.

(c) *Reserve requirements and central bank account structures.* Countries vary in the extent to which required reserves are imposed and are available for use as intraday liquidity in the RTGS system. Central bank account structures also vary in terms of whether the RTGS accounts are separated from the accounts used for required reserves or other purposes (i.e. unified or segregated accounts) and whether banks can hold RTGS accounts at more than one office of the central bank (i.e. centralised or decentralised accounts). Section II.2 discusses these variations in more detail.

(d) *Relationships with other systems*. In Germany, Japan and the United States, RTGS systems coexist with net settlement systems for large-value transfers, and this will also be the case in France.[27] In other countries RTGS systems are or will be the only large-value funds transfer system. RTGS systems are also used for the settlement of retail payments in various ways and in several countries RTGS systems support real-time DVP systems for securities transactions.[28]

2. Components, measures and management of liquidity in RTGS systems

This section looks at issues relating to liquidity in RTGS systems. It first describes each of four possible components of liquidity available to participants in RTGS systems and then considers the different measures of liquidity that can be constructed from these components. It then discusses the management of liquidity from, respectively, an individual bank's point of view and the system's point of view. Finally, it looks at how structural factors can affect liquidity and its management.

2.1 Components of liquidity in RTGS systems

In general terms, for an individual participant in an RTGS system the four possible sources of funds are (a) balances maintained on account with the central bank, (b) incoming transfers from other banks, (c) credit extensions from the central bank and (d) borrowing from other banks through the money markets.

Balances maintained at the central bank can be a basic source of liquidity for the purpose of making funds transfers during the day. At a given point in time during the day, the level of the

[27] In France, the private sector is currently developing a secured DNS system for large-value funds transfers (SNP, Système Net Protégé) that will operate in parallel with TBF.

[28] A real-time securities DVP system is understood to mean a model 1 DVP system operating in real time. The DVP Report defined model 1 as DVP systems which settle transfer instructions for both securities and funds on a gross basis, with final transfer of securities from the seller to the buyer (delivery) occurring at the same time as final transfer of funds from the buyer to the seller (payment).

balance for an individual participant is determined by the starting/overnight balance and any payment activities (including both RTGS payments and any other transactions across the account), credit extensions by the central bank and central bank monetary operations that have taken place by that time.[29] Starting balances may be generated by reserve requirements that are usually imposed for monetary policy reasons. Provided they are available for payment purposes during the day, required reserves can be a helpful source of intraday liquidity, as has proved to be the case in several G-10 countries. The importance of required balances may, however, vary between countries, depending on the nature of the reserve maintenance regime (e.g. the level of the required reserve ratio and any averaging provisions).[30]

Incoming transfers can also be an important source of intraday liquidity. The importance of incoming transfers depends on the patterns and predictability of payment inflows and outflows. If, for instance, payment flows tend to result in a specific pattern for a particular bank (such as net payment outflows) or if the intraday timing of incoming and outgoing transfers tends to be asymmetrical, incoming transfers may be less reliable as a funding source for outgoing transfers. Furthermore, the usefulness of incoming transfers may also be affected by the availability of information on them; the more information that is available in real time, the more effectively banks may be able to use incoming transfers in their liquidity management.[31]

Intraday liquidity may be provided by the central bank through credit extensions. As described in Section II.1, many central banks provide intraday credit, typically free of interest charges, through fully collateralised intraday overdrafts or intraday repos. As already noted, Fedwire charges a fee for the use of the uncollateralised intraday overdraft facility that it provides up to a limit based on a bank's creditworthiness and capital. Central banks may also have some kind of overnight central bank liquidity facility that RTGS participants may access under certain conditions. However, overnight credit extensions from the central bank (e.g. overnight loans or overdrafts) may be considered a relatively costly funding source to support intraday payment activities, because the funds only needed for an intraday period must be borrowed overnight and they can in some cases incur an implicit or explicit extra cost (e.g. penalty rate) in addition to the discount or market rate.[32]

Banks in an RTGS system may also be able to obtain funds by borrowing from other banks through the interbank money markets. Money market credit extensions such as overnight and term loans may allow banks to fund intraday payment flows, depending on the time of day that market conventions set out for loans to be arranged, made available and repaid. For example, if banks can borrow from overnight interbank markets throughout the operating hours of the RTGS system, the loan proceeds could be available to fund transfers intraday (i.e. depending on when the funds are credited to the borrowing bank's account). While credit extensions from the central bank can be regarded as external liquidity support that injects additional liquidity into the system, money markets can only serve to redistribute funds already within the system, although that may nevertheless make an important contribution to reducing the reliance on banks' reserve balances and central bank credit extensions.

Intraday money markets could also act as a private sector liquidity source in the RTGS environment. In such markets banks would lend reserve balances on an intraday basis provided that the intraday timing of loans being arranged and repaid could be assured and the transaction costs of such arrangements were not prohibitive. If such a market existed, banks could operate with lower balances because of the ability to redistribute balances across banks during the day. At the moment,

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29 Non-RTGS payments mean, for example, credits or debits from net or securities settlement systems or from other transactions with the central bank besides credit extensions.

30 Recently, there has been a broad tendency for the level of required reserves to decrease in many G-10 countries.

31 Issues relating to the availability of information on queued incoming transfers are discussed in subsection II.4.2.

32 See Section III.2 for a discussion of the issue of "spillover" from intraday credit to overnight credit. See Part II of Annex 1 for more information about the available liquidity facilities.

however, the only example of an intraday money market in the G-10 countries that has developed from an RTGS environment seems to be that in Switzerland, and even that is a very limited market for special time-critical payments in connection with securities transactions. An intraday interbank market also exists in Japan but this market is not directly related to the intraday liquidity needs under RTGS but rather to the need for bridging liquidity between four designated net settlement times in BOJ-NET.[33] The possibility of the development of intraday money markets in an RTGS environment is considered in more detail in Section III.2.

2.2 Measures of intraday liquidity

On the basis of the four components discussed above, liquidity as applied to the operation of RTGS systems may be measured both from an individual bank's perspective and from a system perspective. From a bank's perspective, intraday liquidity may be taken to be the bank's ability to settle a given value and number of transfers within a given time constraint.

One way to characterise this concept would be to define so-called *"net" intraday liquidity* on the basis of *actual* cash flows. As already noted, a bank's actual balance at the central bank at a given point in time during the day is determined by the starting balance as well as any payment or monetary activities and credit extensions that have taken place by that time. This actual balance, however, may not necessarily represent the liquidity immediately available for the bank to initiate new outgoing transfers at that time, because some or all of the transfers that it has already initiated may be queued within its internal system or in the centrally located queue. A bank's net intraday liquidity, which may correspond more closely to its ability to settle its outgoing transfers at a given point in time, could be defined as the actual balance minus the value of all pending transfers.

Alternatively, a bank's net intraday liquidity could be defined on the basis of the sum of actual and *potential* cash flows. Such a concept has been adopted in some RTGS systems as a measure of available liquidity,[34] although in some other cases it has been felt that incorporating potential cash flows may be too difficult. Potential cash flows refer to potential funds which a bank could mobilise or use for cover. For example, a bank might include queued incoming transfers as a source of liquidity that it expects to be available shortly for its own outgoing transfers. In this case, a bank's net intraday liquidity is defined as the actual balance *plus* the value of queued incoming transfers *minus* queued outgoing transfers. As potential sources of liquidity, a bank might also include, for example, unused credit lines or liquid collateral.

Concepts of illiquidity. If net intraday liquidity is negative, the bank can be viewed as being *illiquid* in the sense that it is unable to settle some or all of its queued outgoing transfers. However, care needs to be taken in interpreting the concept of a bank's illiquidity. Although transfers processed over an RTGS system have some degree of time-criticality, not all transfer orders are time-critical in the sense that they must be settled either at or by a specific point in time during the day or within a specified and limited interval of time during the day. Some funds transfer orders may be time-critical only in a same-day sense even in an RTGS environment. Time-criticality and intraday time constraints may be influenced by the nature of the transfers, transaction pricing policy (see

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[33] Although its implications are different, the intraday call-money market in Japan seems to be the most developed intraday money market in the G-10 countries. It accounts for a significant part of the call-money market in Japan (approximately one-fifth of the overnight call-money market in terms of turnover). It has developed as a market to bridge market participants' funding and investment needs between four designated net settlement times (09:00, 13:00, 15:00 and 17:00). For example, participants with a surplus (shortage) of funds at 13:00 but an anticipated shortage (surplus) of funds at 15:00 will invest (finance) the surplus (shortfall) in the market for this period.

[34] For example, the Bank of France will use a liquidity concept known as "virtual balances" that corresponds to defining a potential cash flow as queued incoming transfers in TBF. TBF will calculate the virtual balance for each participant in the system.

below) and rules relating to end-of-day closing procedures. Accordingly, even if a bank becomes illiquid, it may be able to delay certain less time-critical transfers in order to allow subsequent incoming transfers to provide the necessary liquidity. The scope for such liquidity management will vary, and typically will narrow towards the end of the day. In practice, therefore, for illiquidity to have a significant impact on a bank, it must occur over some "significant" interval of time.

System liquidity and gridlock. From a system perspective, the concept of intraday liquidity could be related to the "amount" of funds that enables the system to process transfers between all or most of banks in a timely manner. However, it is more difficult to analyse system liquidity because it is not simply the sum of each bank's net intraday liquidity as defined above. Whether the system is liquid or not also depends crucially on the distribution (or concentration) of liquidity among banks in relation to their payment needs. For instance, *gridlock* could be characterised as a case of system illiquidity in which the failure of some transfers to be executed prevents a substantial number of other transfers from other participating banks from being executed. Of course, gridlocks could occur when the aggregate liquidity is insufficient, but they might occur even if the liquidity in the system, taking into account all queued incoming and outgoing transfers, was adequate overall but poorly distributed. Suppose two systems had the same aggregate sum of bank liquidity: one might be liquid while the other might be in gridlock if liquidity was concentrated among a few banks in that system (see Box 2). Because of this, some systems provide banks with ways of breaking gridlock.

BOX 2

THE PROBLEM OF LIQUIDITY DISTRIBUTION

Consider two RTGS systems. Both have four banks and identical payment flows (shown in the columns headed NP and P) but the available starting balances on the banks' accounts at the central bank (column SB) are different. Although the aggregate sum of banks' net liquidity is the same (40) in both systems, only Bank D is illiquid in System 1, whereas System 2 is in gridlock.

System 1

Banks	SB	NP	P	L
A	25	5	0	30
B	25	0	10	15
C	25	-5	20	0
D	25	0	30	-5
Sum	100	0	60	40

System 2

Banks	SB	NP	P	L
A	100	5	0	105
B	0	0	10	-10
C	0	-5	20	-25
D	0	0	30	-30
Sum	100	0	60	40

where: SB = the balance available to make RTGS transfers at the beginning of the day;
NP = the net receipt of transfers by a given point in time (t) during the day;
P = the amount of queued outgoing transfers at time t;
L = the net intraday liquidity at time t = SB + NP - P.

Another important issue in connection with system liquidity is that there might be negative externalities relating to the use of a bank's liquidity.[35] For instance, a bank may deliberately be slow in processing transfers in order to economise on its own liquidity by relying on the receipt of incoming transfers from others.[36] If such behaviour is widespread, there is the potential for a kind of

35 The term "externality" refers to a case in which the behaviour of one participant has a direct effect, which is not controlled through the price mechanism, on the situation faced by another participant.

36 It could be argued that fear of retaliation by other banks for such behaviour might prevent banks from doing this.

self-imposed gridlock as each bank delays sending its payments until others do so, with the result that (in an extreme case) none are sent.

2.3 Management of intraday liquidity: an individual bank's perspective

The need to have intraday liquidity typically entails a positive cost for banks in the form of funding costs and/or opportunity costs. Banks therefore have incentives to manage intraday liquidity by attempting to minimise it subject to certain constraints. Constraints on intraday liquidity management vary from system to system. In general, banks are likely to try to avoid undue delays in time-critical transfers (both because of customer relations and on account of possible legal liabilities) as well as to try to minimise end-of-day overdrafts or processing penalties.[37] For these purposes, for example, banks may hold precautionary balances to guard against urgent and unexpected transfers. Reserve requirements could also be a constraint, particularly if the requirement has to be met each day.[38]

An optimal level of intraday liquidity for an individual bank may be determined by the balance between the costs of obtaining or maintaining liquidity and the costs of delaying settlement. As noted in subsection II.1.1, the former (liquidity costs) may include direct funding costs, opportunity costs of maintaining funds in the central bank accounts and opportunity costs of tying up collateral or securities for central bank credit. The opportunity cost associated with collateral for obtaining intraday liquidity could be relatively low if banks already hold the relevant types of asset in sufficient quantities, which they might do as part of their portfolio strategy or for other reasons. Although it may not be easy to measure in practice, from an analytical point of view the concept of "settlement-delay costs" could be defined as the potential or actual economic costs incurred if the settlement of funds transfer orders were delayed. The degree of settlement-delay cost in a particular RTGS system may depend on the time-criticality of the underlying transactions, transaction pricing policies as described below and, more generally, market practices. Given the level of liquidity costs, banks are likely to have stronger incentives to obtain or maintain intraday liquid funds as delaying settlement becomes more costly.

With a given starting balance, banks may operate intraday by adjusting the use of intraday or overnight credit, sequencing incoming and outgoing transfers or, in limited circumstances, selling assets for same-day settlement. Of these possibilities, *sequencing transfers* is a way of controlling intraday payment flows by scheduling the timing of outgoing transfers according to the supply of liquidity provided by incoming transfers. Importantly, to the extent that incoming and outgoing transfers are successfully sequenced, it could generate virtual "offsetting effects" on RTGS payments and hence contribute to substantially reducing the necessary liquidity. The most common way of sequencing is to use queuing arrangements. Regardless of whether it is centralised or decentralised, queuing allows banks to sequence transfers in a systematic way. Queuing is described and discussed in detail in Section II.4.

Another method of sequencing transfers may involve message codes indicating the time of day that an individual outgoing transfer should be settled. Such time-of-day message codes may be used to store transfer orders within the central processor in the system or within the internal system of

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37 In SIC, for example, if transfer orders are cancelled at the end-of-day processing, the receiving bank is entitled to charge the sending bank interest at the market rate plus a penalty surcharge of 500 basis points.

38 In countries where the level of required reserves is instead calculated as an average balance over a maintenance period (e.g. two weeks, one month), reserve requirements may not necessarily be a binding constraint for intraday liquidity management on a particular day, because banks can deviate temporarily from the target reserve maintenance plan in order to make unexpected transfers. However, even then reserve requirements are likely to have an impact as the end of the reserve maintenance period approaches because the scope to correct one day's shortfall by a subsequent day's surplus is correspondingly reduced.

the sending bank.[39] Time-of-day message codes might allow banks to better forecast liquidity requirements by increasing the certainty of the timing of debits and credits associated with transfer orders involving a standard time-lag between the transaction date and the settlement date (e.g. securities and foreign exchange transactions), intraday and overnight loans and other time-critical transfers such as those for the settlement of balances in net settlement systems.

Even if they attempt to coordinate incoming and outgoing transfers as closely as possible, banks may still face several limitations in minimising intraday liquidity requirements. First, as noted above, if transfers are time-critical, that limits the extent to which banks can delay them. Second, individual transfer orders are often very large. Breaking down a particularly large transfer into two or more smaller amounts may facilitate sequencing, and in some RTGS systems this is actually done as a standard means of liquidity management. Nevertheless, the resulting transfers can still be large, which would make closer sequencing difficult. Third, banks cannot have complete information about the transfers they are due to receive and send on that day, so that they have to sequence transfers more or less on the basis of predictions.

2.4 Management of intraday liquidity: a system perspective

The management of intraday liquidity from a system perspective may concern both management of the *aggregate level* of liquidity relative to payment requirements in the system and management of the *distribution* of liquidity among banks. For the former purpose, the central bank may typically provide individual banks with credit directly for settlement purposes or indirectly through monetary operations according to its policy.

It is possible that the optimal liquidity management from an individual bank's perspective may not necessarily be best for the system as a whole. As noted earlier, a bank may make a deliberate attempt to delay the processing of transfers to economise on its own liquidity by relying on the expected receipt of liquidity from others. To minimise the possible negative effects of such behaviour on system liquidity, RTGS systems sometimes incorporate mechanisms to discourage "selfish" behaviour and to encourage early processing and/or settlement of transfers. One way is to lay down rules governing banks' outgoing payment flows, such as guidelines requiring banks to send a certain proportion of their daily payment messages by specified times. Such a rule would discourage banks from delaying transfers. However, it may be inappropriate in some cases; for instance, some banks may have atypical intraday patterns of transfers, making it unrealistic for them to observe such a rule. Or it may be that the rule is incompatible with the pattern of transfers deriving from DVP or (future) PVP arrangements, where the timing of transfers is critical. At the least, therefore, some flexibility may be needed in setting and applying such a rule.[40]

An alternative method may be to apply a transaction pricing policy that would encourage the early processing (input) and settlement of transfer orders. For instance, SIC applies a pricing schedule for sending banks that penalises (i.e. sets a higher charge on) late input and settlement of transfer orders, while the receiving bank is subject to a flat pricing schedule. This has led banks to send and settle their bulk low-value payments as early as possible, ahead of large-value funds transfers. Some proposed systems are also considering the possibility of adopting a pricing policy that would set a higher charge on queued or late transfers (i.e. transfers that are entered only shortly before the close of the system). Charging a penalty fee on the transfers that remain unsettled at the end of the day could be used to complement such a transaction pricing policy.

Monitoring system liquidity. Central banks (or system centres) are in many cases concerned with monitoring and managing liquidity in RTGS systems so as to maintain a smooth flow

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[39] Some RTGS systems allow banks to store transfer orders by entering them into the system processor in advance of the value date (a so-called central warehousing facility).

[40] CHAPS uses such throughput guidelines.

of payments and to detect and prevent possible gridlocks. There are significant differences in central banks' technical approaches to monitoring system liquidity. For example, the Bank of Italy envisages an "indicator approach" to real-time monitoring whereby the central bank will pay particular attention to synthetic indicators calculated on the basis of several key parameters such as the total amount of liquidity available in the system, the volume of transfers entered into the system and the volume of settled transactions. The indicators will be used to observe the queues and intraday liquidity in the system as a whole and also to identify any potential gridlocks which may require further investigation of an individual bank's net liquidity position. On the other hand, the Bank of France will take a more "micro approach" whereby it will monitor in real time each bank's net intraday liquidity. In contrast, the Swiss National Bank does not systematically monitor system liquidity in SIC. This reflects its view that monitoring liquidity is mainly the responsibility of participants and that there should be no intervention by the central bank or the system in the centrally located FIFO queue.

2.5 Structural factors affecting liquidity requirements and management

There are various structural factors that may affect liquidity requirements and management in an RTGS system. First, the number of participants may be of significance. Compared with a system with a larger number of participants, an RTGS system with relatively fewer participants might internalise a greater proportion of third-party payments and therefore have a lower level of interbank transfers sent over the system; as a result, less intraday liquidity might be required at the system level to process a given volume of payments. Such a system may also have more concentrated, offsetting payment flows between banks and thus incoming transfers would be a relatively more important source of liquidity. Furthermore, it might technically be less complicated for banks to monitor, control and sequence payment flows in a system with relatively fewer participants.

Second, the relative market size (in terms of payment activity) or asset size of participants may affect liquidity. An RTGS system with a mixture of large, medium and small participants may have a different set of intraday liquidity requirements from a system consisting of participants of broadly equal size. Larger banks, for instance, may have a more balanced intraday flow of incoming and outgoing transfers, so that incoming transfers can provide the liquidity needed to fund outgoing transfers, while smaller banks may process fewer transfers or tend to be net senders/receivers of funds in the RTGS system. Larger banks may also find it easier to obtain the necessary liquidity if they have better access to funding and credit markets or a larger deposit base than smaller banks.

Third, participants' areas of specialisation may matter. If an RTGS system is composed of banks that specialise in a variety of different market segments (such as merchant banking, credit card transactions, deposit-taking, clearing activities, foreign exchange transactions and securities transactions), payment flows and patterns and the resulting liquidity requirements may differ from those in systems where participants tend to offer a more uniform range of products and services.

Fourth, the structure of the payment systems and flows outside the RTGS system may affect RTGS liquidity. Non-RTGS payments can be an important "exogenous" factor affecting a bank's RTGS liquidity. In practice, the mechanism through which non-RTGS payments influence RTGS liquidity may take a variety of forms. Typically, net settlement obligations resulting from other settlement systems (e.g. cheque clearing, other large-value transfer systems, ACH transactions and securities settlement systems) are settled periodically over the RTGS system or at least processed through the same central bank account as that on which the RTGS system relies for intraday liquidity (see Section III.1). In such circumstances where RTGS payments and the settlement of non-RTGS payments are interrelated and "competing" uses of liquidity could therefore arise, banks may use internal systems capable of integrating their RTGS and non-RTGS payment activities on an intraday basis to manage their overall liquidity. At the same time, since the settlement of foreign exchange transactions accounts for a substantial part of the total value handled by many RTGS systems, existing or proposed netting arrangements for such transactions (e.g. FXNET, ECHO and Multinet) may, by requiring only the net value of the transactions to be settled, also have an effect on the value and timing of transactions, and consequently on the liquidity, in some RTGS systems.

Fifth, the structure of central bank accounts may be an important factor influencing RTGS liquidity. As the comparative table in Annex 1 shows, there are differences between G-10 countries in the way central bank accounts are organised: central bank accounts for RTGS may be unified with or segregated from central bank accounts for other purposes, for example for required reserves. Moreover, central bank accounts may be centralised (i.e. banks hold accounts for making transfers at only one office of the central bank) or decentralised (i.e. they are permitted to hold accounts at more than one office).[41]

One question is whether, under a decentralised account structure, banks are able to monitor balances and shift them efficiently between accounts on a real-time basis for liquidity purposes. In general, the structure of central bank accounts in a country is determined by a number of different considerations and therefore an optimal account structure will not necessarily depend only on the settlement arrangements for RTGS systems. However, in countries that have a decentralised account structure and where RTGS systems are operating or planned, there seems to be a broad tendency to centralise/consolidate central bank accounts, or at least to centralise the arrangements for processing the account data. This may suggest that a more centralised structure is sometimes a more efficient and straightforward structure for an RTGS environment, in particular in terms of liquidity management. For example, in preparation for TBF, the Bank of France is moving from a decentralised account structure in its branches to a centralised one at the head office. In Germany the Bundesbank has so far provided several facilities to help banks manage liquidity in a more centralised way in EIL-ZV under the decentralised account structure.[42] In addition, it plans to convert the current decentralised electronic data-processing structure into a new centralised one and to take further steps to provide more comprehensive information about queued payments with a view to enabling banks to conduct more efficient liquidity management. In the United States the Federal Reserve is taking the approach of using centralised accounts but with distributed sub-accounts to provide for segregation and flexibility as regards transaction information.

3. Message flow structures

As noted earlier, a lag between the time at which information is made available to receiving banks and the time at which settlement takes place may have important risk implications in large-value funds transfer systems. Even in the RTGS environment, where both processing and final settlement are made in real-time, several circumstances can be identified in which the treatment of payment messages or the associated information could be a source of risk. This section looks at four different types of message flow structure.[43]

To initiate a funds transfer the sending bank dispatches a payment message which is subsequently routed to the central bank and to the receiving bank as the system processes and settles the transfer. Arrangements for routing payment messages in the majority of RTGS systems are or will be based on a so-called *V-shaped* message flow structure. In this structure the *full message* with all the information about the payment (including, for example, the details of the beneficiary) is initially

41 In some G-10 RTGS systems, a banking group or a bank holding company has separate settlement accounts for each of the subsidiaries of the group.

42 For example, under the so-called routing system (*Leitwegsteuerung*), credit institutions can ask for EIL-ZV credit transfers being sent to them to be transmitted and settled through routes which differ from those indicated by the bank code numbers on the transfers: for instance, a credit institution can ask that all transfers to its branches are passed via its head office and credited to the latter's Bundesbank giro account (rather than to the branches' Bundesbank accounts).

43 The report will also discuss particular issues relating to information on queued payment messages in subsection II.4.2.

passed to the central bank and is sent to the receiving bank only after the transfer has been settled by the central bank (see Box 3).

Some G-10 RTGS systems, and particularly those that use the S.W.I.F.T. network, apply an alternative structure, known as a *Y-shaped* structure.[44] In this case, the payment message is transmitted by the sending bank to a central processor. The central processor takes a *subset* of information that is necessary for settlement from the original message and routes this core subset to the central bank (the original message being kept in the central processor). Upon receipt of the core subset, the central bank checks that the sending bank has sufficient covering funds on its account and informs the central processor of the status of the transfer, for instance queued or settled. Once settled, the full message containing the confirmation of settlement is rebuilt by the central processor and sent to the receiving bank. The business information exchanged between the sending and receiving bank (such as the identity of the beneficiary) is therefore not known by the settlement agent.

So far only CHAPS has adopted an *L-shaped* structure, which is conceptually similar to a Y-shaped structure. This configuration was chosen because it could be implemented by modifying rather than rewriting the software supporting the previous DNS arrangement. The payment message dispatched by the sending bank is held at a system "gateway" attached to the sending bank's internal processing system and a subset of information contained in the original message (a settlement request) is sent to the central bank. If the sending bank has sufficient covering funds on its account, settlement is completed and the central bank sends back a confirmation message to the sending bank's gateway. Upon receipt of this confirmation (and only then), the original payment message is released automatically from the gateway of the sending bank and sent to the receiving bank.

In part, these different structures reflect differences in both the network configuration of the system and the operational role of the central bank. In both the V and Y-shaped structures, all messages from the sending bank are routed first to a central entity (S.W.I.F.T., a central processor or the central bank itself) and, after settlement, all messages to the receiving bank are sent by that central entity. By contrast, there is no central entity for delivering messages in the L-shaped structure, where message routing is based on the bilateral exchange of information between banks, reflecting the decentralised architecture of the CHAPS system. In terms of its operational role in the system, the central bank is directly involved in both the settlement and processing of payment messages in the V-shaped structure, while in the Y and L-shaped structures the process of message routing can be handled by the network operator or the banks themselves, with the central bank only acting as the settlement agent.

It is important to note, however, that these three types of structure all share the common feature that the receiving bank will receive the full payment message only *after* the transaction has been settled by the central bank. In these structures, therefore, the message flow structure per se cannot give rise to the possibility that the receiving bank will act upon unsettled payments.[45]

Alternatively, RTGS systems could apply a T-shaped structure, in which the sending bank routes payment messages directly to the receiving bank (through the message carrier), with copies (made by the message carrier) sent simultaneously to the central bank. This means that the receiving bank will first receive the full, unsettled payment message immediately after the sending bank has dispatched it and will subsequently also receive a confirmation message from the central bank once settlement has taken place. The T-shaped structure has generally been viewed as being incompatible with the basic principle of RTGS that a funds transfer should be passed to a receiving bank if and only if it has been settled irrevocably and unconditionally by the central bank. The receiving bank may not easily be able to distinguish between settled and unsettled payment messages

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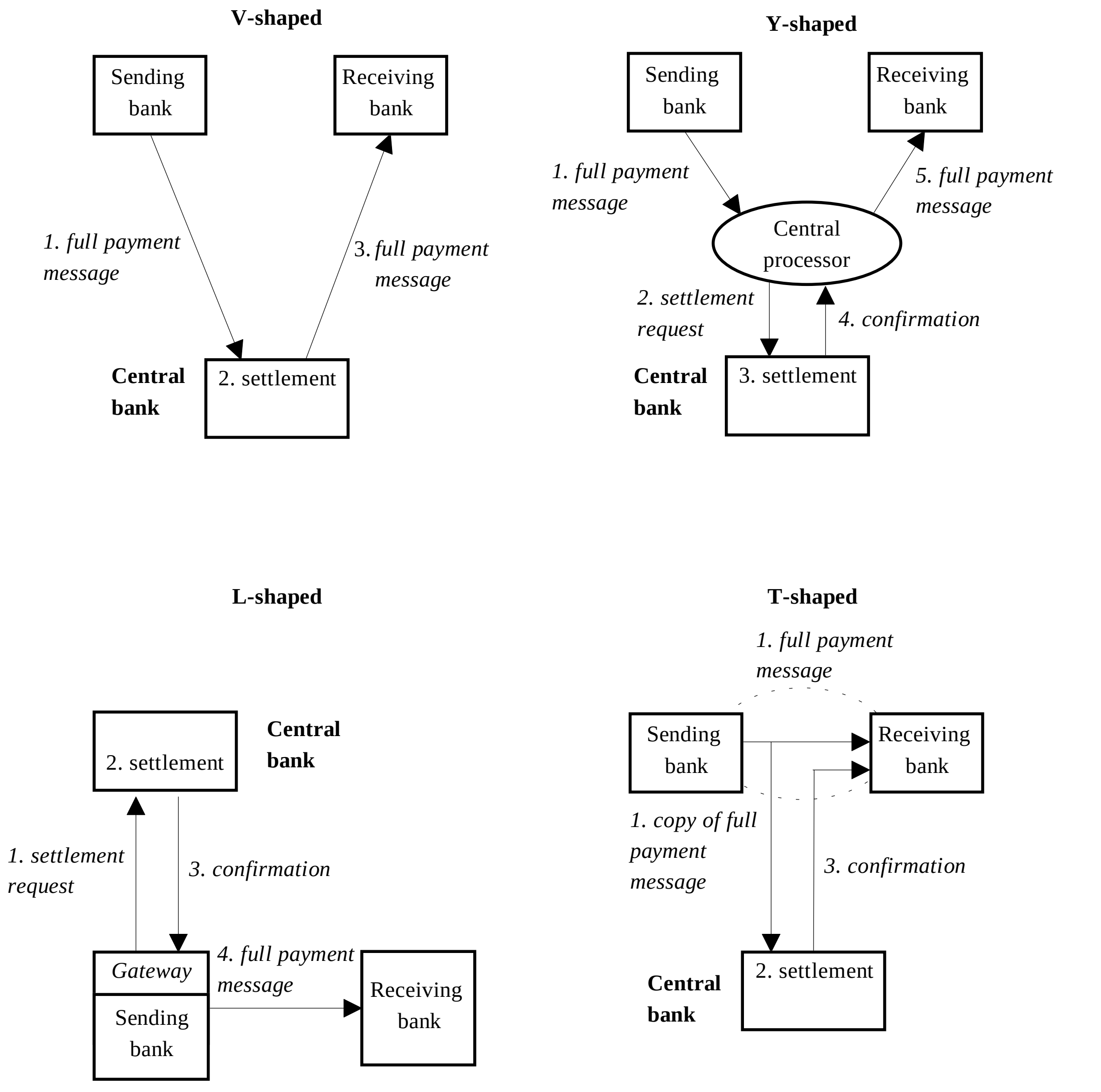
44 A Y-shaped structure is (will be) used by RTGS systems in Belgium and France. It is also reported that RTGS systems in Greece, Ireland and Portugal will apply this structure.

45 As will be discussed in subsection II.4.2, however, the transparency of queued incoming transfers does create this possibility (as does the possibility of banks exchanging information outside the system).

at the time of receipt of the (unconfirmed) messages; even where it can make the distinction, competitive pressures may cause it to credit the funds to the beneficiary customer on the basis of the unsettled message or it may anticipate the arrival of the funds in other ways (e.g. by reducing the liquidity it obtains from other sources). To the extent that this happens credit and liquidity risks would be generated in the system in a manner analogous to that discussed in Section I.2. As this aspect has been recognised as a drawback in the RTGS environment, no planned or existing G-10 RTGS systems are based on the T-shaped structure.

BOX 3

MESSAGE FLOW STRUCTURES



4. Queuing arrangements

Broadly defined, queuing refers to an arrangement whereby funds transfer orders are held pending by the sending bank or by the system in a certain order so as to prevent any limits set against the sending bank from being breached or to manage liquidity more generally. In RTGS systems, queues are most commonly generated when sending banks do not have sufficient covering funds in their central bank account. As described in Section II.1, individual banks' queues may be held at the system's central processor (*system or centrally located queues*) or they may be held within the banks' internal systems (*internal queues*). These two broad possibilities according to the *location* of the queues are not mutually exclusive; banks may maintain internal queues in addition to the queues at the centre, as is done in some RTGS systems with centrally located queues. Queuing can also differ according to the *management* of the queues, that is, how an individual bank's queue is controlled. The management may be carried out by the centre (*centralised management*) or by banks individually (*decentralised management*). Irrespective of whether the queues are physically located at the centre or within banks' internal systems, the management of queues could in principle be either centralised or decentralised. Combinations of these possibilities in terms of the location and management can thus lead to various forms of queuing.[46]

This section looks at queuing in RTGS systems. It first provides an overview of the key design features that are typically seen in centrally located queuing, then considers the information facilities provided under such arrangements (and in particular the degree of "transparency" of queued incoming transfers), and finally discusses the possible implications of different approaches to queuing.

4.1 Key components of centrally located queuing

Methods of queue processing. To date, most centrally located queuing arrangements have adopted a form of FIFO ("first in, first out") rule for queue processing. Where the FIFO rule is applied, funds transfer orders are held in the order in which they are dispatched by the sending bank; the payment at the top of the queue is released and settled when covering funds become available, and only then is the payment behind it in the queue considered for settlement. Some systems apply variations on the strict FIFO rule; for example, ELLIPS uses a "bypass FIFO" rule under which the system tries to process the first transfer in the queue, but if that cannot be executed owing to lack of funds it then tries to settle the next transfer instead.[47]

It seems that the FIFO rule (or a variation on the FIFO rule) is the predominant method of centrally located queuing because of its simplicity. Moreover, although non-FIFO rules or more sophisticated mathematical algorithms might be more efficient in settling a greater number of transfers, the same efficiency may be achievable in a more straightforward way by combining simple FIFO with facilities such as prioritisation, reordering or optimisation as described below.

In practically all centrally located queuing arrangements, the system provides facilities whereby priority codes are attached to the funds transfers. Where this is the case the transfers are placed in the queue on the basis of the assigned priorities and are released for settlement on a FIFO basis within each priority level (i.e. no transfers of a particular priority will be settled until all those of a higher priority have been settled). In some systems, the priorities are chosen by the sending banks

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[46] In practice, some possible forms of queuing are less realistic. For example, it is unlikely that queues could routinely be managed by the centre if they were held within the banks' internal systems.

[47] Bypass FIFO is sometimes referred to as "dynamic FIFO". Under this rule, a FIFO feature remains in the sense that, each time it has succeeded in settling a transfer in the queue, the system will move back to the top of the queue to test whether further transfers can be settled. It is reported that the proposed RTGS system in Australia will apply a non-FIFO method referred to as "next-down looping" under which the system will first test *all* queued transfers in the order in which they are placed in the queue (settling those that it can) and only then return to the top of the queue to begin the process again.

according, for example, to their assessment of the urgency of the transfer, whereas in other systems transfer orders are prioritised automatically by the system according to the type of transaction. In the latter case, a high priority tends to be attached to transfer orders relating to central bank operations or settlement obligations stemming from other systems such as securities DVP systems and netting systems. The use of priorities helps banks to achieve greater flexibility in FIFO processing.

Queue management or intervention facilities. In addition to prioritisation facilities, centrally located queuing arrangements in recent or planned systems sometimes include *queue management or intervention facilities* that allow the system centre (i.e. the central bank or system operator) and/or individual banks to control the number/value of queued transfers.[48] One approach to queue management is *reordering.* Such facilities are designed so that the system centre and/or individual banks can reorder the transfers in the queue by changing the original order of receipt or priorities with a view to minimising the number/value of queued transfers. While prioritisation facilities allow banks to sequence their transfers before they put them into the system, reordering can be characterised as a facility for managing queues with discretion after the transfers have been placed in the queue. Typically, where reordering is allowed, it can only take the form of moving a payment to the end of the queue or changing its priority code (in both cases the effect being similar to that of cancelling and re-entering the payment). See Box 4 for examples of queue processing and reordering.

Another approach to intervention is to use so-called *optimisation routines*.[49] The term "optimisation" is used in a number of different ways, sometimes even in a broad sense to refer to any form of intervention by the system centre to minimise the number/value of queued transfers. In this report, optimisation routines are more narrowly defined as any pre-specified procedures or algorithms that the system centre can activate to minimise the number/value of queued transfers given available funds *at designated times or if gridlock occurs.* Optimisation routines typically attempt to settle queued transfers simultaneously rather than settling in sequence as in the case of reordering (see Box 5). As noted earlier, the accumulation of queues or gridlock can occur in a situation where funds transfers cannot be settled in sequence owing to the distribution of liquidity among banks (also sometimes referred to as a "circle situation"), even though overall system liquidity including all queued transfers is sufficient. Optimisation routines may be able to provide an effective solution in such situations, although, as discussed below, they may also have some disadvantages.

Several methods of optimisation have been proposed. In some systems, optimisation will be based on a concept of "simulated net balance" that incorporates the net balance of queued transfers (i.e. queued incoming transfers minus queued outgoing transfers) in addition to the actual cash balance. Such a concept of simulated net balance corresponds to the potential cash flow model of net intraday liquidity in which queued incoming transfers are regarded as "potential cover" for outgoing transfers. In calculating simulated net balances, some systems will also count the net positions (which are not yet settled) in other systems such as securities settlement systems or retail payment systems. An optimisation routine will then attempt to settle as many of the queued transfers as possible subject to the condition that the simulated net balance for every participant is within the limits set (e.g. if it is non-negative). Other systems will apply methods that will not calculate the simulated balance explicitly, but will search for transfers in the queue for which offsetting transfers can be found; for example, the search could be based on a FAFO ("first available, first out") rule whereby the transfer that can find an offsetting transfer or transfers will be executed first.[50]

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[48] In this report prioritisation in FIFO queuing is not regarded as a form of queue management.

[49] Optimisation routines are sometimes called "circle processing" or "trial booking" mechanisms.

[50] In legal terms, offsetting procedures are likely to be based on the simultaneous gross settlement of the relevant transfers.

BOX 4

QUEUE PROCESSING AND REORDERING: AN ILLUSTRATION

Assumptions. Bank A has a balance of 100. Bank A then sends five outgoing transfer orders in the sequence T1 (value: 40), T2 (70), T3 (20), T4 (30) and T5 (10). For simplicity, no incoming transfers or central bank intraday credit are available during the time under consideration. The processing of the transfers depends on the queuing method used.

FIFO: The first transfer order T1 is tested for cover and settled. However, the resulting balance of 60 is insufficient to settle the second transfer T2. Consequently, T2 and all other transfers are queued. (The number of settled transfers is one and the settled value is 40.)

Bypass FIFO: T1 is settled (the resulting balance is 60) and T2 is queued exactly as in the case of FIFO. The system will then "bypass" T2 (since it is too large to settle with the remaining balance) and test T3 for cover. Since the balance of 60 is sufficient to settle T3, T3 will be settled (the resulting balance is 40). The system will then return to T2 to test for cover again, but T2 will still not be settled and will continue to be queued. (Note that in this example the balance cannot increase, by assumption. However, if that assumption were relaxed, T2 could be settled if the balance increased to 70 or more by the time of re-testing for cover.) The system will bypass T2 again and test T4 for cover. T4 will be settled and T2 will be re-tested. This iteration process will continue, enabling T5 also to be settled, leaving just T2 in the queue. (The number of settled transfers is four and the settled value is 100.)

FIFO with prioritisation: Assume that Bank A can prioritise the transfers according to two priority classes (*high* and *low*) at the time of input, with the FIFO rule applying within each priority. Consider three cases:

- In Case 1, Bank A inputs T2 and T4 into the system as high-priority transfers and inputs the others as low-priority. T1 is settled even though it is low-priority because, being the first payment to be entered into the system, there are no other payments (high or low-priority) queued at that stage. The remaining balance of 60 is insufficient to settle the next payment (T2), which is therefore queued. All remaining payments are therefore also queued because T2 is high-priority: T3 and T5 are low-priority and will therefore not be settled while any high-priority payments are queued, and T4, although also high-priority, is behind T2 in the FIFO high-priority queue. The outcome therefore happens to be the same as with a simple FIFO queue with no priority facility.

- In Case 2, Bank A inputs T2 as low-priority and all the others as high-priority. Again, T1 settles and T2 is queued, leaving a balance of 60. However, because T2 is low-priority, high-priority payments T3, T4 and T5 will be settled (the balance of 60 being sufficient to do this). In this case, the outcome therefore happens to be the same as with bypass FIFO.

- In Case 3, T4 is high-priority and the others are all low-priority. Again, T1 settles while T2 is queued because of insufficient funds. Low-priority T3 will then also be queued behind T2, but high-priority T4 (value 30) can be settled with the balance of 60. Low-priority T5 will also be queued behind T2 and T3. This case therefore produces a different outcome.

<u>*FIFO*</u>	<u>*Bypass FIFO*</u>	<u>*FIFO with prioritisation*</u>		
		<u>*Case 1*</u>	<u>*Case 2*</u>	<u>*Case 3*</u>
		T2 and T4 high-priority	*All high-priority except T2*	*T4 high-priority*
(T1) 40 settled	(T1) 40 settled	(T1) 40 settled	(T1) 40 settled	(T1) 40 settled
(T2) 70 queued	(T2) 70 queued	(T2) 70 queued	(T2) 70 queued	(T2) 70 queued
(T3) 20 queued	(T3) 20 settled	(T3) 20 queued	(T3) 20 settled	(T3) 20 queued
(T4) 30 queued	(T4) 30 settled	(T4) 30 queued	(T4) 30 settled	(T4) 30 settled
(T5) 10 queued	(T5) 10 settled	(T5) 10 queued	(T5) 10 settled	(T5) 10 queued
Total settled 40	Total settled 100	Total settled 40	Total settled 100	Total settled 70
Total queued 130	Total queued 70	Total queued 130	Total queued 70	Total queued 100

FIFO with reordering: Assume that the system centre or Bank A can reorder the queued transfers under the FIFO rule. For example, if T2 is moved to the end of the queue, all other transfers (T1, T3, T4 and T5) will be settled and only T2 will remain queued; this reordering produces the same result as bypass FIFO and Case 2 under FIFO with prioritisation described above.

(T1) 40 settled		(T1) 40 settled
(T2) 70 queued	*reordering*	(T3) 20 settled
(T3) 20 queued	------------------>	(T4) 30 settled
(T4) 30 queued		(T5) 10 settled
(T5) 10 queued		(T2) 70 queued

Revocability of queued transfers. Another important aspect of queuing is whether or not the sending bank can cancel queued transfers. Although end-of-day revocability typically applies automatically in RTGS systems to those transfers that have failed to settle by the close of the system, intraday revocability is in most cases not allowed and in some others is restricted to exceptional circumstances such as input error. However, in SIC and (at a later date) in EIL-ZV the sending bank can revoke queued transfers without the consent of the receiving bank, but in SIC only until a certain cut-off time.[51]

4.2 Issues arising in connection with the transparency of queued incoming transfers

RTGS systems provide online, real-time information facilities whereby banks can obtain data on the status of transfers, accounting balances and other basic parameters. An important element that helps to define the operational environment of queuing is the information available to banks or the system centre with regard to queues. Under centrally located queuing, the system centre normally provides banks with a range of information not only on outgoing transfers in their own queues but also on any incoming transfers being sent to them that are held in other banks' outgoing queues; indeed, all existing or planned G-10 RTGS systems with centrally located queues allow real-time access to the information on queued incoming transfers in some form or other (in other words, queued incoming transfers are to some degree "transparent"). However, the information about such queued incoming transfers and the conditions under which it is provided to banks vary significantly across systems.

The key issue concerning the transparency of queued incoming transfers is its effect on the risk and efficiency of the process. One view is that transparency could induce the receiving bank to act upon queued incoming transfers which by definition remain *unsettled*, thereby potentially generating risks in RTGS systems. According to this view, this is another case in which risks may arise from a lag between the time when information about the payment is received and the time when the payment is actually settled. For example, on the assumption that incoming transfers held in other banks' queues will normally settle in due course, a receiving bank might use the information about these transfers for liquidity management purposes in order to reduce its precautionary balances of liquidity or to minimise the liquidity it needs to raise from other sources; however, if the queued transfers did not in fact settle, the receiving bank could face a liquidity shortfall. Particularly if this occurred close to the end of the day, it might then be difficult for the bank to raise the liquidity it needed from alternative sources. The bank would thus be exposing itself to possible liquidity risk. Perhaps more importantly, the receiving bank might credit its customers' accounts in advance in anticipation of queued incoming transfers. In this case, credit risk could arise. These risks might also have systemic consequences, particularly if a large number of banks or a major bank with a relatively large amount of queued transfers adopted such behaviour.[52] These possible liquidity, credit and systemic risks are similar in nature to those associated with conditional transfers in unsecured DNS systems and the T-shaped message flow structure described above.

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[51] The policy in SIC reflects at least two considerations. First, intraday revocability is considered in SIC to be an effective way to resolve gridlock: for example, banks can revoke a very large transfer in the queue and break it into two or more smaller portions which are re-entered into the system. In this respect, intraday revocability could be regarded as a form of reordering. Second, it is also believed that the intraday revocability in SIC helps to discourage receiving banks from acting on queued incoming transfers imprudently (see subsection II.4.2).

[52] The consequences would vary depending on whether customers were obliged to repay the funds if the sending bank became insolvent before settlement.

BOX 5

GRIDLOCK, REORDERING AND OPTIMISATION: AN ILLUSTRATION

The following examples attempt to illustrate the essence of how reordering and a type of optimisation mechanism can solve a gridlock. It should be noted that, because the examples are for illustrative purposes, they abstract from some of the complications that may accompany gridlocks in practice.

Assumptions. There are three banks, A, B and C, and all have a balance of 100. The following transfers are being held under FIFO queuing. Note that (Tij) indicates the jth transfer being processed by Bank i and "A ⇒ B 120" means that Bank A will transfer 120 to Bank B. For simplicity, no central bank credit or other liquid funds are available during the time under consideration.

Bank A	Bank B	Bank C
(TA1) A ⇒ B 120	(TB1) B ⇒ A 180	(TC1) C ⇒ A 120
(TA2) A ⇒ B 80	(TB2) B ⇒ C 120	(TC2) C ⇒ B 100

Given the balances (100) and the order in which the payments are queued, none of the transfers can settle and the system is thus considered to be in gridlock.

Optimisation: Assume that the system can activate a FAFO-type optimisation mechanism. The system will select (TA1) and (TA2) and settle them simultaneously with (TB1). Since Bank B's balance will then become 120 (100 + net transfers from Bank A of 20), transfers (TB2), (TC1) and (TC2) will subsequently be settled without further intervention.

Alternatively, assume that the system's optimisation is based on simulated net balances. In this case, the banks' simulated net balances are as follows. Since simulated net balances are non-negative for all banks (i.e. net intraday liquidity including potential cover is sufficient to settle outgoing transfers), all transfers will be settled simultaneously.

	Balance	Queued outgoing transfers	Actual net liquidity	Queued incoming transfers	Simulated net balance
Bank A	100	200	- 100	300	200
Bank B	100	300	- 200	300	100
Bank C	100	220	- 120	120	0
Total	300	720	- 420	720	300

Reordering: Reordering could also solve this gridlock. Suppose that the system centre switches the order of (TA1) and (TA2). Bank A will now be able to settle (TA2) given its initial balance of 100. Bank B will then be able to settle (TB1) because its balance has increased by the incoming transfer from Bank A (i.e. the new balance = the initial balance of 100 + the incoming transfer from Bank A of 80 = 180). Subsequently, settlement of all the other queued transfers in the system will become possible in the following sequence:

Bank A will settle TA1 (120) with the new balance (200 = 20 + 180).

Bank B will settle TB2 (120) with the new balance (120 = 0 + 120).

Bank C will settle TC1 (120) and TC2 (100) with the new balance (220 = 100 + 120).

An alternative view stresses the possible advantages of transparency in reducing liquidity risk rather than increasing it. Better information on expected payment flows implies - other things being equal - a smaller probability of a liquidity shortfall. Even after any resulting adjustment of precautionary balances, the net effect of better information might be an overall reduction of liquidity risk. Another possible advantage of transparency could be a reduction in liquidity curves if, as a result of improved information, banks do choose to hold smaller precautionary balances. Greater transparency might also enable banks to sequence incoming and outgoing transfers in a more efficient way, thereby additionally improving their liquidity management. Furthermore, to the extent that banks view the information as important, they might set up their own advice-of-payment arrangements outside the system if the information was not provided within the RTGS system itself.

Others feel that the advantages of transparency can outweigh the disadvantages provided that restrictions are placed on the release of the information. For example, it may be that the more detailed the information (e.g. if it includes beneficiary details), the greater the likelihood that the receiving bank will credit funds in advance. Recognising this, some RTGS systems allow banks to look at aggregated information such as the total number and/or amount of transfers but not at the detail of individual transfers. Another issue relates to the way in which access to the information is granted - more specifically, whether it is released automatically or only on request. Considering that the automatic release of the information might involve greater risks, some RTGS systems provide the information only on request. There is also the view that receiving banks will be discouraged from acting imprudently on incoming queued transfers if sending banks have the ability to cancel such transfers - that is, the sending banks' ability to cancel will serve as a "warning signal" to the receiving banks, making it less likely that they will place undue reliance on the information. SIC, as noted above, permits the sending bank to cancel queued payment messages at any time up to a certain cut-off time partly on these grounds.

The costs and benefits of information on queued incoming transfers may depend on how important incoming transfers are as a source of intraday liquidity and whether the system typically operates with long queues. If other sources of intraday liquidity are relatively scarce and the queues tend to be long, then the real-time availability of such information may be much more critical to the system's efficiency. However, at the same time, the longer the queues, the greater the associated risks if banks do not use the information prudently. The usefulness may also depend on the operating environment of the RTGS system, such as the number of participants and the central bank account structure. For instance, under a decentralised central bank account structure, the transparency of the information could in some cases help banks to monitor balances and use them efficiently across accounts.

4.3 Assessments of different approaches to queuing

As noted earlier, different approaches to queuing have been taken in G-10 RTGS systems. The types of centrally located queue range from arrangements in which the system centre actively intervenes in the queues by reordering and/or optimisation, to "no-management" types in which there is no intervention by the system centre or banks. At the other end of the spectrum, there is "fully decentralised" queuing in which the responsibility for queuing is left entirely to individual banks, with the system centre having no queues. There are also a number of hybrid arrangements.[53]

In considering various approaches to queuing, one potentially important aspect is whether the system centre or the individual banks manage the queues. From the viewpoint of reducing the need for liquidity, the more the system centre can intervene in the queues by reordering and/or using optimisation routines, the more efficient the queuing should in principle be because the centre can

53 For instance, in EIL-ZV and TOP, both the system centre and banks are or will be able to reorder the queue. As noted earlier, queuing in CHAPS is based primarily on internal queues, but the Bank of England has the ability to provide an optimisation mechanism when gridlocks arise.

observe the queued transfers of all banks and thus maximise all available information to rearrange the transfers in the queue into an order that minimises liquidity needs. To the extent that it succeeds in reducing the number and value of queued transfers, such centralised management can contribute to efficiency and the realisation of early settlement in RTGS systems.

At the same time, if centralised management is adopted, several important issues may need to be addressed. First, there could be legal issues: if, for example, some transfer orders were placed lower down in the queue by the centre and then failed to be executed because the sending bank defaulted, the centre might be held liable (e.g. for any consequential damages). Such legal issues may be more acute if the system centre has discretion in its management rather than processing transfers according to an algorithm agreed between the system centre and participating banks. The question is then how easy it is to devise and agree on an appropriate algorithm. Because of this, centrally located queuing arrangements often only process transfers in FIFO order within a given priority. Second, if centralised management is conducted regularly during the day or is expected to occur in certain contingency situations, banks may come to rely on it as an alternative to their own active payment flow or liquidity management. One view is that such "moral hazard" problems could be a particular disadvantage of optimisation routines if the latter induce banks to reduce liquidity holdings, which might lead to longer queues and even increase the potential for gridlock. Third, a balance may need to be struck between the control of the queues by the centre and the scope for competition by banks. Banks may feel that it would be inappropriate for them not to have full control over their queued transfers, not least because from the perspective of individual banks the effectiveness of queue management should be evaluated in terms of how speedily they are able to make transfers relative to other banks. Centralised management could narrow the scope for such competition.

Decentralised approaches to management, whereby banks manage their internal queues or their queues at the centre, can provide banks with greater flexibility in managing their queues and greater scope for competition. However, the use of decentralised management also raises some issues. First, compared with centralised management, decentralised management might be less efficient if each bank had to manage its own queue with insufficient information about what was being held in other banks' internal queues. Furthermore, aggressive behaviour by banks could increase negative externalities as described earlier, perhaps even leading to settlement delays and gridlocks. Third, there may be complications if the system is "linked" to other settlement systems. For example, if fully decentralised queuing included funds transfers related to a DVP securities settlement system, the requests for those transfers would first have to be routed through the internal systems of the individual banks so that they could manage them. This could affect the efficiency of the DVP process. It may therefore be necessary in the context of decentralised management for system operators and participants to consider these issues and, where appropriate, address them through relevant operating procedures and/or changes to participants' behaviour.

In practice, the choice regarding queue management techniques may be determined primarily by the system's technical requirements or by the cost of providing and operating centrally located queues.[54] The choice may also be affected by differing views about the importance of centrally located queuing. On the one hand, the existence of centrally located queuing enables the system to incorporate a system-wide, built-in mechanism for sequencing transfers that could offer "offsetting-like" efficiency. Centrally located queuing could thus be viewed as a critical design feature affecting the efficiency of an RTGS system and could also serve as an important basis for introducing more sophisticated liquidity-saving mechanisms into the architecture of RTGS systems. On the other hand, the existence of centrally located queuing might imply that *the system itself* potentially encourages settlement lags by allowing "processed but unsettled" payment messages to stay in the system. Some feel that this may not be fully compatible with what they consider to be the core feature of RTGS, namely the ability to provide continuous settlement. According to this line of argument, the

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[54] In some systems, the incorporation of elaborate centrally located queuing is not compatible with the system's existing software.

responsibility for queuing could be left to banks or the role of centrally located queuing could be marginal even if it is provided.

5. The design of RTGS systems: concluding remarks

As the above analysis has shown, the concept of RTGS is straightforward but the systems themselves can take many different forms. These differences partly reflect the fact that circumstances vary from country to country, so that arrangements that are appropriate for one country may not be relevant for another. In many cases a pragmatic approach has been adopted to certain design features. Finally, as mentioned earlier, RTGS systems are on the whole a relatively recent concept and thus there has often been little operational experience on which to base comparisons between different options.

Given these factors, while it may be difficult to draw any universally applicable conclusions about the merits of particular features of RTGS systems, it might be useful to set out the key criteria that are likely to be used when choosing between different options. Following the presentation of Part II, RTGS systems can be categorised according to three main considerations, namely (a) whether the central bank provides intraday credit to participants in the system and, if so, on what terms, (b) the message flow structure and (c) the facilities, if any, available for queuing. Although there are many other ways in which systems differ, these three areas seem to capture the most important aspects.

Whether *intraday credit* is provided or not may depend partly on whether interbank funds transfer systems are seen simply as mechanisms that enable settlement to take place, in which case it may be decided that no specific liquidity facilities will be provided, or whether the provision of intraday liquidity is seen as being a straightforward extension of a central bank's existing role as a provider of liquidity to the banking system. The decision to extend intraday credit may also reflect a view that intraday credit is necessary to enable the system to function smoothly. Where credit is provided, there are variations in the terms set (e.g. whether the credit has to be collateralised and what fee or interest rate, if any, is charged), reflecting a number of important considerations. For example, central banks differ in the way they prefer to manage any risks associated with providing credit. Moreover, in some systems a key consideration may be a desire to keep the cost to banks of obtaining intraday liquidity as low as possible, while in other systems this may be less critical or a positive cost may be seen as a useful way of encouraging banks to economise on their use of any central bank liquidity facility.

As far as the *message flow structure* is concerned, the key choice is often between the V-shaped and Y-shaped structures, and an important consideration here is the role of the central bank relative to the private sector in the day-to-day operation of the system: for some, the attraction of the Y architecture is that it enables a distinction to be drawn between the central bank's core role as settlement agent and the rest of the system processing, which can be a separate, private sector function. Whether this is an issue typically depends in part on the nature of the arrangements in place before RTGS was introduced (i.e. the extent to which the central bank was involved in the day-to-day operation of the previous non-RTGS system) and thus on what has come to be regarded as normal or desirable in the market concerned. Other relevant factors may include potential risks associated with the message flow (which is why the T-shaped structure has been criticised) and the design of the existing system (in those cases where the new RTGS system is being adapted from a previous system and thus where particular architectures, such as the L-shaped structure, may be used).

Approaches to queuing may depend importantly on views about the relative roles of the private sector and the central bank, the central bank's policies regarding the granting of intraday credit and the extent to which banks can obtain liquidity easily from their own sources. If, as noted above, an interbank funds transfer system is seen as being simply a settlement mechanism, then it may also be that no centralised *queue management facilities* are provided beyond basic FIFO processing. Or the balance between centralised and decentralised queue management may depend on the extent to which banks see such management as a competitive issue rather than one on which they want a standard approach to be adopted. Consideration of the balance to be struck between risk, cost and liquidity may also determine whether queued incoming transfers are transparent or not. More generally, queue management may be an area where the relative novelty of RTGS systems is particularly relevant: key policy considerations apart, differences in queue management techniques may simply reflect the fact that so far there is not enough experience to judge how desirable the different methods are.

Finally, it is important to stress that, in designing an RTGS system, attention must be paid to the wider environment in which the system is to operate. Mention has already been made of the fact that circumstances vary from country to country, and this is true not just of the payment system environment itself but also of the wider financial system: for example, the RTGS system may have to interact with other systems such as securities settlement systems, or its introduction may have some monetary policy implications. Moreover, while RTGS is one approach to managing payment system risks, there are also other approaches such as the introduction of secured DNS systems. Part III therefore looks at some of these wider issues concerning RTGS.

PART III GENERAL CONSIDERATIONS RELATING TO THE DEVELOPMENT OF RTGS SYSTEMS

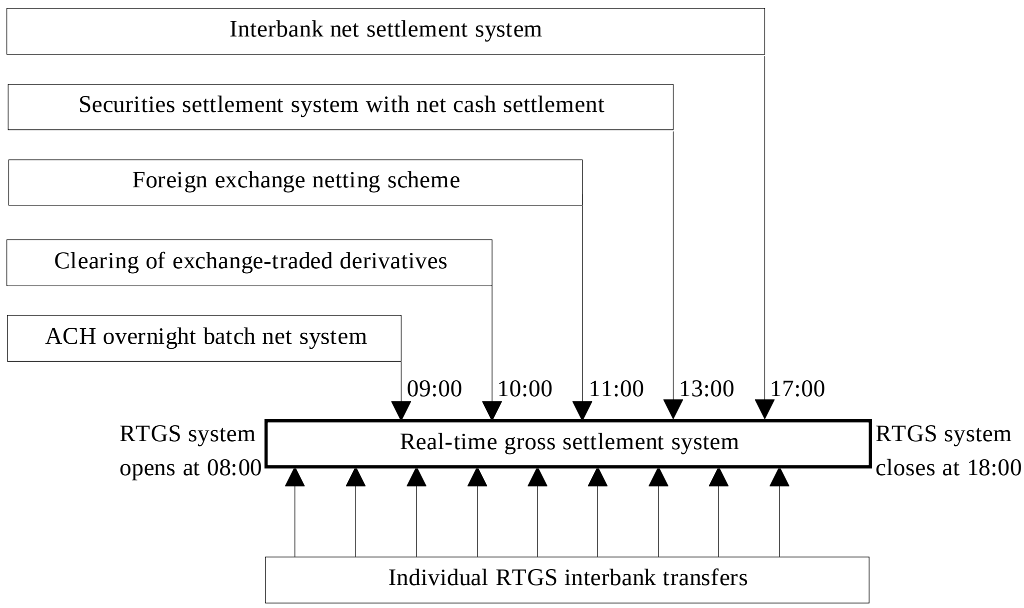
1. Interrelationships between RTGS systems and other payment and settlement systems

Types of interrelationship. RTGS systems usually operate with some form of direct or indirect relationship with other payment or settlement systems. The nature of the relationship may vary depending on such factors as the type of system with which the RTGS system is linked and whether it is a domestic or international relationship.

In the *domestic* context, there are two major types of interrelationship. The first type concerns DNS systems for interbank funds transfers in which participants' net settlement positions are settled over an RTGS system at one or more designated times. A key feature of this type of interrelationship is that final settlement of transfers in DNS systems is effected when debits or credits based on participants' net settlement positions are posted to their central bank accounts through the RTGS system. The net settlement positions may stem from various types of system, for example large-value DNS systems or retail payment systems (see Box 6).

BOX 6

HYPOTHETICAL EXAMPLE OF LINKAGES BETWEEN SETTLEMENT SYSTEMS



The second type of interrelationship concerns securities DVP mechanisms. The nature of the DVP relationship between an RTGS and a securities settlement system (SSS) depends on how the DVP system is structured and operates.[55] One important relationship arises from a real-time DVP system. As noted earlier, a real-time DVP system is a model 1 DVP system operating in real time, in

[55] The DVP Report analysed different structural approaches, including a model 1 system, for achieving securities DVP.

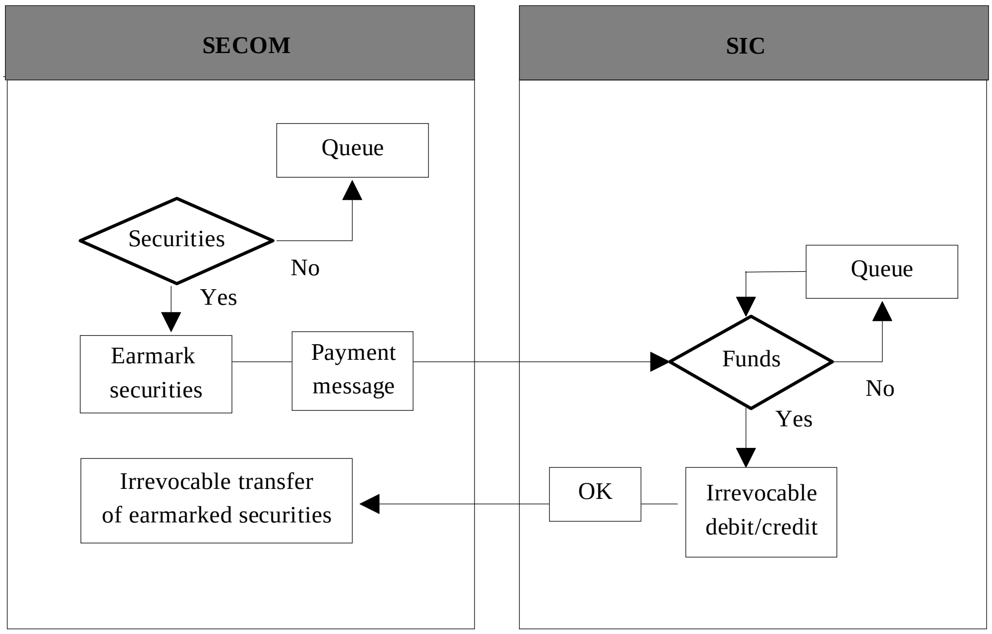
which transfers for both securities and funds settle on a trade-by-trade basis, with simultaneous final transfers of securities and funds. Depending primarily on whether or not the securities system maintains both securities and funds accounts for participants, real-time DVP can be achieved either (a) through an online communication link between the RTGS system and the securities settlement system (e.g. the SIC-SECOM link in Switzerland - see Box 7) or (b) within the securities settlement system itself (e.g. the Fedwire book-entry securities transfer system). In both cases, the cash legs of securities transactions are settled continuously by RTGS, which creates a close, real-time interrelationship between the RTGS system and the SSS.

Other forms of interrelationship occur when the RTGS system is involved in the designated-time settlement of the cash leg of securities transactions - typically the net positions resulting from the cash leg of securities transactions.[56] The economic feature of this relationship is essentially the same as the foregoing RTGS-DNS relationship (see Box 6).

BOX 7

LINKAGE BETWEEN AN RTGS SYSTEM AND A SECURITIES SETTLEMENT SYSTEM: THE CASE OF THE SIC-SECOM LINK IN SWITZERLAND

In Switzerland, an online link between SECOM (the securities settlement system) and SIC that provides real-time DVP has existed since March 1995. The settlement procedure when both the buyer and the seller of securities are SIC participants is illustrated as follows (see also the diagram below). On the settlement date, SECOM earmarks the corresponding securities in the safe custody account of the seller. If sufficient securities are available, a payment message is automatically transmitted from SECOM to SIC. SIC checks the cash account of the buyer and, if sufficient covering funds are available, the SIC account of the buyer and the seller are debited and credited respectively. SIC transmits a message confirming the payment to SECOM, which then makes the final transfer of the securities. If sufficient funds are not available, the payment message is kept in the central queue in SIC and tested for cover until settlement can take place.

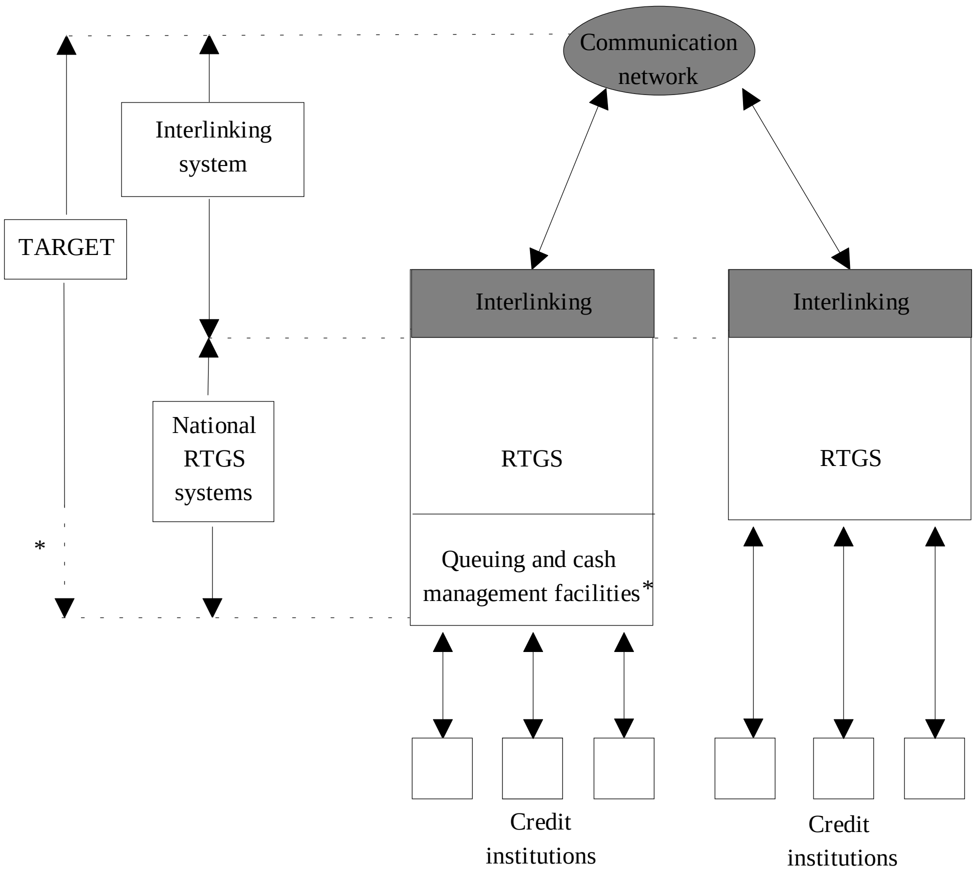


56 In the case of the planned securities DVP system in France (RGV), intraday final transfers of securities will be assured by a guarantee mechanism using automatic intraday repos extended by the central bank, and the RTGS system (TBF) will settle only the end-of-day cash positions in RGV. However, a close, real-time linkage will be established between the two systems so that participants can transfer cash from TBF to RGV (e.g. to increase cash balances in RGV to purchase securities) or from RGV to TBF (e.g. to shift a liquidity surplus stemming from securities transactions to the RTGS account) at any time during the day.

BOX 8

TARGET SYSTEM

The TARGET (Trans-European Automated Real-Time Gross Settlement Express Transfer) system is being built to facilitate the implementation of the single monetary policy in stage three of economic and monetary union and to provide a sound and efficient mechanism to settle "cross-border" payments denominated in the single currency (the euro). National RTGS systems in the EMU member states will be linked to each other via a common infrastructure using common procedures (the "Interlinking" system). The TARGET system will be operational on 1st January 1999.



* Queuing and cash management facilities are provided on an optional basis by some RTGS systems.

A cross-border transfer through TARGET is initiated when the sending credit institution transmits a payment message to the local national central bank (the sending NCB) through the local RTGS system. Assuming the sending credit institution has sufficient funds available, the amount of the payment will be irrevocably and immediately debited from the account the sending credit institution holds at the NCB. The sending NCB will then transfer the payment message through the Interlinking network to the receiving NCB. The receiving NCB will credit the receiving credit institution's account.

At the *international* level, as analysed in two earlier CPSS reports,[57] future PVP mechanisms for foreign exchange transactions could involve important cross-border relationships between two or more national RTGS systems. Greater overlap of the opening hours of RTGS systems

57 *Central Bank Payment and Settlement Services with respect to Cross-Border and Multi-Currency Transactions* (September 1993) and *Settlement Risk in Foreign Exchange Transactions* (March 1996).

would facilitate this process. As noted earlier, although it is very different from the sort of cross-border linkage used in a PVP mechanism, the TARGET system currently being developed by the EU central banks represents a second type of cross-border linkage between national RTGS systems (see Box 8).[58]

Implications of interrelationship. Of the possible consequences of the system linkages described above, the resulting *liquidity interdependence* between an RTGS system and other payment and settlement systems is likely to be particularly important. On the one hand, linkages between an RTGS system and other systems could improve the intraday distribution of liquidity across payment systems because RTGS can allow banks to use final funds during the day for the purpose of settlement in other systems and more intraday payment flows between participants could thus occur. On the other hand, as noted in Section II.2, if an RTGS system is involved in the settlement processes of other payment and settlement systems, "exogenous" settlement pressures would be generated by the linked system on the settlement process in the RTGS system (and vice versa). This could affect intraday liquidity requirements at the level of both individual banks and the system in the RTGS system.

The impact on RTGS liquidity depends on the size and timing of the exogenous settlement pressures.[59] Where the interrelationship occurs only at designated times, as in an RTGS-DNS interrelationship, the impact may be local and concentrated in a particular short period of time. If settlement is to take place, it is important that the participants in the DNS system ensure that they have the necessary covering funds available at the designated times.[60]

When an RTGS system is interrelated continuously with other systems as in the case of real-time DVP systems, the impact on RTGS liquidity can be more widespread and significant. Under this kind of linkage, participants may want or need to "earmark" the necessary intraday funds in their central bank account for the settlement of the transactions in the linked systems (in principle on a continuous basis during the day). This might increase the demand for intraday central bank credit, or might increase the number/value or duration of queued transfers if the necessary liquidity is not obtained promptly. Where the settlement of the transactions is effected through the linkage as in the case of real-time DVP, the expected liquidity position in the RTGS system would, in turn, affect the completion of settlement of the transactions under the linkage.

Whether intraday liquidity requirements in the RTGS system are increased by the interrelationships is an empirical question. However, to the extent that the need to settle the transfers from the linked systems gives rise to "competing" uses of balances at the central bank, intraday liquidity management issues are likely to arise. In particular, to the extent that the transfer orders stemming from the linked systems are time-critical, banks may need to address how they could be reconciled with other time-critical funds transfer orders, such as those relating to central bank operations, in terms of the use of RTGS liquidity. These points suggest that central banks (or system providers) need to analyse carefully the possible liquidity implications that may arise from any interrelationship. To ensure that such implications do not impinge on the efficient operation of either the RTGS system or the linked systems, consideration may need to be given to some design features

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58 PVP is designed to enable two separate payment messages (the two sides of a foreign exchange transaction) to settle simultaneously, while the TARGET link is designed to enable a single payment message to be passed from one system to another.

59 At the level of individual participants, the magnitude of any impact on RTGS liquidity may also depend on whether participants in the linked system are direct participants in the RTGS system who have access to an intraday credit facility or to centrally located queuing (where available), or indirect participants who, on the other hand, do not typically have such access.

60 Some RTGS systems have a pre-settlement period during which participants with net debit positions in the linked system can ensure covering funds before their balances are actually posted to the RTGS accounts. In some systems the settlement time itself lasts for a certain period (e.g. half an hour), during which time the system will, if necessary, repeatedly try to post all balances.

of the RTGS systems (e.g. facilities for queuing such as prioritisation and queue management) and also to those of the linked systems.

2. Some possible monetary policy considerations

Against the general background of reductions in reserve requirement obligations, a demand for settlement (working) balances is becoming more relevant in determining banks' total demand for balances at the central bank. The demand for settlement balances can be affected by the design and operational features of interbank funds transfer systems and therefore the implementation of an RTGS system could raise particular questions in this connection. The direction and magnitude of this effect, however, depend on a variety of factors including the rules governing reserve holdings and overdrafts, the nature of payment information flows, the technical ability of banks to manage their intraday payment flows and the incentives to do so.

The possible development of intraday money markets. The analysis in Part II illustrates how banks operating in an RTGS environment may need to adjust the balances on their central bank accounts in the course of the day in order to effect their funds transfers. This adjustment process means that the development of RTGS systems could generate an intraday demand for bank reserves and that positive intraday holdings of settlement balances could have intraday value (apart from their value in meeting any end-of-day requirements). In this respect, the question has been posed whether RTGS systems could contribute to or stimulate the development of intraday money markets. As noted in Section II.2, intraday money markets could serve as an important private sector source of intraday liquidity in the RTGS environment. An embryonic intraday market seems to have emerged only in Switzerland so far in relation to the introduction of an RTGS system (the intraday market in Japan is linked to the periodic net settlement times in BOJ-NET). In the United States, Fedwire has existed as an RTGS system for a number of years, but for a variety of possible reasons, no intraday money market has yet emerged there.

Several factors could determine whether an active intraday money market would develop. With regard to the possible supply of intraday funds, the accumulation of positive balances by banks on their central bank account during the day would create an opportunity for them to lend the funds in the interbank market. Whether banks would prefer to lend funds on a day-to-day or an intraday basis would depend, among other things, on their expected liquidity position during and at the end of the day and on how they assessed the conditions in the money market (e.g. whether they expected the central bank to withdraw reserves from or add reserves to the banking system on that day or whether they anticipated that market factors would significantly affect reserve availability that day).

As regards the possible demand for intraday funds, one factor would be the central bank's policy with respect to the provision of intraday credit. If it offered no such facilities (or if it offered them on unattractive terms), banks would have to rely on interbank markets to obtain liquidity and might have an incentive to borrow in such markets for short periods of time during the day. If banks could obtain intraday credit from the central bank on relatively advantageous terms, this would limit the incentive for banks to engage in intraday money market transactions. This would be the case, for instance, if central bank intraday credit was provided without charge and the opportunity cost of tying up any securities needed as collateral for intraday overdrafts (or for intraday repos) was low.[61]

Another demand factor would be the relative costs of settlement delays in RTGS systems. Such costs could consist of, for example, a loss of customer business (if customers moved their business to banks able to provide a faster service) or the consequences of an inability to settle payments relating to a linked system (such as the payments related to securities settlements). If such costs were felt to be rather low, banks would have little incentive to obtain funds in the interbank

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[61] The corollary of this is that a collateral constraint (an overall shortage or poor distribution) might lead to the development of an intraday market in collateral or funds.

market for a limited amount of time during the day or to specify contractual settlement times more precisely. As noted earlier, not all funds transfers in RTGS systems are necessarily time-critical in the sense that they must be settled either at or by a specific point in time or within a limited interval of time during the day. In such circumstances banks could decide to accept a settlement delay and await incoming funds rather than enter into intraday transactions. If, on the other hand, banks were to consider that certain transfers were time-critical, the perceived cost of settlement delays could be higher and this could motivate them to turn to a market for intraday funds. As noted above, for example, settlement of other payment and settlement systems through the RTGS system at specific points during the operating day could be time-critical. Such transfers could thus provide incentives for participants in the RTGS system to enter into intraday funds transactions in order to satisfy liquidity needs within particular periods of time. The (limited) intraday money market in Switzerland is a case in which payments of principal, interest and dividends under a real-time DVP system motivated SIC participants to engage in intraday money transactions to cope with liquidity requirements relating to those payments.

Transaction costs may also be relevant. For instance, it would not necessarily be a cost-effective solution for banks to develop an intraday money market if the transaction costs relating to lending and borrowing funds for periods of several hours or minutes were much higher than the cost associated with available central bank intraday credit. Transaction costs would include the "set-up" costs for the required infrastructure and the development of intraday trading techniques.

Whether an intraday money market would emerge as a market response to the development of RTGS systems is uncertain. The short and tentative analysis provided here suggests that, under current design features of most RTGS systems, the private sector may not necessarily see major advantages in developing "fully-fledged" intraday money markets with characteristics comparable to those of overnight markets. It should be noted, however, that, in principle, the existence of a liquid intraday money market could help banks to operate with lower operating balances and to reduce their reliance on central bank credit facilities. To the extent that intraday money market transactions could be carried out without collateral (or with different collateral), it could also permit banks to economise on collateral needed to secure central bank credit in the form of intraday overdrafts or repos. Intraday money markets could be a private sector solution to facilitating the redistribution of banks' settlement balances during the day in an RTGS system and could therefore contribute to improved efficiency of such systems.

If private interbank markets for intraday funds were to develop, the question for monetary policy would be what relationship such markets might have with established day-to-day money markets in which monetary policy is typically conducted.[62] There are various reasons to expect that in current circumstances any linkages, including those between the interest rates in the two markets, would be weak. It is uncertain whether the level of aggregate reserve balances held during the day and at the end of the day would normally be determined by the same factors. In countries where reserve requirements are in place, for instance, the reserve balances that count towards the reserve requirement are typically measured at the end of the day.

Furthermore, arbitrage opportunities between intraday, traditional overnight and other markets may be limited or constrained by market and settlement practices. For example, technical difficulties in arranging and executing the payment and repayment legs on a precise intraday, overnight, or true 24-hour basis may prevent the establishment of market conventions for contracts that specify precise delivery times for funds. To the extent that markets for non-overlapping periods that span 24-hour periods do not exist, precise arbitrage between very short-term markets may not be possible. Nonetheless, if intraday funding markets do develop alongside existing overnight markets, some rough arbitrage between such short-term markets could be expected, leading to some interrelationships between intraday, overnight and other markets.

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62 Day-to-day money markets are also often referred to as overnight, 24-hour or call-money markets.

Spillover problems. As described in Part II, the central bank could provide banks with intraday credit in support of their RTGS operations in the form of overdraft or intraday repo facilities. The provision of such intraday credit implies that the central bank makes reserves available to the banking system on an intraday basis to accommodate an intraday demand for such working balances. The question is whether such a practice could affect the supply of and demand for overnight central bank credit. In particular, there has often been discussion about whether the terms (interest charge) on which such credit is granted and the amount provided can have an impact on day-to-day money market conditions and are thus relevant for the conduct of monetary policy.

As long as the central bank determines the terms on overnight credit separately and differently from those on intraday credit, conditions in the day-to-day money market should not be directly affected by the terms on which intraday credit is provided. The "segmentation" between the two types of market would remain as long as banks are required to repay all intraday credit at some point in time during the day and they would be unable to substitute overnight borrowings with a combination of intraday borrowings. Nevertheless, there might still be concern about the possibility that intraday credit could be transformed at the end of the day into overnight refinancing. One approach to containing such potential direct spillovers is for the central bank to apply a sanction, for instance in the form of a sufficiently high penalty rate, on any intraday loans or advances that had not been reimbursed by the end of the day. Imposing stiff penalties would not only provide banks with a strong incentive to repay all intraday credit by the end of the day, but would also encourage them to manage their liquidity efficiently during the day. Moreover, it would reduce any possible moral hazard resulting from the provision of standing intraday credit facilities. Such penalty schemes have in fact been adopted or are being envisaged by several G-10 central banks.[63]

3. Distinctions between RTGS and net settlement systems

This section gives a brief overview of risk management techniques used to secure DNS systems so that they comply with or exceed the Lamfalussy standards. The key features of selected DNS systems are summarised in the comparative table in Annex 2. The section concludes with some remarks on relationships between RTGS systems and secured DNS systems.

3.1 Risk management in net settlement systems

Until the end of the 1980s, risk management in many net settlement systems relied primarily on membership criteria and, indirectly, on the prudential regulation and supervision of individual participants. Only a few systems had introduced mechanisms to control the size of intraday exposures or to allocate any losses if one or more participants failed to settle ("failure-to-settle procedures"). Most had no more than a provision to unwind the settlement to exclude some or all of the transactions with a defaulting participant. One result of the growing awareness of settlement and systemic risks in such *unsecured* DNS systems has been the introduction of RTGS systems. This approach has been taken in many systems operated by central banks, as described above. However, another approach, which is observed mainly in private sector systems, has been to retain the principle of net settlement but address the risks by introducing clearly defined risk control mechanisms. The following focuses on this approach - that is, the implementation of *secured* DNS systems

63 The Bank of France, for instance, intends to set a penalty rate on overnight repos in TBF at 200 basis points above the rate on the overnight marginal lending facility to prevent spillover. Some central banks see no need to apply a penalty rate because in their countries the rate on the overnight marginal lending facility is set sufficiently above the market interest rate.

An important framework for risk management in DNS systems was given by the Lamfalussy standards, set out by the G-10 central banks in the Lamfalussy Report in 1990. While the standards were originally established to provide a basic framework for the design and operation of cross-border and multicurrency netting schemes, they have increasingly been viewed as applicable to large-value DNS systems in general. For example, the EU central banks' recommendations regarding the minimum common features of domestic payment systems include the principle that large-value net settlement systems should meet the Lamfalussy standards in full.[64] In addition, the Federal Reserve amended its payment system risk policy in December 1994 by incorporating the Lamfalussy standards for the design and operation of privately operated large-value multilateral netting schemes.

From the point of view of risk control mechanisms, Lamfalussy Standards III and IV are particularly important in stipulating the minimum requirements with regard to the system's ability to limit credit and liquidity exposures and to ensure timely completion of daily settlements (i.e. certainty of settlement) in the event of an inability to settle by the participant with the largest single net debit position. There are a number of ways in which the standards can be met, which can very broadly be classified into three groups - "defaulters pay" methods, "survivors pay" methods and "third parties pay" methods - although in practice many systems use a combination of methods. In each case, the core risk control element is the setting of a limit or cap on the multilateral net debit position of each participant; a sending bank is not able to process any transfer orders that would cause it to exceed its net debit cap. The cap, sometimes called a net sender cap, sets a ceiling on the loss that can arise should a participant default and fail to settle. The three methods vary, however, both in the way the cap is determined and in how, if a default does occur, the resulting loss is shared (i.e. liquidity or loss-sharing arrangements).

Under a *defaulters pay* arrangement, the size of the cap is determined by the participant itself, with the participant having to secure its position in some way - for example, the cap is determined by the amount of collateral the participant provides. In the event of a participant failure the collateral will, if necessary, be used to ensure that the defaulter's obligations to the remaining members of the system are still met. For example, the system's clearing house may initially use the collateral to draw on a prearranged line of credit to obtain the funds to cover the defaulter's obligations and ensure that settlement of the system can take place; subsequently it can sell the collateral to provide funds to repay the credit line. The arrangement is known as defaulters pay because the principle is that the defaulting participant itself, rather than the clearing house or the other participants in the system, bears all the loss. Because each participant fully collateralises its own debit position, the system can in principle ensure that settlement takes place without any loss to the remaining participants regardless of the number of banks that fail.

In contrast, the essence of a *survivors pay* arrangement is that the loss is shared in some way among the remaining participants ("survivors"). The key requirement is that the survivors should have both the ability and the incentive to control their potential loss. Although there are different ways to achieve this, a typical approach is based on the setting of so-called bilateral credit or bilateral net receiver limits. These bilateral caps, set by the participants themselves, control the bilateral flow of payment messages from one participant to another; they allow each participant to limit the extent to which it has a net credit position vis-à-vis another participant. A sending bank is not able to process any transfer orders that would cause the receiving bank's bilateral net credit position with the sending bank to exceed the bilateral credit limit set by that receiving bank.

Bilateral caps typically serve two purposes where they are used in a DNS system. First, for each participant in the system, the multilateral net sender cap is set as some function of the sum of

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64 Principle 5 in the *Report to the Committee of Governors of the Central Banks of the Member States of the European Economic Community on Minimum Common Features for Domestic Payment Systems* (November 1993) : "Provided that they settle at the central bank, large-value net settlement systems may continue to operate in parallel to real-time gross settlement systems, but, in the near future, they should: (a) settle on the same day as the exchange of the payment instruments; and (b) meet the Lamfalussy standards in full."

the bilateral caps that have been set against it by the other participants; this means that the net sender cap for one participant is determined by the judgements the other participants in the system have made about its creditworthiness in determining their bilateral caps vis-à-vis that participant.[65] Second, if a participant defaults, the resulting loss is shared pro rata among the survivors according to the bilateral cap each had set against the defaulter.

To ensure that each participant can meet its share of the loss caused by the default of any other participant, it is required to put up collateral. As with a defaulters pay arrangement, the collateral can be used to cover any shortfall arising from a survivor being unable to meet its share of the loss. However, the amount of collateral can vary. To meet Lamfalussy Standard IV, each participant must put up collateral to cover the loss that would arise if the participant with the largest net debit position were unable to settle, that is, the system can in principle guarantee completion of settlement if any one participant fails to settle. Some systems require more collateral, however, to increase the probability that they would be able to ensure settlement even if more than one participant were to fail simultaneously. Unlike defaulters pay arrangements, a key feature of survivors pay arrangements is that, although they can guarantee that settlement can still take place under specified conditions, by definition the surviving banks are likely to face "losses" in the sense that, compared with the settlement positions they would have had if there had been no default, the amounts they have to pay in the settlement will be larger (or the amounts they receive smaller) because of the effect of the loss-sharing.

Finally, some liquidity or loss-sharing schemes incorporate a *third parties pay* arrangement. In particular, in one system the central bank plays the role of final guarantor of the certainty of settlement by absorbing any loss or shortfall that might be caused in excess of the collateral posted by participants.

Further enhancements. In several G-10 countries, initiatives have recently been taken to enhance the risk control mechanisms in DNS systems or to establish new DNS systems, in particular with a view to achieving stronger forms of certainty of settlement. For instance, CHIPS initiated a set of modifications called "the Settlement Finality Improvements" in January 1996, which included a reduction of net debit caps, an increase in minimum collateral requirements and a clarification of the procedures for liquidating collateral in the event of settlement failures. The final phase of these improvements was implemented by CHIPS in January 1997 and CHIPS' simulations indicate that as a result it would be able to settle even in the event of the simultaneous failure of its two largest participants. LVTS, which is a new large-value DNS system under development in Canada, will adopt loss-sharing arrangements on the basis of a combination of survivors pay and defaulters pay collateralisation in conjunction with the central bank's guarantee of settlement in all circumstances to deal with *all* multiple failures.[66]

Some DNS systems have also incorporated mechanisms for making irrevocable and unconditional funds transfers during the day rather than only at the end of the day. In some cases this has resulted in hybrid systems which combine features, including risk control measures, of gross and net settlement systems. One example is EAF2 in Germany, which is characterised by a two-phase procedure. During the first phase (08:00 to 12:45) batch processings are carried out every 20 minutes

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65 For example, in CHIPS a participant's net sender (debit) cap is equal to 3% of the sum of the bilateral caps set against it.

66 Participants can choose either of two possible ways or tranches (Tranche 1 and Tranche 2) to send a transfer order. Tranche 1 is a defaulters pay collateralisation mechanism in which the sending participant fully collateralises the net value of the transfers that it is sending, whereas Tranche 2 is structured on the basis of a survivors pay loss-sharing arrangement similar to that in CHIPS. Recent legislation has provided statutory support for the netting arrangement and the settlement rules of LVTS.

in which outgoing funds transfers are offset as far as possible against incoming transfers.[67] Offset transfers become immediately irrevocable and unconditional so that banks can transfer funds to their receiving customers without incurring credit risk. However, the actual incoming transfers are not booked immediately on the books of the central banks and any net liquidity inflows resulting from the batch processings can therefore not be used outside the system. Funds transfers which cannot be offset during one batch processing are automatically carried over into the next cycle. At the end of the first phase all a participant's bilateral debit and credit positions resulting from the batch processings are cumulated into a single debit and a single credit balance and booked on its settlement account at the central bank.

At the beginning of the second phase (13:00 to 14:15) there is a multilateral netting and settlement of all the funds transfers which have not been offset in the first phase. If the calculated multilateral net debit position cannot be covered by a participant at the time, the system will remove, through the use of a special algorithm based on agreed criteria, individual transfers to reduce net debit positions below the available cover. Unexecuted transfers are carried over into a second multilateral netting and settlement process during which participants are granted another 45 minutes to obtain cover. If cover is insufficient the special algorithm will again withdraw individual transfers until the total existing cover is sufficient. Unexecuted transfers are then deemed to be revoked and are deleted.

Table 4

Salient features of risk control measures in selected DNS systems

	CHIPS	**EAF/EAF2**	**LVTS (planned)**	**ECU clearing**
Same-day settlement	Y (1981)	Y (1990)	Y	Y (1988)
Real-time monitoring	Y (1970)	Y (1996)	Y	Y (1996)
Bilateral credit limits	Y (1984)	-	Y	-
Multilateral net debit cap	Y (1986)	-	Y	Y (1993)
Loss-sharing rule	Y (1990)	-	Y	Y (1993)
Collateral requirement	Y (1990)	Y (1996)	Y	envisaged
Central bank guarantee	-	-	Y	-
Multiple batch	-	Y (1996)	-	-
Centrally located queue	-	Y (1996)	envisaged	Y (1996)

Note: Y indicates that the system incorporates the corresponding risk management technique. The year in which the technique was introduced is shown in brackets.

[67] Unlike in bilateral net settlement systems all funds transfers entering the batch processing are not offset completely and the resulting net positions are not settled by debiting/crediting the settlement account of the counterparties. The bilateral net liquidity positions (debit or credit) resulting from the batch processings are booked on separate accounts. Participants can define maximum sender amounts for each bilateral relationship which will define how much they are willing to send out in excess of what is received from a counterparty (thereby limiting the bilateral debit positions vis-à-vis the counterparty). Each participant's maximum sender amounts are transferred before the start of the first phase from its central bank account to special accounts (taking up, if so desired, part of its secured intraday credit facility from the central bank) and assigned to its respective bilateral partners as security.

EAF2 processes mainly large-value credit transfers in Deutsche marks related to money market and foreign exchange transactions between banks in Frankfurt. Experience with the system, which started operating in early 1996, has shown that participants take advantage of the bilateral offsetting feature during the first phase, since 70% of the value of transactions becomes final as early as 10:30. More than 99% of the value of all transfers is executed after the first multilateral netting and settlement process.

3.2 RTGS, secured net and hybrid systems

RTGS systems and secured DNS systems use different methods to control intraday credit and liquidity exposures and systemic risk. In addition, as described above, various alternative models are possible under both approaches, which may result in different balances between risk and efficiency as well as in different allocations of risk management responsibilities between the central bank and the private sector.

Nonetheless, it is also possible to identify several techniques to address payment system risk that are common to both RTGS and secured DNS systems. For example, modern secured DNS systems, like RTGS systems, are based on *real-time processing* of payment messages; in the case of DNS systems this processing is necessary, for example, to calculate the multilateral net debit position of the sending bank and to ensure that it remains below the limit set. Moreover, the use of limits in secured DNS systems raises the possibility that, as in RTGS systems, payment messages will be *queued* before they can be processed and sent to the receiving bank. If liquidity in the system is scarce (because of tight net sender caps) queue management techniques similar to those in RTGS systems may need to be adopted; the issues discussed earlier in the report, such as centralised versus decentralised queue management, minimising externalities, the transparency of queues and avoiding gridlock, are all therefore potentially relevant to secured DNS systems. Similarly, DNS systems can also adopt different message flow structures (V, Y, L or T-shaped).

A major difference between the two types of system lies in the form of the intraday liquidity in the system. In existing RTGS systems the principal form of credit (if any) is the (explicit) credit provided by the central bank, whereas in a DNS system the multilateral net debit positions are a form of (implicit) credit provided by system participants to each other. However, even here there can be similarities. For example, an RTGS system with collateralised central bank credit and a defaulters pay DNS system have in common the fact that sending banks have to fully collateralise their positions and so (provided the collateral arrangement is robust) there is no risk to the provider of the credit; in both types of system, sending banks can, in principle at least, supplement their liquidity by borrowing on the money markets from other participants and thus prevent limits from delaying payments; and, as noted in Part II, some interbank exposures may arise in certain RTGS designs (e.g. because of queue transparency or the message flow structure), while central banks may have exposures in secured DNS systems (e.g. where an element of "third party pays" applies).

As risk controls are tightened and more sophisticated payment flow management techniques are applied, the two types of system may in certain respects come to look increasingly similar while in other respects retaining their significant differences. Some systems already combine certain features of both RTGS and DNS systems and it is also possible that there will be a further development of such "hybrid" arrangements. Because of the many possible forms that RTGS and secured DNS systems can take, an assessment of the balance between the efficiency, risk control and cost of an individual system will depend on the particular features that the system adopts.

ANNEX 1

Comparative table of RTGS systems in the G-10 countries[1]

(as at end-September 1996)

I. General information

	Belgium	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	United Kingdom	United States
Name of the system ( ) = planned	ELLIPS	(TBF)	EIL-ZV	(BI-REL)	BOJ-NET	(TOP)	RIX	SIC	CHAPS	Fedwire [Fedwire Funds Transfer Service]
Year of implementation ( ) = scheduled	1996	(1997)	1988	(1997)	1988	(1997)	1986	1987	1984	1918
Ownership CB = central bank	CB/ELLIPS	CB	CB	CB	CB	CB	CB	CB[2]	CHAPS[3]	CB
Network operator (message carrier)	S.W.I.F.T. (S.W.I.F.T.)	S.W.I.F.T. (S.W.I.F.T.)	CB (Deutsche Telekom AG)	SIA[4] (SIA)	CB (Commercial telephone companies)	CB/ACH (PTT Telecom)	CB (Swedish Telecom)	Telekurs AG (Telekurs AG)	CHAPS (British Telecom)	CB (Commercial telephone companies)
Opening-closing time of system (local time) - *standard money market hours (local time)*	06:30-16:45 (GMT+1) *09:00-16:45*	07:30-18:30 (GMT+1) *08:15-17:00*	08:15-15:00 (GMT+1) *09:30-13:00*	08:00-16:20 (GMT+1) *08:00-16:20*	09:00-17:00 (GMT+9) *09:00-17:00*	07:30-16:30[5] (GMT+1) *08:00-15:30*	08:00-16:30 (GMT+1) *09:00-16:15*[8]	18:00-16:15 (GMT+1) *09:00-16:00*	08:30-15:45[6] (GMT) *07:30-15:30*[9]	08:30-18:30[7] (GMT-5) *08:30-18:30*

[1] For France, Italy and the Netherlands, the table describes the characteristics of the new RTGS systems that are in preparation. BI-REL and TOP will replace the present RTGS systems (BISS and FA respectively). For Germany, the table describes the new restructured RTGS system (EIL system). Canada has no RTGS system. y = yes, n = no, – = not applicable/ not available. [2] SIC is operated by the Swiss National Bank. Telekurs AG (a private company owned by Swiss banks) is under contract to provide the computer centre services. The hardware and software belong to Telekurs AG. [3] The Bank of England owns the central RTGS settlement system. The CHAPS network is owned by the CHAPS Clearing Company. [4] An interbank organisation. [5] For regular interbank payments. Between 16:30 and 17:30 (the internal closing time), the Netherlands Bank carries out end-of-day procedures, which may include payments resulting, for instance, from queue management. [6] Opening hours for CHAPS. The central system operated by the Bank of England opens earlier and closes later. [7] The opening hours will be 00:30 to 18:30 as from 8th December 1997. [8] The foreign exchange market is open from 08:30 to 16:15. [9] For same-day value.

I. General information (continued)

	Belgium	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	United Kingdom	United States
Criteria for membership[10]	RM	O	O	O	RM	O	RM[11]	O	–[12]	O[13]
Number of participants										
- number of direct participants	22	approx. 5,700[14]	approx. 5,700[14]	approx. 800	423	approx. 200	27	214	16	approx. 10,000
- two-tiered system	y	n	y	n	n	n	y	n[15]	y	n
Number of transactions (1995) ( ) = forecasts										
- daily average	3,200[16]	–	22,000	(40,000)	348[17]	–	1,300[18]	382,429	–	328,000[18]
- peak	5,000[16]	–	65,000	–	–	–	1,430[18]	1,154,296	–	362,000[18]
Value of transactions (1995, USD billion)										
- daily average	39[16]	–	75	170	3[17]	–	45[18]	110	–	989[18]
- peak	50[16]	–	160	300	–	–	50[18]	221	–	1,416[18]

[10] O = open membership (any bank can apply), RM = restricted membership (subject to criteria). [11] Minimum capital requirement (ECU 5 million). [12] APACS and the CHAPS Clearing Company apply objective entry criteria. [13] Open to all "depository institutions", federal government agencies and certain other institutions. [14] Participants in the Electronic Counter total 823. [15] Except for regional banks' clearing centre. [16] Data relate to the period October to December 1996. [17] Estimated as at August 1996. These figures relate only to RTGS. BOJ-NET supports DNS as well as RTGS. The share of transactions settled by RTGS is 1.2% of the total in terms of number and 0.1% in terms of value. [18] 1996.

I. General information (continued)

	Belgium	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	United Kingdom	United States
Coexistence with net settlement systems (name of major system) for large-value payments	n	y	y (EAF2)	n	y (FEYCS)	n	n	n	n	y (CHIPS)
Is the system used for the settlement of retail payments?	y	y	n[19]	y	y	y	y	y	y	y
- on an RTGS basis	n	n	n	n	n	n	n	y	y[20]	n
- designated-time settlement of net positions	y	y	n	y	y	y	y	n	y[21]	y
Does the system support securities DVP?	y	y	y	y	y	y	y	y	y[22]	y
- real-time DVP	n	n	y	y[23]	y	y	y[24]	y	n	n[25]
- designated-time settlement of net positions of the cash leg	y	y[26]	n	y	y	y[27]	y	n	y[28]	y[29]

[19] Settlement in special systems. [20] Low-value payments can be made via CHAPS, but their number is very limited when compared with the total number of retail payments made each day. [21] The main retail clearings are settled as a result of net-net postings to RTGS settlement accounts at designated times during the day. [22] Real-time DVP is not currently available. The net-net figures from the Central Gilts Office and Central Moneymarkets Office are settled at designated times on the RTGS accounts. [23] Envisaged only for OTC transactions. [24] From 1st December 1995 on an optional basis. [25] A separate system, the Fedwire Securities Transfer Service, provides real-time DVP for US Treasury securities, many federal agency securities, certain mortgage-backed securities issued by government-sponsored enterprises and securities of certain international organisations. [26] RGV (French DVP system) will process multiple settlements throughout the day. [27] Settlement of money market paper issued and deposited in the Clearing Institution of the Netherlands Bank. [28] Via real-time accounts rather than CHAPS. [29] Private sector clearing organisations and securities depositories.

II. Intraday liquidity support

	Belgium	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	United Kingdom	United States
A. From central bank										
Central bank account structure										
- unified account	y	y[30]	y	y	y	y[31]	–	y	n[32]	y
- mobilisation of required reserves	–	y	y	y[33]	y	y	–	n	y[34]	y
- centralised account	y	n	n	y	n	y	y	y	y	y[35]
Intraday overdrafts	y	n	y[36]	y	n	y	y	n	n	y
- quantitative limits	y	–	n	y[37]	–	n	n[38]	–	–	y
- collateralised	y	–	y	y	–	y	y	–	–	y[39]
- uncollateralised	n	–	n	n	–	n	n	–	–	y
- charges for intraday overdrafts	n	–	n	n	–	n	n	–	–	y

[30] Credit balances held on accounts with the Bank of France other than those used for large-value settlements are also taken into account in monitoring compulsory reserves (however, they will remain separate from the former for consolidation purposes). [31] In 1997, the Netherlands Bank will change its account structure to make the cash reserve account the settlement account. [32] The cash ratio deposit account is separate from the RTGS account. [33] Only 12.5% of the reserves can be mobilised. [34] The CHAPS banks are able to draw intraday on their cash ratio deposits (CRDs). CRDs are non-interest-bearing deposits placed by the banks with the Bank of England to finance its activities. [35] Exceptions exist, generally involving accommodations for mergers and offices of US branches and agencies of foreign banks. [36] The intraday overdraft and overnight credit arrangements (see next page) are both part of the same lombard credit facility, using the same assets as collateral. In the course of the day, the facility can be used for non-interest-bearing intraday overdrafts to the extent that it has not already been drawn down for overnight credit. In practice, the overnight facility (which bears the relatively high lombard interest rate) is generally only used if accounts show debit balances at the end of the day: credit institutions authorise the Bundesbank to provide the credit automatically in these circumstances (this being a standing facility using assets already pledged). [37] Under discussion. [38] The only limit is the value of the collateral pledged. [39] Financially healthy depository institutions with positive caps that frequently exceed their caps by material amounts solely as a result of book-entry securities transactions are required to collateralise all of their book-entry securities overdrafts. In the case of overdrafts which are not due to book-entry securities transactions, collateral may be taken in certain limited, specific situations.

II. Intraday liquidity support (continued)

	Belgium	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	United Kingdom	United States
A. From central bank (continued)										
Intraday repos	y	y	n	n	n	n	y[40]	n	y	n
- quantitative limits	y	n	–	–	–	–	n	–	n	–
- charges for intraday repos	n	n	–	–	–	–	n	–	n	–
Are standing overnight credit facilities available at any time during the day?	y	y	y[41]	y	y	n[42]	y	y	n	y[43]
B. From money market										
Intraday money market	n	n[44]	n	–[45]	y[46]	n	n[47]	n[48]	n	n
Overnight market	y	y	y	y	y	y	y	y	y	y

[40] Possible, but not requested. [41] See footnote 36. [42] In TOP the lombard credit will be automatically extended at the end of day in order to eliminate any debit position on the cash reserve account. [43] Overnight loans from the Federal Reserve Banks tend to be granted and repaid on a 24-hour basis, usually in the afternoon or early evening. [44] The impact of intraday irrevocability on the creation of an intraday money market cannot be currently assessed. [45] Envisaged by Italian commercial banks after the start of BI-REL. [46] The intraday money market in Japan is not always available during the system's operating hours. The intraday transactions are designated only to bridge two of the four designated net settlement times (09:00-13:00, 13:00-15:00, 15:00-17:00). [47] Under discussion. [48] A very limited intraday funds market exists in Switzerland for time-critical payments in connection with securities transactions (e.g. bond redemptions).

III. Queuing arrangement and information structure

	Belgium	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	United Kingdom	United States
Centrally located queuing	y	y	y	y	n	y	y[49]	y	(y)[50]	n
- standard rule for queuing	Bypass FIFO	FIFO	FIFO	FIFO	–	FIFO	–	FIFO	–	–
- priority	y	y	y	y	–	y	–	y	–	–
- reordering by participants	n	n	y	n	–	y	–	y[51]	–	–
- reordering by the operator	n	n[52]	y	n	–	y	–	n	–	–
- optimisation	y	y	y	y	–	y	–	n	(y)	–
- real-time information on queued incoming transfers	y	y	y	y[53]	–	y	–	y	–	–
- on request	y	y	y[54]	y	–	y[55]	–	y	–	–
- released automatically	n	y	y[56]	n	–	n	–	n	–	–
- revocability of queued transfers										
- end-of-day	n	y	y	y	–	y	–	y	(y)	–
- during the day	n	n	y	n	–	y[57]	–	y	(y)	–
Message flow structure	Y	Y	V	V	V	V	V	V	L	V
Is pricing used as an incentive mechanism for the efficient processing of payments?	y	y[58]	y	y	n	y	n	y	n	n

[49] Planned for 1997. [50] But only as a fallback mechanism if needed to resolve gridlock (i.e. "circles processing") or if funds are not available on account (the brackets show these cases). [51] Only cancellation of queued payments. [52] However, in order to minimise the number of payments pending in the queues, at the end of the day an optimisation routine will be performed that will override the FIFO rule. [53] Only for total amount. [54] For payments with priority 1. [55] Only limited information; it does not contain the information needed to allow the receiving bank to credit the beneficiary. [56] As overall information for payments with priority 2 at the end of the processing cycles. [57] Only if the receiving participant agrees. Cancellation can only be made by the Netherlands Bank. [58] Under discussion.

ANNEX 2

Comparative table of selected net settlement systems[1]

(as at end-September 1996)

I. General information

	Canada	France	Germany	Japan	United States	European Union
Name of the system	Large Value Transfer System (LVTS)	Système Net Protégé (SNP)	Electronic Clearing Frankfurt (EAF2)	Zengin Data Telecommunications System (Zengin System)	Clearing House Interbank Payments System (CHIPS)	Private ECU clearing and settlement system
Year of implementation (scheduled)	(1997)	(1997)	1996	1973	1970	1986
Ownership CB = central bank	The Canadian Payments Association (CPA)	Centrale des Règlements Interbancaires (CRI)	CB	Tokyo Bankers Association	The New York Clearing House Association	ECU Banking Association
Network operator	CPA	CRI	CB	Tokyo Bankers Association	The New York Clearing House Association	S.W.I.F.T.
(message carrier)	(S.W.I.F.T.)	(S.W.I.F.T.)	(Datex-P network of Deutsche Telekom AG)	(NTT Data Communications Systems Corporation)	(Leased commercial telephone lines)	(S.W.I.F.T.)
(netting facilitator)	CPA	CRI	CB	(Zengin Center)	(CHIPS)	(S.W.I.F.T.)
Opening-closing time of system for same-day value (local time)	08:00-18:30 (GMT-5)	08:00-16:45 (GMT+1)	08:00-14:15 (GMT+1)	08:30-15:30 (GMT+9)	07:00-08:00 EST (GMT-5)	07:30-14:00 (GMT+1)
- deadline for acceptance of same-day transactions	18:30	15:45	12:45	15:30	16:30 EST	14:00
- third-party	18:00	after 14:30[2]	12:45	15:30	–	–[3]
- participant transactions	18:30	15:45	12:45	–	16:30 EST	14:00
- time-frame when netting occurs	Continuous throughout the day	15:45-16:15	Bilateral: continuously[4] Multilateral: at 13:00 and 14:00	17:00[5]	Continuous throughout the day	14:00 - 15:45[6]

[1] For Canada and France, the table describes the characteristics of the new system under development and therefore some features may change. y = yes, n = no, – = not applicable/not available. [2] The agreement of the receiving participant is necessary. [3] Depends on clearing banks' internal rules. [4] Every 20 minutes from 08:00 to 12:45. [5] Net balances for each participant are calculated at the Zengin Center after the closing time and then sent to each participant and the Bank of Japan by 16:30. Settlement occurs across accounts with the Bank of Japan at 17:00.

I. General information (continued)

	Canada	France	Germany	Japan	United States	European Union
Criteria for membership[11]	RM	RM	RM	RM	RM	RM
Number of participants	approx. 20	approx. 30	66	3,481[7]	104[8]	47[9]
- number of direct participants	approx. 20	approx. 11	66	162[10]	16 settling 88 non-settling	47
- two-tiered system	n	y	n	y	y	n
Number of transactions (1995, thousands)						
- daily average	–	–	71[12]	3,757	203	6
- peak	–	–	117[12]	14,307	382	10
Value of transactions (1995, USD billion)[13]	–	–				
- daily average	–	–	412[12]	88	1,230	62
- peak	–	–	851[12]	445	1,960	121
Ratio of transactions value to GDP (at annual rate)	–	–	43	4	43	2[14]

[6] Immediately after 14:00, the ECU netting centre (S.W.I.F.T.) determines the preliminary net balance of each clearing bank and notifies it to the BIS and the respective banks. Between 14:00 and 15:15, banks must reduce their preliminary net debit or credit balances to an amount not exceeding ECU 1 million by asking the creditor/debtor clearing banks to grant them overnight loans/deposits in ECUs at the settlement rate notified by the BIS. Shortly after 15:15, the netting centre determines the final netting balances, which must be confirmed to the BIS by each bank before 15:45. [7] End-March 1996. [8] End of 1996. [9] End-February 1996. [10] Financial institutions that hold an account with the Bank of Japan. [11] O = open membership (any bank can apply), RM = restricted membership (subject to criteria). [12] Figures relate to the precursor system EAF. [13] Converted at yearly average exchange rates. [14] GDP of the European Union.

II. Payment message processing and settlement

	Canada	France	Germany	Japan	United States	European Union
Message flow structure	Y	Y	V	V	V	Y
Payment messages processing						
- first in, first out (FIFO)	y	y	y	y	y	y
- priority given to specific types of transaction	y	n	n	n	n	y
Centrally located queuing	envisaged	envisaged	y	n	n	y
Incentives to control message flows	y	n	y	n	y	n
- pricing based on time of day	n	n	n	–	n	n
- system rules requiring % of messages to be input by certain times	y	n	n	–	y	n
- other	n	n	Bilateral offsetting[15]	–	–	n
How far in advance does the system allow future-dated payment messages to be input?	–	–	–	5 business days	–	5 clearing days
Irrevocability of payment messages						
- when input	n	n	y[16]	n	n	n[18]
- when received	y	y	n	y[17]	y	n[18]
- specified time	n	n	–	–	n	n[18]
Time-frame for incoming payments from net debtors	18:30-20:00	16:15-16:45	13:15-14:00[19]	17:00[20]	16:30-17:30 EST	14:00-15:15
Time-frame for outgoing payments to net creditors	18:30-20:00	16:15-16:45	14:00-14:15	17:00[20]	–[21]	14:00-15:15
When does finality occur?	End-of-day[22]	End-of-day	When bilaterally offset (Phase 1) or multilaterally settled (Phase 2)[23]	End-of-day	End-of-day[24]	End-of-day

[15] Incentive for early input in bilateral relations: only payments which are well balanced and do not exceed the MSAs (see footnote 25) are included in the offsetting and thus become final early. [16] In Phase 1, before payments have been offset. [17] Payment messages are revocable if the funds have not yet been credited to the customer's account or if the receiving bank (and the customer) accepts cancellation of messages even after the funds have been credited to the customer's account. [18] When netted. [19] Cover management during the first and second multilateral clearings. [20] Both incoming and outgoing payments are simultaneously settled by the designated-time net settlement mode of BOJ-NET. The settlement time can be extended to 17:30 or 18:00 on certain business days.

III. Risk controls and liquidity arrangements

	Canada	France	Germany	Japan	United States	European Union
Limits	y	y	n[25]	y	y	y
- bilateral net receiver limit	y	y	–	n	y	n
- multilateral net sender limit (net debit cap)	y	y	–	y	y	y
- other	–	–	–	–	–	y[26]
Loss-sharing arrangement	y	y	n	y	y	y[27]
- survivors pay	y	y	–	n	y	y
- defaulters pay[28]	y	n[29]	–	n	n[29]	n
- combination of these two options	y	n	–	y[30]	n	n
Collateral	y	y	y	y	y	Envisaged
- each participant fully collateralises its largest net debit position	y	n	–	n	n	–
- shared collateral pool	y	y	–	y	y	–
- combination of these two options	y	n	–	n	n	–
- other	–	–	y[31]	y[30]	–	Certain EU central banks[27]

21 Any time after all incoming payments have been received from debtor settling participants, but no later than 18:00 EST. 22 Intraday finality is guaranteed once the payment message has passed the risk control tests. 23 In Phase 1 settlements in the sense of booking on the Bundesbank giro accounts are carried out only at the end of the operations. 24 Settlement is complete when each debtor settling participant has made its required transfer, and the Federal Reserve Bank of New York, or CHIPS as its agent, has effected all steps necessary on its part to make the transfers to each creditor settling participant, whether or not credit advices have been received. 25 Maximum sender amounts (MSAs) are set by the sending bank. This is comparable to fully collateralised bilateral net sender limits. Inclusion of payments in the bilateral offsetting is possible to the extent that the MSA of one or both participants is not exceeded. Excess payments are placed in queues and carried over to the next offsetting cycle. 26 Multilateral net credit cap. 27 In the event that a participant with a net debit position is unable to find a participant with a net credit position which agrees to lend its surplus, the BIS Intermediation Facility (BIF) will be activated to channel that surplus through all other clearing banks, which are each obliged to onlend up to a maximum of ECU 5 million to the "net debit" bank. After activation of the BIF, if necessary the Emergency Settlement Facility (ESF) can be used. Under this credit facility, the clearing banks grant bilateral credit lines to each other which may not exceed ECU 25 million per beneficiary clearing bank. In addition to these arrangements some EU central banks have introduced collateralised liquidity facilities to operate alongside BIF. See also footnote 6. On 16th September 1996, the EBA fully implemented a system of binding intraday limits with a mechanism whereby no payment can be delivered to a receiving bank unless both the sending and receiving banks' resultant net positions are within the multilateral debit and credit limits which have been established for both banks (BIF plus ESF). Since the credit lines are at present not collateralised, the liquidity sharing arrangements is at the same time a loss-sharing arrangement according to which each bank is committed to provide liquidity and to cover a loss up to the amount of the bilateral credit limit granted to a failing bank. 28 Defaulters pay means that each participant fully collateralises its own debit position. 29 In this system (also typically in the case of survivors pay arrangements) the collateral provided by the defaulting participants will be taken first to cover losses or shortfalls. 30 Each participant is obliged to post collateral equivalent to 50% of its net debit cap with the Bank of Japan. In the event that the collateral posted by the failed participant is insufficient to cover the loss incurred, the shortfall is made up jointly by other participants. 31 MSAs are fully collateralised.

III. Risk controls and liquidity arrangements (continued)

	Canada	France	Germany	Japan	United States	European Union
Liquidity backup arrangements						
- intraday	y	n	y	y	y	n
- overnight	y	n	y	y	n[32]	y
- provided by system participants	y	n	n	n	y	y[27]
- provided by external private sector sources	n	n	n	n	n	n
- other	Central bank	–	Central bank[33]	Central bank[34]	–	BIS; also certain EU central banks[27]
Is the system's risk management designed to ensure the completion of settlement in the event of failure to settle the single largest net debit position?	y	y	y[35]	y	y	y[27]
- multiple failures?	y	n	y[35]	y	y	n
Does the system have a procedure for unwinding transactions in cases where other means of ensuring settlement have been exhausted?	n	y	y	y	y	y
- on a partial basis	n	n	y[36]	y[37]	n	n
- all transactions	n	y	n	n	y	y

[32] It is the intent of CHIPS rules that before the end of daily settlement the collateral of a defaulting participant will be sold and the proceeds distributed to the participants that provided liquidity to cover the net debit balance of the defaulting participant. [33] Giro overdraft lombard credit. [34] In the event of a participant's default, the Bank of Japan will provide against collateral the necessary liquidity on its behalf. [35] Cancellation of those payments which are still in queues and had not been included in the bilateral offsetting or in the multilateral settlement. [36] Partial cancellation of uncovered payments in queues. [37] In the event of a participant's default, payments on the value date are not unwound or revoked. Payments input in advance for settlement on the next business day and thereafter will be revoked.

IV. Structure of the system

	Canada	France	Germany	Japan	United States	European Union
Legal basis for netting						
- type of netting	Multilateral payment netting	Multilateral payment netting	Bilateral offsetting (Phase 1) Multilateral netting (Phase 2)	Multilateral payment netting	Multilateral payment netting	Multilateral payment netting
- specific law governing funds transfer activity	y	y	n	n[38]	y[39]	n
- general law	y	y	y	y[40]	y[41]	n
- other	–	–	–	–	–	y[42]
Does netting occur						
- on a bilateral basis between the system and a participant?	n	n	n	y[43]	n	n
- on a bilateral basis between participants?	n	n	y (Phase 1)	n	n	n
- on a multilateral basis among participants?	y	y	y (Phase 2)	n	y	y
Is the netting system linked to any other system?						
- RTGS	n	y	n	n[44]	y	n
- securities	n	n	n	n	n	n
- ACH	–	n	n	n	n	n
- other	–	–	Accounting system of the central bank	y[44]	–	–

[38] Rules and regulations on domestic funds transfers relating to the Zengin System. [39] Article 4A of the New York Uniform Commercial Code covers funds transfer activity. [40] Civil Law and Commercial Code. [41] The Federal Deposit Insurance Corporation Improvement Act of 1991 includes netting provisions. [42] Different legal systems govern different parts of the system. For example, the ECU Banking Association's Articles of Association and its Clearing Rules are drawn up under French law whereas its agreements with the BIS and S.W.I.F.T. are governed by Swiss and Belgian law respectively. [43] Payment netting occurs on a bilateral basis between the Bank of Japan and a participant. [44] Net balances are settled over BOJ-NET (designated-time net settlement mode) under the CPU linkage.

V. Role of central bank

	Canada	France	Germany	Japan	United States	European Union
Does the central bank participate in the netting system?	y	n	n	y	n	n
- as a participant	y	–	–	n	–	–
- as the central counterparty	n	–	–	y	–	–
- other	–	–	–	–	–	–
Does the netting system settle on the books of the central bank?	y	y	y	–	y	n[45]
Does the central bank provide services to the netting system?	y	y	y	y	y	n
- collateral management	y	y	y	y	n	–
- custody	y	n	y	y	y	–
- other	–	–	–	–	–	–
Does the central bank extend credit to the netting system?	y[46]	n	n	y[47]	n	n[27]
Is there a guarantee associated with the netting?	y[46]	n	n	y[47]	n	n

[45] Settlements occur on the books of the BIS. [46] To deal with any contingency in which the sum of exposures to the LVTS at the time of failure was greater than the collateral posted by participants, the Bank of Canada will guarantee settlement in all circumstances. [47] The Bank of Japan will extend credit to guarantee settlement in the event of default of participants.